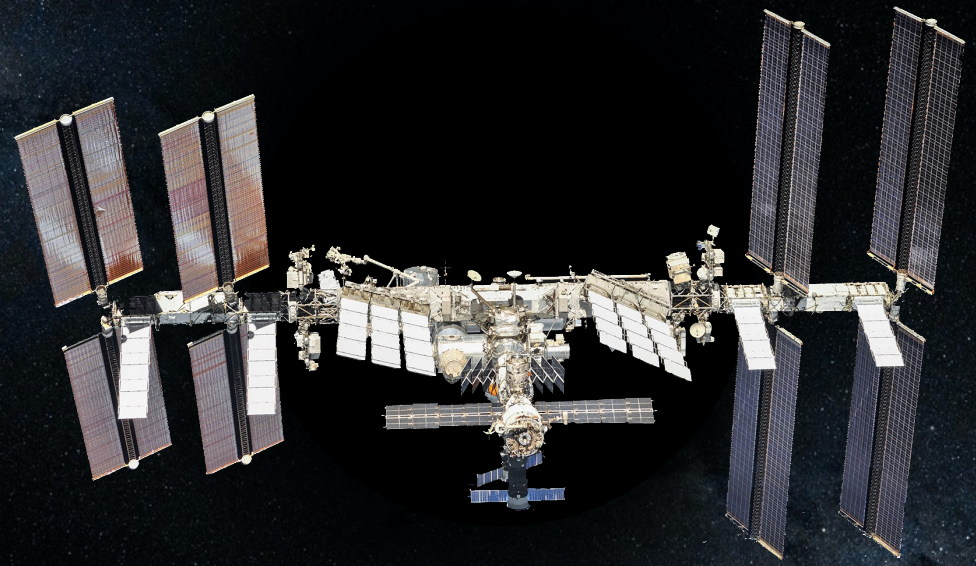
National Aeronautics and Space Administration



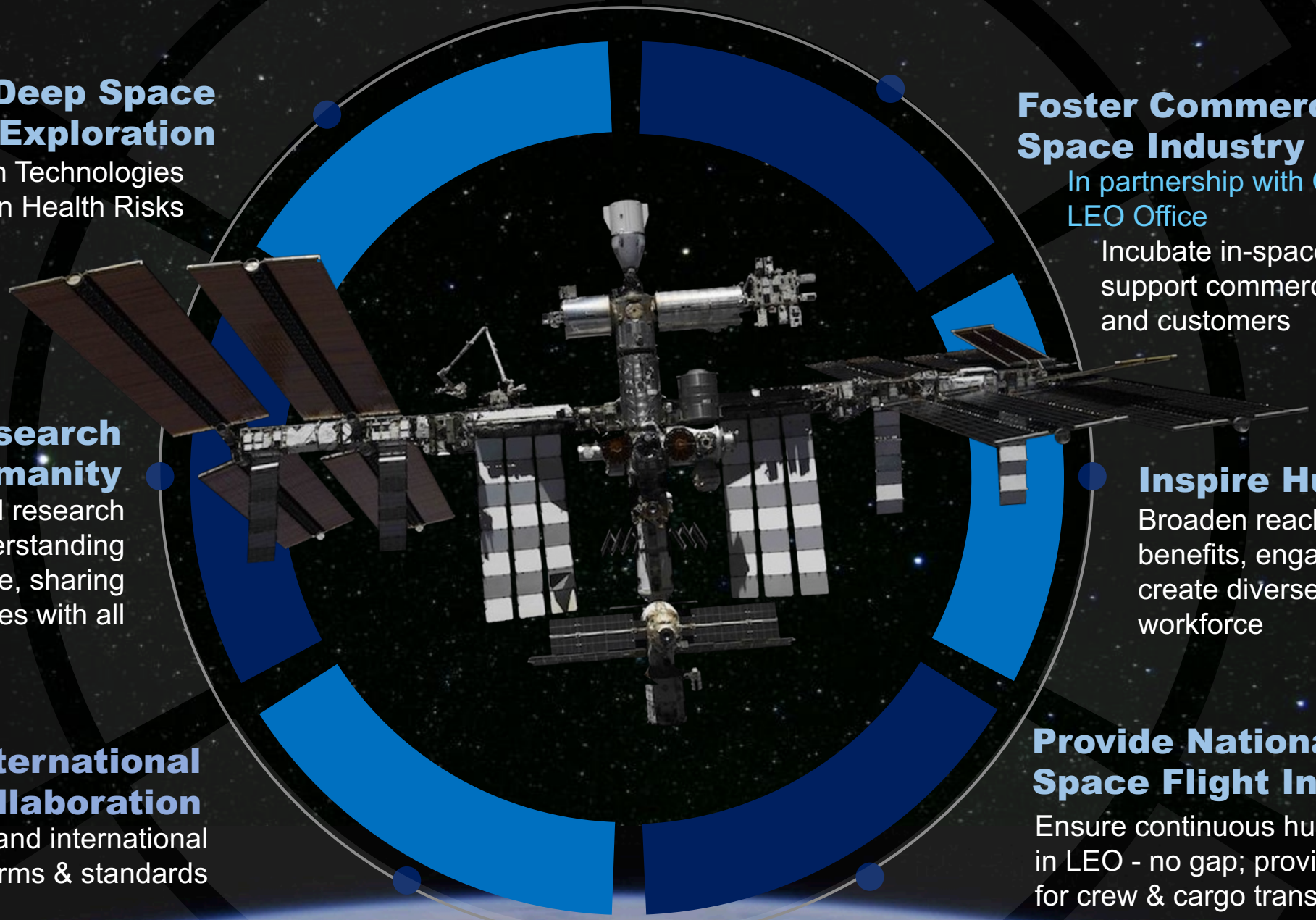
International Space Station Status

Robyn Gatens
International Space Station Director
Space Operations Missions Directorate
October 2022

Agenda

- ISS Increment Overview
- ISS Operational Status
- Utilization Highlights
- ISS Extension and Transition

ISS Mission Goals – The Decade of Results



Enable Deep Space Exploration

Validate Exploration Technologies and Reduce Human Health Risks

Foster Commercial Space Industry

In partnership with Commercial LEO Office

Incubate in-space manufacturing, support commercial LEO facilities and customers

Conduct Research to Benefit Humanity

Life-saving medical research & applications, understanding climate change, sharing discoveries with all

Inspire Humankind

Broaden reach of space benefits, engage public, create diverse future STEM workforce

Enable International Collaboration

Maintain & expand international partnerships, set norms & standards

Provide National Human Space Flight Infrastructure

Ensure continuous human presence in LEO - no gap; provide destination for crew & cargo transportation

ISS Increment Overview

Increment 67 Overview

- Axiom-1 Launch/Docking (Private Astronaut Mission)
- RS EVA #52
- Axiom-1 Undock/Splashdown (Private Astronaut Mission)
- SpaceX-Crew4 Launch/Docking
- RS EVA #53
- SpaceX-Crew3 Undock/Splashdown
- Boeing-OFT2 Launch/Docking/Undocking (Uncrewed)
- Progress 79P Undock
- Progress 81P Launch/Dock
- Northrop Grumman CRS-17 Release
- SpaceX CRS-25 Launch/Dock
- RS EVA – ESA
- RS EVA #54 and 54A
- SpaceX CRS-25 Undock
- Soyuz 68S Launch/Dock (integrated crew)
- Soyuz 67S Undock/Landing

Flight Engineers Robert Hines of NASA; Samantha Cristoforetti of ESA (European Space Agency); Denis Matveev of Roscosmos; Commander Oleg Artemyev of Roscosmos; and Flight Engineers Sergey Korsakov of Roscosmos; Jessica Watkins of NASA; and Kjell Lindgren of NASA

Increment 68 Overview

- SpaceX-Crew5 Launch/Dock (integrated crew)
- SpaceX-Crew4 Undock/Splashdown
- Progress 82P Launch/Dock
- Northrop Grumman CRS-18 Launch/Berth
- SpaceX CRS-26 Launch/Dock (iROSAs)
- U.S. iROSA EVAs (Prep 1B, install 4A, install 3A and Prep 1A)
- RS EVAs 55, 56, 57, 58 and 59
- SpaceX CRS-26 Undock
- Northrop Grumman CRS-18 Release
- Boeing-CFT Launch/Dock/Undock/Splashdown
- Progress 81P Undock
- Progress 83P Launch/Dock
- SpaceX-Crew6 Launch/Dock (integrated crew + UAE)
- Northrop Grumman CRS-19 Launch/Berth
- SpaceX CRS-27 Launch/Dock
- SpaceX CRS-27 Undock
- Soyuz 69S Launch/Dock
- Soyuz 68S Undock/Landing

NASA astronaut Frank Rubio; Roscosmos cosmonaut Dmitri Petelin; Japan Aerospace Exploration Agency (JAXA) astronaut Koichi Wakata; NASA astronauts Josh Cassada and Nicole Mann; and Roscosmos cosmonauts Sergey Prokopyev and Anna Kikina.

Crew Rotation/Integrated Crew

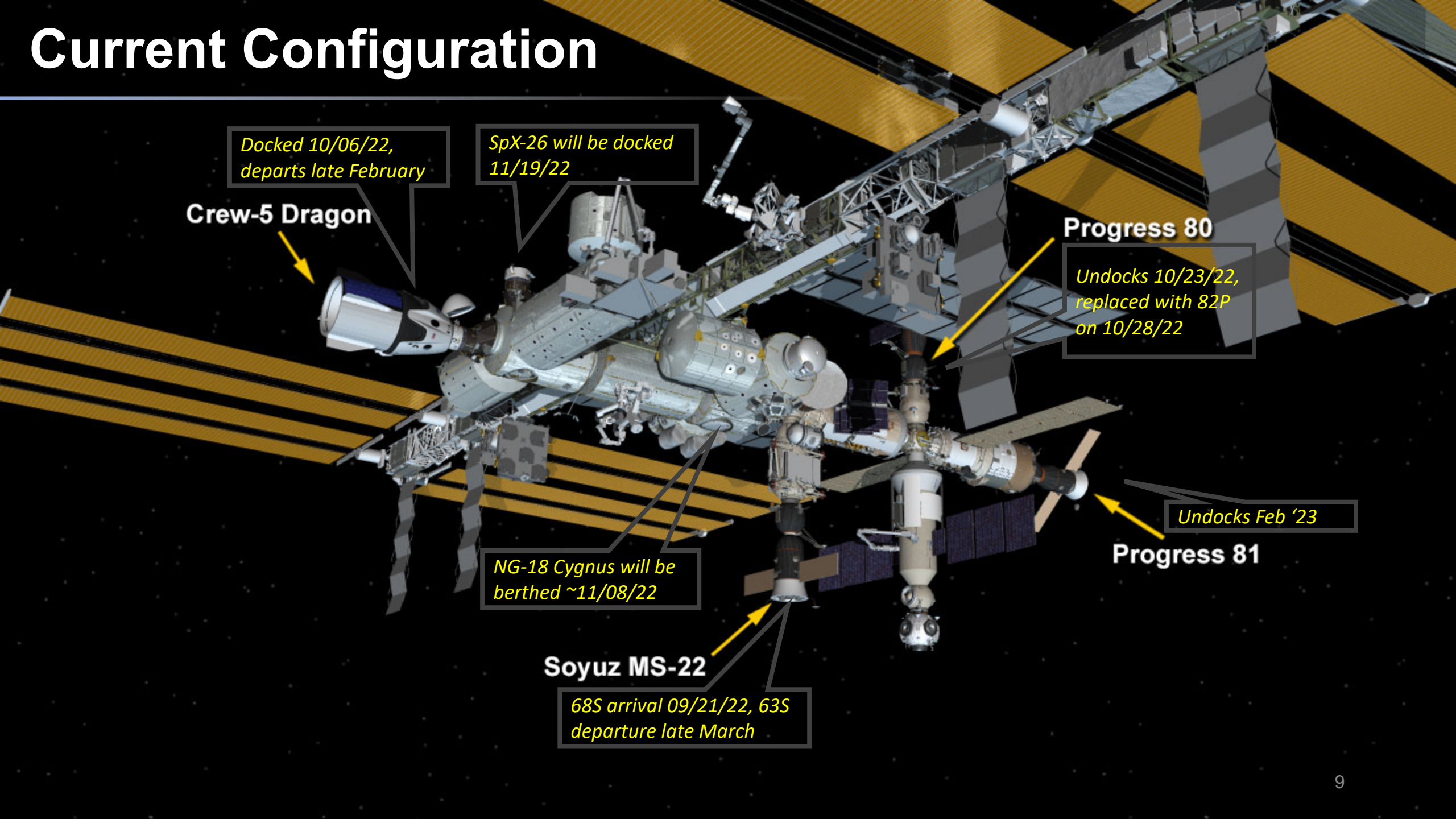
- NASA/Roscosmos signed integrated crew agreement in July, 2022 for cosmonauts to fly on USCV and astronauts to fly on Soyuz
  - Ensures Russian and NASA crew presence on ISS if either USCV or Soyuz vehicle or crew encounters pre-flight or in-orbit anomaly that disrupts crew vehicle traffic plans

- Current agreement provides for one crew swap per year
  - Fall 2022: Crew-5 (Anna Kikina)/68S (Frank Rubio)
  - Spring 2023: Crew-6/69S
  - Spring 2024: Crew-7/71S

- Assessing options for Fall 2023

ISS Operational Status

Current Configuration



Upcoming Spacewalks (EVAs)

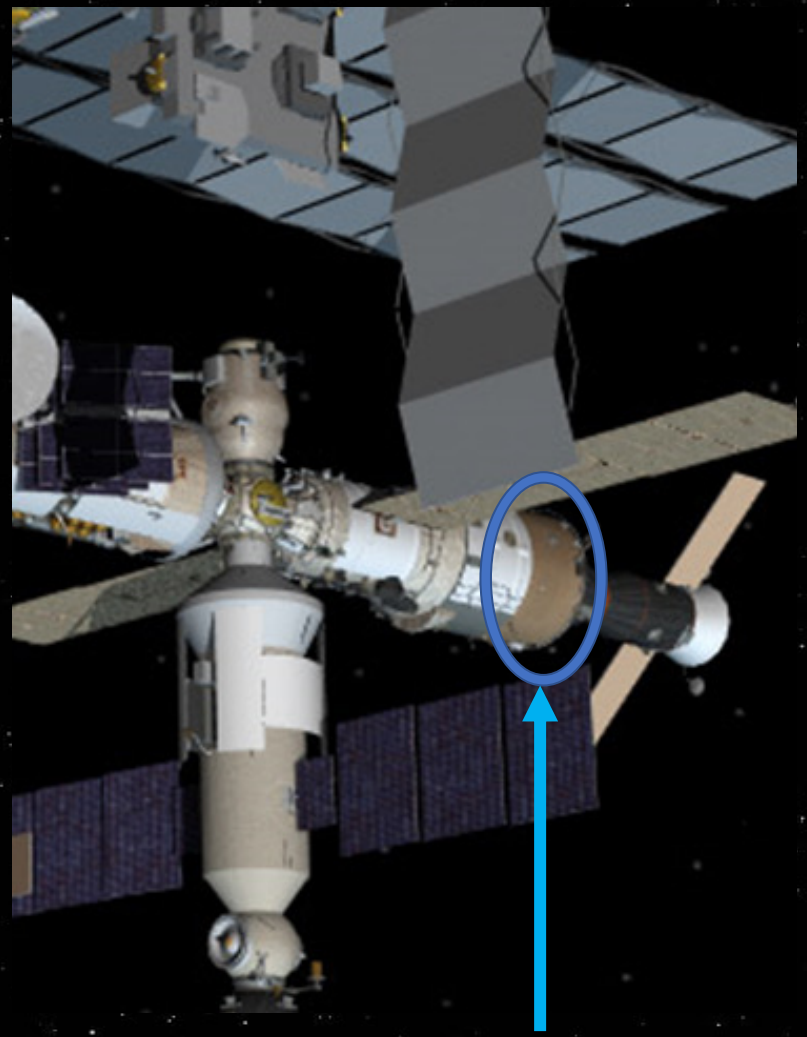
- **U.S. EVA – ISS Roll-Out Solar Array (iROSA) Prep 1B and 1A**
  - Separate pair of EVAs (Nov for 1B and mid-Jan for 1A)
  - Primary tasks will be to install ISS Power Augmentation (IPA) Mod Kits and route appropriate cables to mast canister in prep for install.
- **U.S. EVAs – iROSA Install 4A and 3A**
  - Two separate EVAs that will take place tentatively in late November or early December.
  - Primary objective to install the new 3A and 4A iROSAs onto the Mod Kits that were installed Fall ‘21 and Spring ‘22 respectively.
- **RS EVAs – November/December**
  - RS EVA #55 – Russian radiator prep for transfer
  - RS EVA #56 – Russian radiator transfer by European Robotic Arm
  - RS EVA #57 – Russian airlock transfer by European Robotic Arm
  - RS EVA #58 – Russian radiator deploy

EVA Investigation – FRR Decision

- **Anomaly**
  - Upon completion of U.S. EVA #80 (March 2022), the space station crew observed a thin layer of moisture inside astronaut Matthias Maurer's helmet after airlock re-pressurization.
- **Impact**
  - Identified as a close-call and immediately declared a stop to all planned U.S. Operating Segment (USOS) spacewalks pending an investigation into the cause.
  - Water samples and some suit hardware was returned to Earth for inspection.

- **Resolution**
  - Following a very extensive investigation, the team confirmed there were no hardware failures within the suit. The cause was likely due to integrated system performance.
  - Ops procedures were updated and additional absorption pads developed to minimize scenarios that could result in water accumulation as well as help contain any liquid in the helmet.
  - At FRR in October, NASA approved a "GO" to return to nominal operations based on the mitigation efforts and other results of the investigation.

ISS Significant Items of Interest



ISS Atmosphere Leak Location
(Aft end of Service Module)

Atmosphere Leak

- Identified atmosphere leakage increase in September 2019. The leak presents no immediate danger to the crew, or vehicle, at its current state. Multiple measures in work to identify the source(s) of the leak from the PrK section of the Russian Service Module (SM).
- Kapton tape applied to the PrK pressure shell and labeled for tracking purposes. Two cracks have been permanently repaired with no issues, and sealant has been applied to a 3rd suspected area. Strain gauge data is being collected for events of interest. Thus far, all strains measured to date are low and in-family with predictions.
- In the near term, that section of the SM will be isolated appropriately to minimize consumables loss.
- Teams across the partnership continue to work together in joint forums to identify additional leak source(s) and provide further leak mitigation and/or resolution.
- There is sufficient gas currently in-orbit, and planned to be launched, to sustain appropriate levels of atmospheric pressure until the issue is resolved.

ISS Significant Items of Interest

- **End-of-life Deorbit Planning**
  - Deorbit planning to date relies on use of 3 Russian Progress vehicles operating simultaneously
    - Marginal capability and Russian concerns with complexity – requested NASA explore US capabilities
  - NASA released RFI to industry in August for a US Deorbit Vehicle that would provide a more robust capability for final deorbit along with continued Russian propulsion support through end-of-life. Responses received and forward planning in work.
- **U.S – Russia Relations**
  - Day-to-day ISS operations continue to run smoothly, including crew training and staffing in Russia
  - First integrated crew rotation successfully underway
- **Science Demand**
  - Demand for internal and external ISS payload space, as well as upmass resources and crew time has been increasing
  - Work underway at Agency to assess prioritization processes going forward to maximize returns from ISS while planning for work to transition to CLD's later in the decade

Utilization Summary

ISS Technology Demonstration Fly-Off Plan

2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032

Legend

Bar lengths indicate Tech Demo duration. Arrows indicate continued on-orbit utilization.

- Initiated on ISS
- Ground development
- Planned ISS testing
- Targeted on CLD
- [xxxx] Capability Gap #

Material Flammability & Fire Propagation [2934]

Exploration Potable Water Dispenser for Sparing/Dormancy Periods [2918]

Fire Detection, Suppression, Monitoring, Cleanup [2935]

Filtration System for Lunar/Martian Dust [2962]

Suited Autonomous Health Monitoring & Decision Support [2941]

Particulate Monitoring [2900]

In-Flight Microbial Monitoring [2901]

Autonomous Logistics for Dormancy and Crew Readiness [2907]

Radiation Monitoring and Mitigation [2949]

Recover >90% Water from Urine Brine [2914]

Atmosphere CO_2 Removal [2896]

Robust Condensing Heat Exchanger [2960]

Non-Metabolic Solid Waste Processor [2932]

Atmosphere Monitoring [2899]

Compact Low Logistics Commode [2931]

Robust Advanced Water Recovery System [2925]

Autonomous Medical Diagnostic & Treatment Capabilities [2904]

Improve Reliability/Decrease Complexity of Oxygen Generation System [2903]

Low Mass/Volume Crew Clothing System [2958]

Exploration Exercise System [2952]

Fecal Resource Recovery [2963]

Recover/Recycle O_2 from CO_2 [2897] — 50% O_2 Recovery

In-Flight Water Quality Monitor [2902]

Sensorimotor, Neuro-ocular, Cardio Countermeasures [3492, 3514, 3515]

Crew Health & Performance Integrated Data Architecture & Informatics Tools [2905, 2954]

Food System, Crop Production & Health [2945, 2946]

May be required for CLD Ops not required for Tech Demo

Benefits CLD; not required for TD

Baseline feeds CO_2 reduction TD

Lower Priority

Medium Priority

Targeted CLD Tech Demos

AUPA (AWPA lower priority)

AOGA

75% O_2 Recovery

Updated: 8/29/22

Exploration Capabilities Development Technology Demonstrations: FY22 Accomplishments

The International Space Station has met Performance Goal (PG) 2.1.1 to *Initiate technology demonstrations on ISS to advance deep space exploration* by initiating 7 technology demonstrations during FY21, which exceeds the FY21 goal to initiate 5 tech demos.

Monitoring and Logistics Management

RFID Enabled Autonomous Logistics Management (REALM)-3

Current Status:
Smart Stow Deployed and Powered Sep 2022, Drawer Monitor System launching on NG-18

Oxygen Generation

Hydrogen Sensor Demonstration for Oxygen Generation Assembly

Current Status:
Flew and activated successfully in FY22

Food and Nutrition

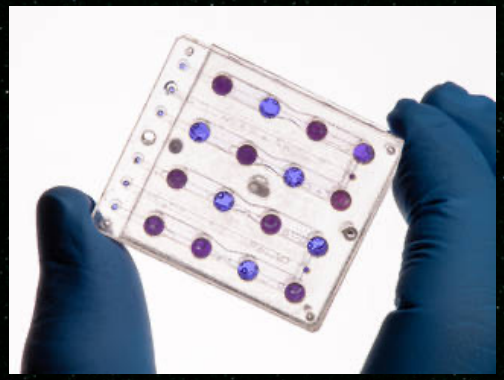
eXposed Root On-Orbit Test System (XROOTS)

Current Status:
Flew on NG-17, activated in FY22, operations are still on going

Radiation Monitoring

Biosentinel

Current Status:
ISS experiment flown and initiated in FY22, identical experiment will be flown on Artemis-1



Exploration Capabilities Development Technology Demonstrations: FY22 Accomplishments

Waste Management and Water Recovery

Universal Waste Management System (UWMS)

Current Status:
Activated successfully, first use on 10/18/2021 (FY22), currently working through technical issues toward crew operational use

Collapsible Contingency Urinal (CCU)

Current Status:
Flown in FY22 and used in Q3

Alternate Fecal Container (AFC)

Current Status:
Flown on SpX-24, however cannot be initiated until UWMS is operational

Exploration Capabilities Development Technology Demonstrations: FY23 Hardware

Life Support

- CapiSorb Visible System: SpX-27
- Upgraded Water Processor Assembly (WPA) Catalytic Reactor Re-fly: SpX-28
- Urine Processor Assy (UPA) Purge Pump and Separator Assy (PPSA): SpX-26
- Exploration Potable Water Dispenser (xPWD): NG-19

Exploration Potable Water Dispenser

WPA Catalytic Reactor

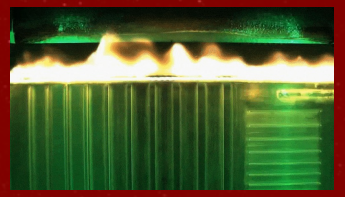
Environmental Monitoring

Spacecraft Atmosphere Monitor TDU1

- Spacecraft Atmosphere Monitor (SAM) Technology Demonstration Unit 2: FY23 TBD
- Anomaly Gas Analyzer (AGA): FY23 TBD

Fire Safety

Saffire-VI: NG-19



PMMA burning on Saffire-V

Exploration Medical

Tempus Pro: SpX-26

Metrics – Agency Priority Goal (APG)

Initiate at least five technology demonstrations on the International Space Station to advance deep space exploration.
Status: GREEN

FY21 Delivered and Initiated (7)	FY22 Delivered and Initiated (5)	FY22 Delivered, To Be Initiated (2)
• Spacesuit Evaporation Rejection Flight Experiment (SERFE) (Initiation began FY21, Q1)	• Universal Waste Management System (UWMS) (Delivered FY21, Initiated FY22, not currently operational)	• RFID-Enabled Autonomous Logistics Management 3 (REALM-3)
• Airborne Particulate Monitor	• BioSentinel	• Alternate Fecal Container (AFC) (cannot be used until UWMS is operational)
• RFID-Enabled Autonomous Logistics Management-2 (REALM-2)	• Exposed Root On-Orbit Test System (XROOTS)	
• Spacecraft Fire Safety (Saffire) V, initiation following NG-14 departure	• Hydrogen Sensor Demo for Oxygen Generation Assembly (OGA)	
• Brine Processor Assembly (BPA)	• Collapsible Contingency Urinal (CCU)	
• 4-Bed CO2 Scrubber		
• Water Processor Assembly (WPA) Catalytic Reactor (Initiated in FY21, returned on SpX-22 for TT&E)		

Metrics – Agency Priority Goal (APG)

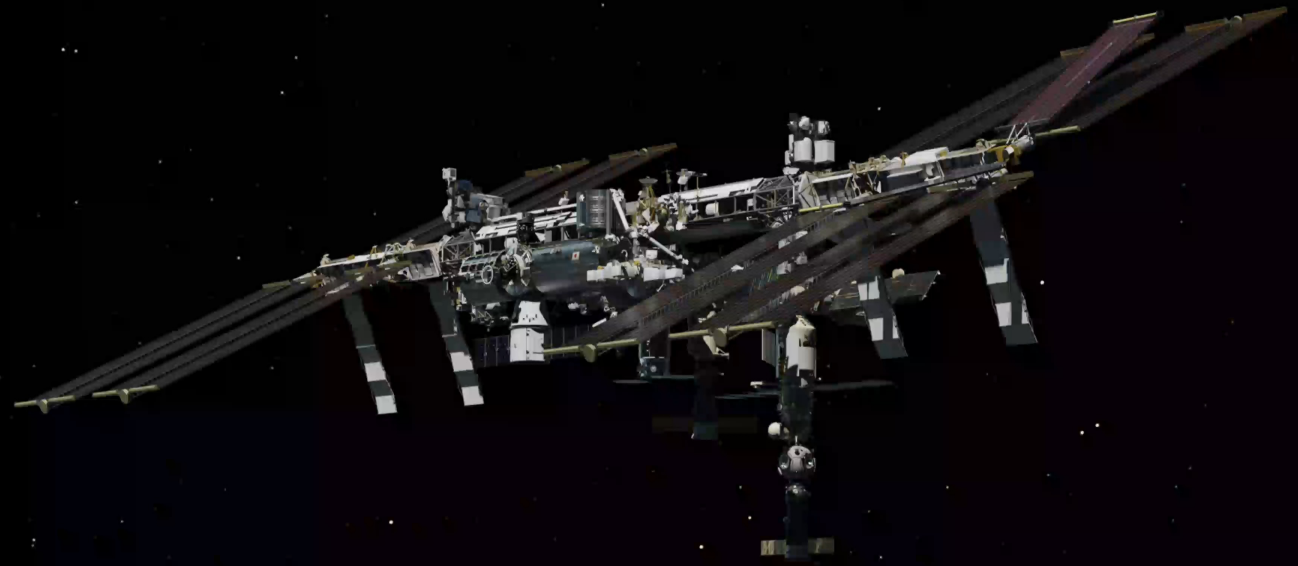
Initiate at least five technology demonstrations on the International Space Station to advance deep space exploration.
Status: GREEN

FY22 Delivered and Initiated (5)	FY22 Delivered, To Be Initiated (2)	FY23 To Be Delivered (8)
• Universal Waste Management System (UWMS) (Delivered FY21, Initiated FY22, not currently operational)	• RFID-Enabled Autonomous Logistics Management 3 (REALM-3)	• Capisorb Visible System (CVS)
• BioSentinel	• Alternate Fecal Container (AFC) (cannot be used until UWMS is operational)	• Exploration Potable Water Dispenser (xPWD) Demo
• Exposed Root On-Orbit Test System (XROOTS)		• Spacecraft Atmosphere Monitor-TDU 2
• Hydrogen Sensor Demo for Oxygen Generation Assembly (OGA)		• Saffire-VI
• Collapsible Contingency Urinal (CCU)		• Tempus Pro
		• Urine Processor Assy (UPA) Purge Pump and Separator Assy (PPSA)
		• Water Processor Assembly (WPA) Catalytic Reactor Re-fly
		• Anomaly Gas Analyzer (AGA)

Research Highlight – EMIT First Measurements

Earth Surface Mineral Dust Source Investigation

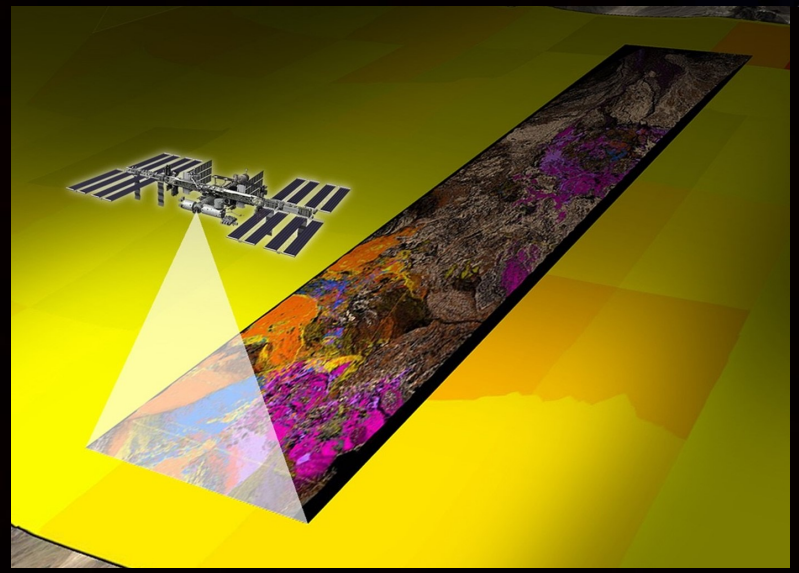
EMIT was developed by NASA JPL and works by measuring the hundreds of wavelengths of light reflected from materials on Earth. Materials reflect different wavelengths of light to produce a spectral fingerprint. The data EMIT collects will help scientists study the role of airborne dust particles in heating and cooling Earth's atmosphere on global and regional scales.

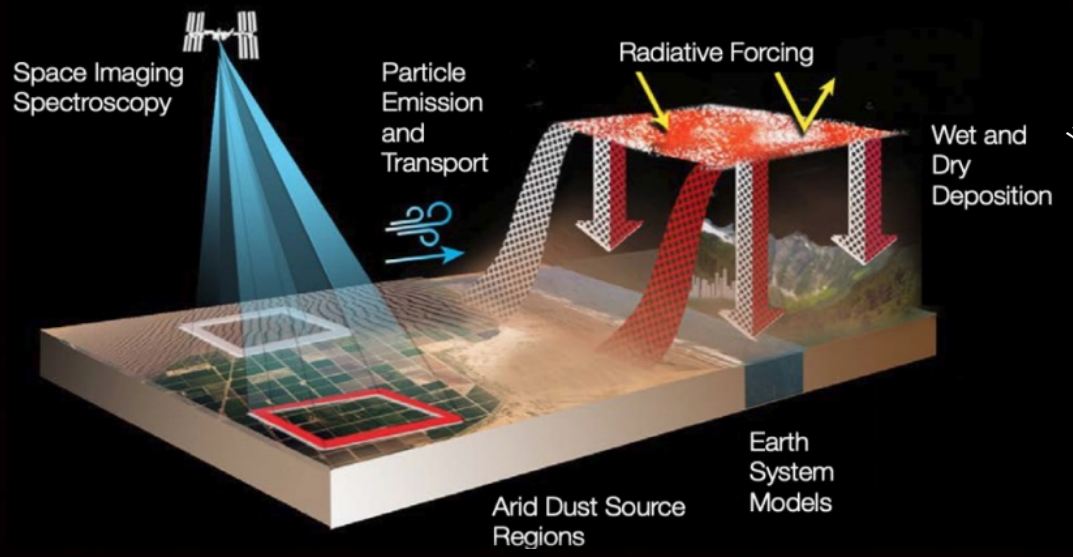


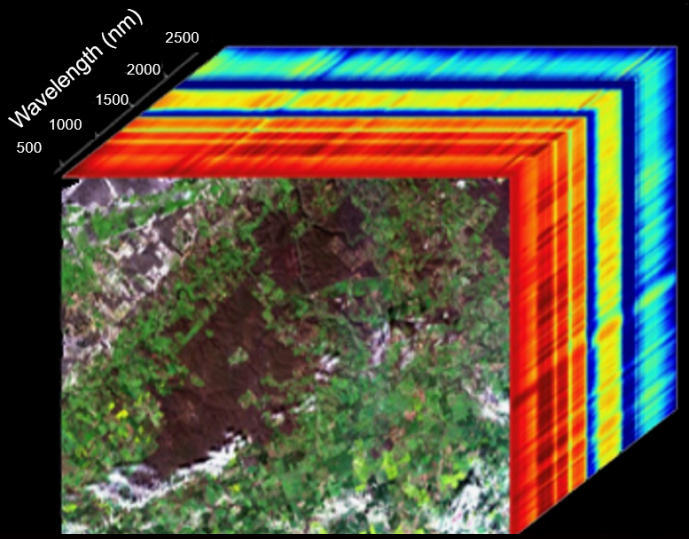
Source: earth.jpl.nasa.gov/emit

Results: (Figure Below)

- The front image shows a mix of materials in western Australia, including exposed soil (brown), vegetation (dark green), agricultural fields (light green), river, and clouds.
- The rainbow colors are the wavelengths of light (spectral fingerprints), from corresponding spots in the front image.







2022 Research Highlight: In-Space Production of Stem Cells

Benefits to Humanity

Title: Integrated Space Stem Cell Orbiting Research (ISSCOR) Lab in low-Earth Orbit (LEO)

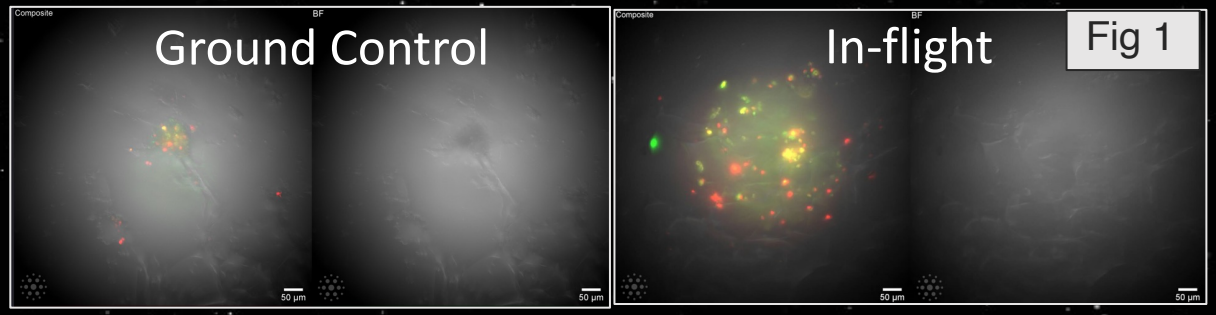
Background: UC San Diego Sanford Stem Cell Clinical Center (SSCC) and Sanford Consortium for Regenerative Medicine (SCRM) Stem Cell Institute in partnership with Space Tango received a NASA In Space Production Applications (InSPA) award in 2020 to utilize ISS microgravity to improve and accelerate stem cell related therapies. This partnership enables the establishment of an on-orbit facility that replicates the terrestrial UC San Diego SSCC/SCRM model. $150 Million Gift Takes Stem Cell Research to New Heights (ucsd.edu)

Purpose: To use the microgravity environment to enhance normal gravity research to improve stem cell knowledge base and capabilities.

Methods: Use of ISS National Lab to demonstrate Hematopoietic Stem Cell response to injury and capacity for repair, aging, and premalignant transformation using Space Tango automated bioreactors on Spx-24, SpX-25 and SpX-26.

References:

The effects of microgravity on differentiation and cell growth in stem cells and cancer stem cells - (Journal of Stem Cells Translational Medicine)
Space microgravity improves proliferation of human iPSC-derived cardiomyocytes - ScienceDirect



Results: Space Tango captured ~30000 images of live tissue organoids with lentiviral fluorescent reporters to quantify changes in cell properties. Post-flight analysis is ongoing.
Previous ISS NL research has shown that microgravity improves stem cell proliferation, expression and survival compared to 1-G.

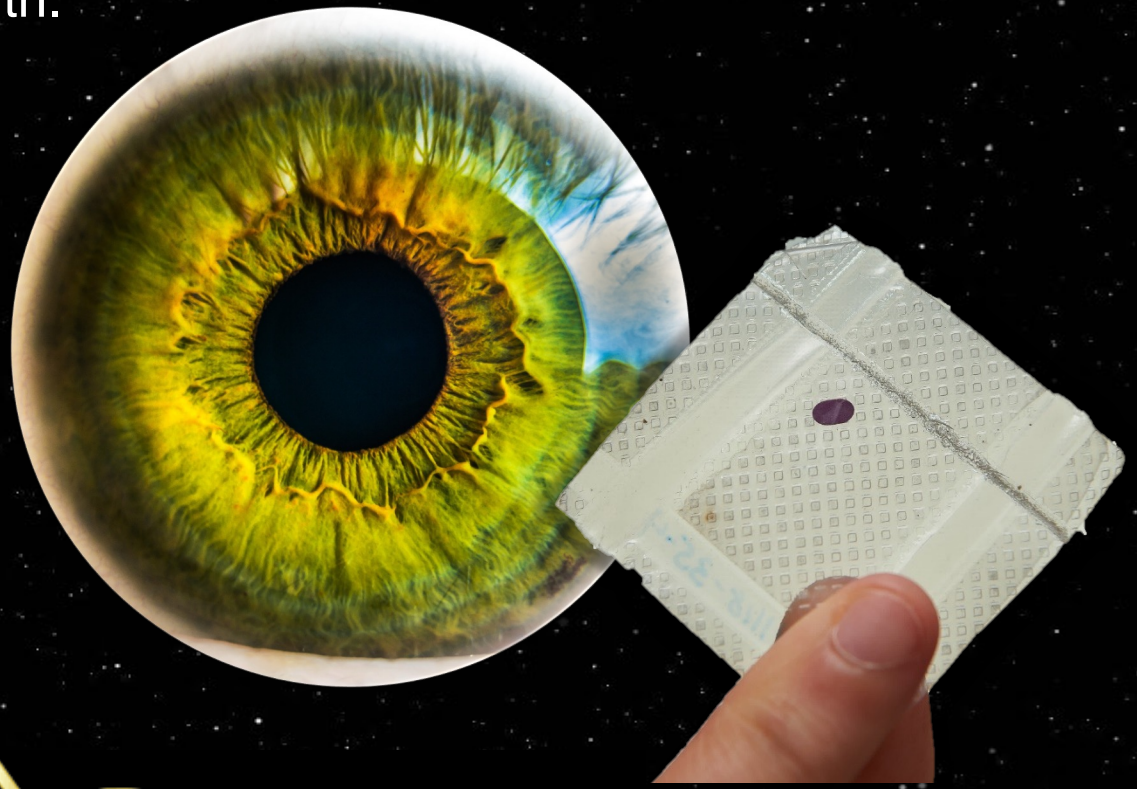
Why it Matters: Stem call facilities in the ISS microgravity environment can lead to breakthrough discoveries using the power of stem cells to develop more robust diagnostics and therapeutics for new pre-cancer diagnostics and therapeutics and degenerative diseases and injury. See ISS National Lab Brain Organoid Research.

Transition to LEO: Sierra Space signed an MOU with UCSD/Sanford to bring their ISSCOR capability to their Orbital Reef, establishing a path for transition from ISS to a Commercial LEO Destination. Sierra Space, UC San Diego Partner to Develop the First Stem Cell Research Institute in Space | Sierra Space

Research Highlight - Protein-based Artificial Retina Manufacturing

Protein-Based Artificial Retina Manufacturing by Lambda Vision Inc., aims to develop a high-resolution, protein-based artificial retina to restore vision to the millions of patients blinded by retinal degenerative diseases.

Results: LambdaVision in partnership with Space Tango and the ISSNL has successfully manufactured 200 layer films on the ISS. Initial analysis indicates they are more uniform than controls manufactured on Earth.



LambdaVision

Helping Patients Regain Sight

ISS Research Statistics

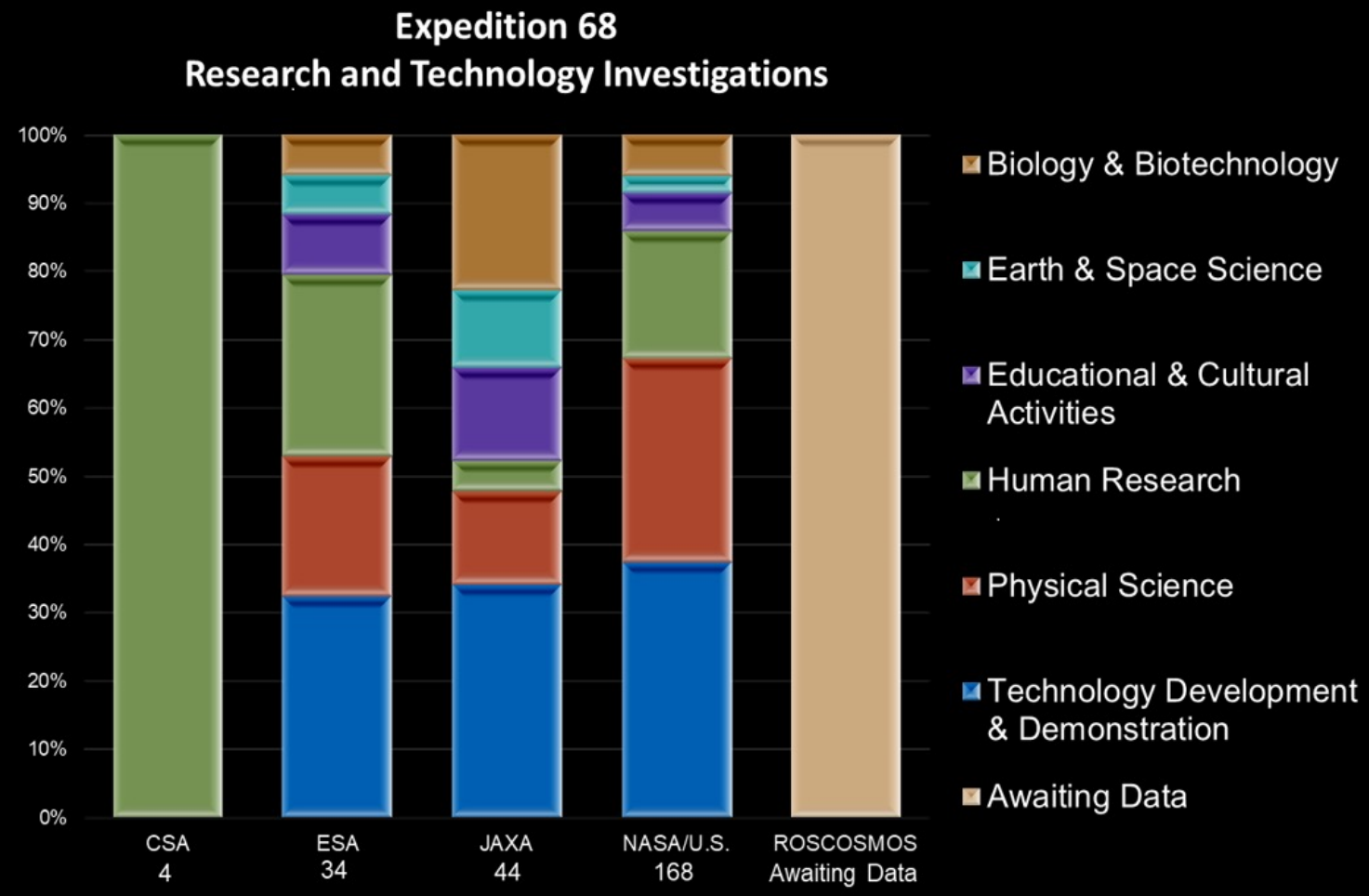
Current Investigations for 68: 250

- 168 NASA/U.S.-led investigations
- 82 International-led investigations
- 102 New Investigations
  - 1 CSA
  - 4 ESA
  - 12 JAXA
  - 85 NASA/US

MCB Approved Statistics Exp. 0-62

- 3040 Investigations
- 4418 Investigators Represented
- 109 Countries/Areas with ISS Research and Education Participation
- Over 2401 Scientific Results Publications (Dec 1998 – Sept 2022)

Estimated Number of Investigations Expedition 0-68: 3486*



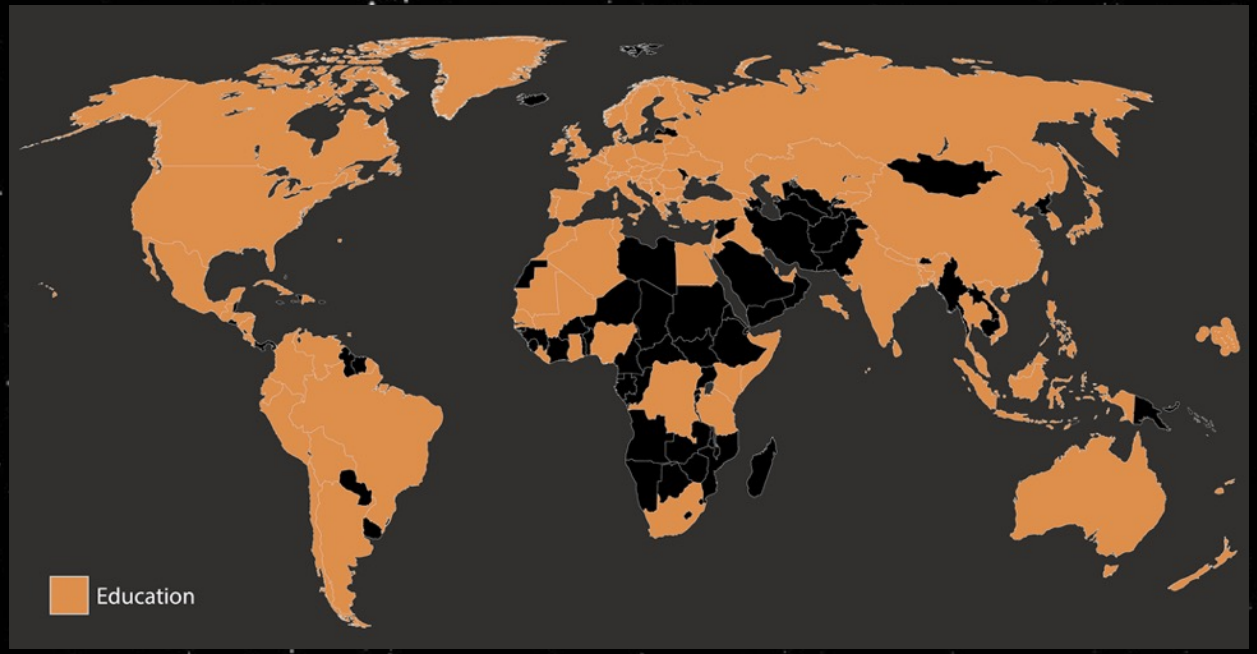
*Pending Post Increment Adjustments

STEM Education and Inspiration

ISS Reach in Numbers

Over the past 20 years, 2.8 million U.S. students in primary and secondary school have designed, launched, operated, or used data from the more than 800 student experiments launched to the ISS as part of these programs

109 countries and regions have performed education research onboard the ISS



300,000 Americans are registered for text/email alerts of ISS Spot the Station viewing opportunities

More than 17.8+ million people follow ISS social media updates, which are amplified across agency accounts with 136+ million followers

Mission Equity Campaign Initiatives (ISSNL)

JAMES A. ABRAHAMSON SPACE LEADER FELLOWSHIP

NLRA 2021-4: LEVERAGING THE ISS NATIONAL LAB TO ENABLE DIGITAL ENGAGEMENT AND HIGHER EDUCATION

SciGirls in Space

Girl Scouts

ISS National Lab Status (CASIS)

- **All Independent Review Team Actions Completed**
  - Primarily new Board and new acting Executive Director
  - User Advisory Committee established and meeting
  - Transparent, peer-reviewed project evaluation process established
  - NASA liaison transitioned to ISS Director
  - Cooperative Agreement simplified
  - Annual Performance Goals restructured to reflect priorities and outcome-based

ISS National Laboratory
CENTER FOR THE ADVANCEMENT OF SCIENCE IN SPACE

- **Successful 2022 ISS R&D conference – in person**
- **Beginning to see more demand than resources available – CASIS working with UAC on prioritization planning**
- **Future national laboratory in LEO**
  - NASA has been studying potential models
  - Formal action from National Space Council
  - OSTP kicked off microgravity research interagency working group

ISS Extension and Transition

ISS Extension Status

- The ISS International Partners have all indicated a desire to continue ISS operations beyond 2024.
  - Canada is evaluating extension as part of their normal budget process and anticipates confirming extension in early 2023
  - ESA's ministerial decision-making forum will meet in November 2022 where a positive extension decision is anticipated
  - JAXA governmental discussions regarding extension are ongoing and a positive extension decision is anticipated
  - Roscosmos Director General has publicly announced their desire to continue ISS operations until 2027/2028, or until their Russian Orbital Space Station (ROSS) is operational, though a formal decision has not been made.

- ISS structural life extension assessment to support 2030 is in work

International Partner ISS Transition Working Group

- All ISS International Partner agencies have indicated a desire to continue ISS-like research and development operations in LEO beyond the ISS
  - Includes crew opportunities, human research, technology demonstrations, basic and applied science, and more
- NASA is working to define potential partnership goals and models for cooperation onboard U.S. CLDs.
- All ISS Partners are working to establish planning milestones and standard interfaces
  - Developing “flexible science” that can work on ISS or a CLD

Resources

National Aeronautics and Space Administration

Learn more about the ISS at nasa.gov/station

Spot the Space Station
No Telescope Needed

Get notifications and learn more at spotthestation.nasa.gov

Follow NASA social media