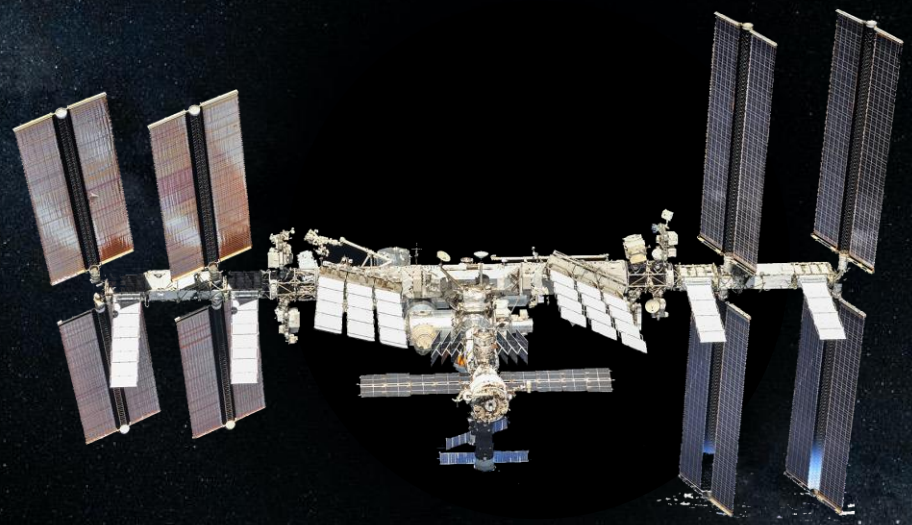
National Aeronautics and
Space Administration



International Space Station Status

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

Agenda

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

2021 STATION HIGHLIGHTS

FULL HOUSE
11 ON STATION
APRIL 2021

13 EVAS
MOST SINCE
2010

IROSA
INSTALLED
FIRST ROLLOUT
SOLAR ARRAY
OVER 3 EVAS

23 TOTAL
ON BOARD

PARAGUAY
DEPLOYED FIRST
SATELLITE
FROM STATION

EVA HOURS
3.73 DAYS OR
89.5 HOURS

EXPEDITIONS
64 (PARTIAL)
65 (FULL)
66 (PARTIAL)

8 CARGO
RESUPPLY MISSIONS
3 PROGRESS
3 DRAGON
2 CYGNUS

5 CREWED
LAUNCHES
CREW-2 DRAGON
CREW-3 DRAGON
SOYUZ MS-17
SOYUZ MS-18
SOYUZ MS-19

STATION SCIENCE
CHILE HARVEST
COOL FLAMES
BISHOP AIRLOCK
GITAI ROBOTIC ARM
EARTH CLIMATE STUDIES
COLD ATOM LAB AR
ASTROBEE WAKES UP
DNA RESEARCH

CREW-1
FIRST SPLASHDOWN
OF U.S. CREWED
SPACECRAFT
SINCE APOLLO 8

CREW-2 LAUNCH
APRIL 23, 2021
KIMBROUGH, MCARTHUR,
HOSHIDE, PESQUET

CREW-3 LAUNCH
NOV. 11, 2021
CHARI, MARSHBURN,
BARRON, MAURER

ISS Increment Overview

Increment 66 Crew Overview

Increment Visiting Vehicle Highlights:

- *Progress 79P Launch/Dock*
- *SpaceX Crew-2 Undock/Landing*
- *SpaceX Crew-3 Launch/Dock*
- *Northrop Grumman CRS-16 Unberth*
- *Russian Flight 6R (RS Node Module) Launch/Dock*
- *SpaceX CRS-24 Launch/Dock*
- *U.S. EVA #78 (SASA R&R)*
- *Soyuz 66S 12-Day (Spaceflight Participant Mission)*
- RS EVA #51
- SpaceX CRS-24 Undock
- Progress 80P Launch/Dock
- Northrop Grumman CRS-17 Launch/Berthing
- Axiom-1 Launch/Docking (Private Astronaut Mission)
- U.S. EVAs #79 (IROSA Prep) and #80 (RBVM Jumper)
- Soyuz 67S Launch/Dock
- Soyuz 65S Undock/Landing (Mark Vande Hei)

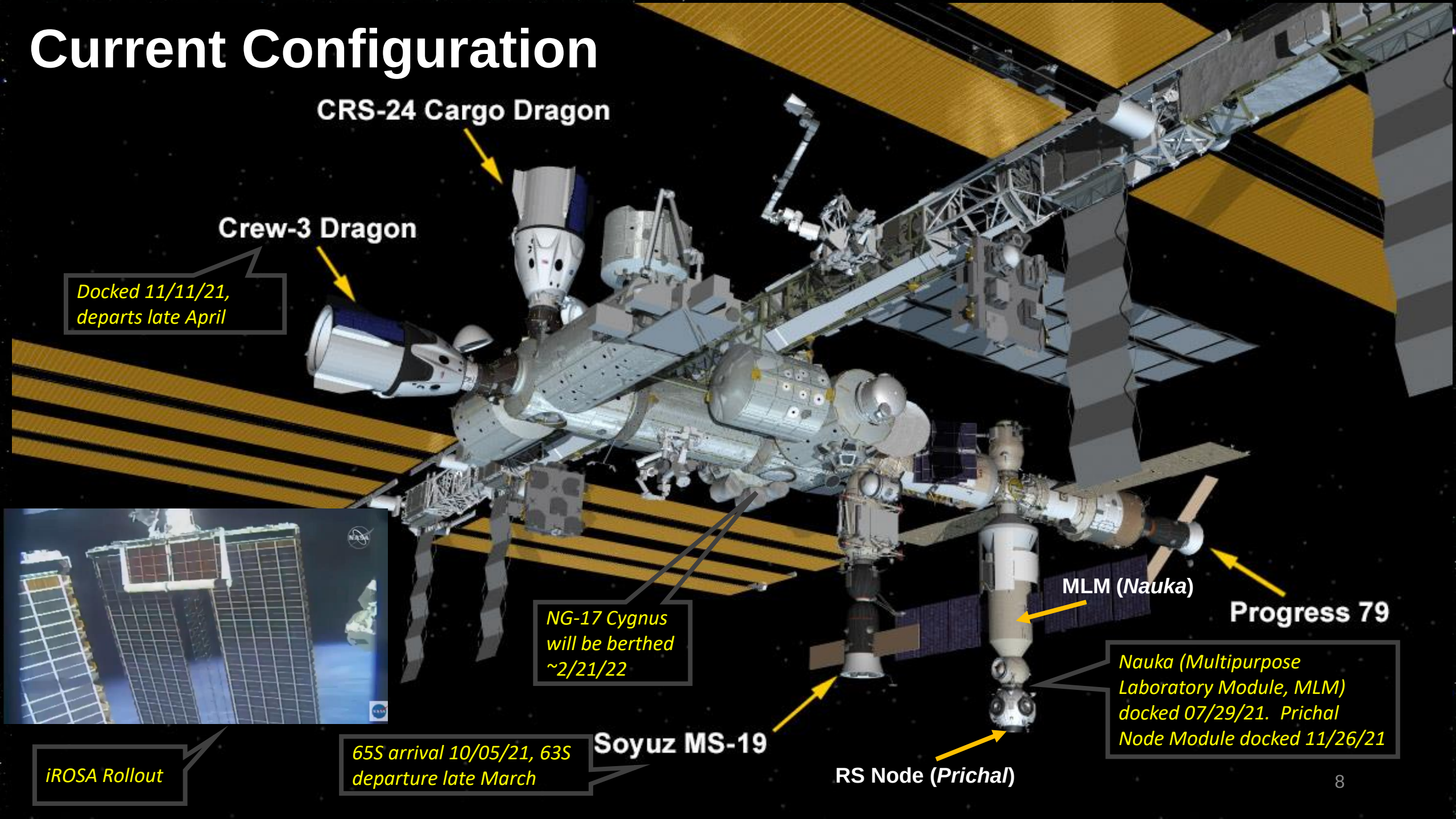
NASA astronauts Raja Chari and Thomas Marshburn; ESA (European Space Agency) astronaut Matthias Maurer; Roscosmos cosmonauts Anton Shkaplerov and Pyotr Dubrov; and NASA astronauts Kayla Barron and Mark Vande Hei.

2022 Crew Rotation Plan

- Mark Vande Hei (Soyuz 64S crew) will stay on ISS through Spring 2022
- Spring rotation plan is 3 cosmonauts on 67S and 4 USOS crew on SpaceX Crew-4
  - With Soyuz rotation preceding USCV rotation, a direct handover from Crew-3/4 is required to maintain USOS crew on ISS
- NASA/Roscosmos working on agreement 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
  - Agreement has cleared Roscosmos review and is with Russian Ministry of Foreign Affairs
  - Meanwhile, NASA and Roscosmos are actively working implementation, including planning and training for crew swap starting with Crew-5/Soyuz 68S in fall 2022

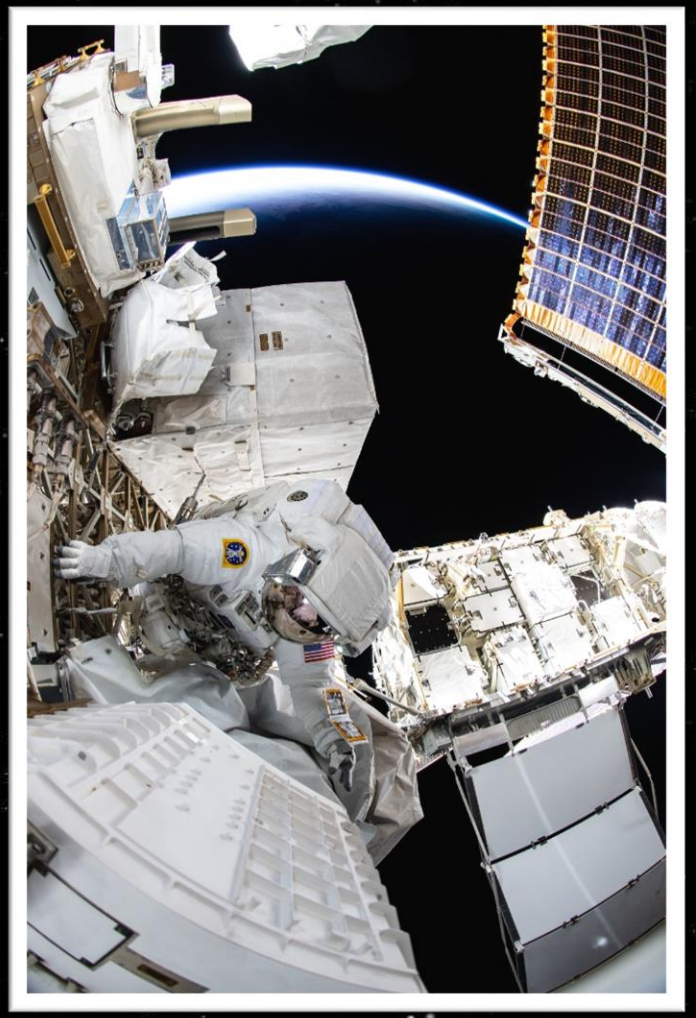
ISS Operational Status

Current Configuration

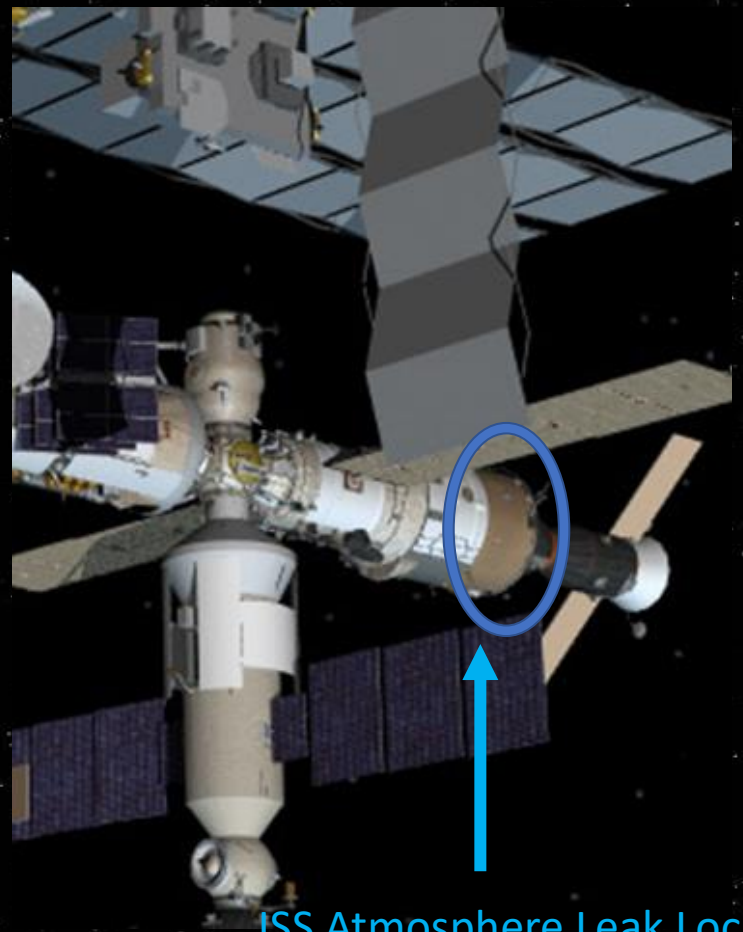


Upcoming Spacewalks (EVA)

- **RS EVA #51**
  - Removes protective covers on passive attachment devices and MLM base points. Mount a portable workstation adapter, connect European Robotic Arm (ERA) control panel and relocate MLM exterior video camera.
- **U.S. EVA #79 - ISS Roll-Out Solar Array (iROSA) Prep**
  - Install Modification Kit on Starboard Truss (S4) 3A Mast Canister
  - Break torque & reset Starboard Truss (S6) Battery Charge/Discharge Unit (BCDU) bolts
- **U.S. EVA #80 - Radiator Beam Valve Modules (RBVM) Jumper Install**
  - Install RBVM jumpers that were removed during US EVA 49, refurbished on the ground, and returned for install. Also, install Bartolomeo Payload Position (PAPOS) Cable Adapter and Port Aft T-Handles.
  - Other tasks include straightening MLI straightening, Camera Port R&R and BCDU Bolt Releases



ISS Significant Items of Interest



ISS Atmosphere Leak Location
(Aft end of Service Module)

- **Atmosphere Leak**
  - Tracking nominal atmosphere leakage increase since 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.
  - Last March, the crew permanently patched a crack and installed a sealant “bridge” to provide a seal in another area of interest.
  - In the near term, that section of the SM will be isolated appropriately to minimize consumables loss.
  - Teams across the partnership have been working together to identify additional leak source(s) and provide further leak mitigation / 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.

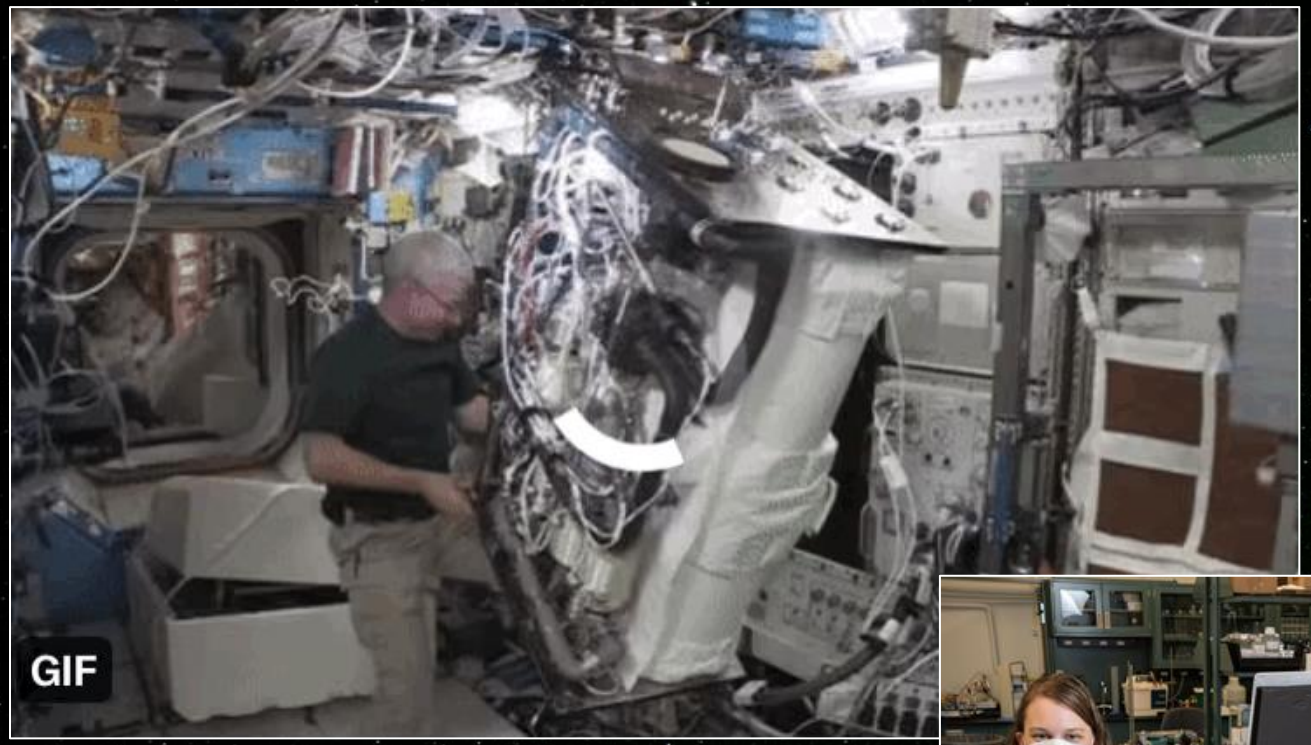
ISS Significant Items of Interest

- **Multipurpose Laboratory Module (MLM) / Nauka Issues**
  - Following MLM docking in July 2021, MLM thrusters inadvertently fired causing a Loss of ISS Attitude Control.
  - Crew and ground followed the prescribed recovery procedures which put the ISS in a configuration (particularly w.r.t. Solar Alpha Rotary Joints (SARJs) and Thermal Radiators) that induced the least risk to excessive loading. ISS thrusters were subsequently utilized to regain attitude control.
  - Analysis indicated no structural load exceedances. Russian commission and independent investigation teams are finalizing their reports.

- **Orbital Debris Environment in ISS orbital regime**
  - On Nov 15, 2021, Moscow Standard Time, a Russian anti-satellite (ASAT) struck a Russian COSMOS satellite and created a debris field in LEO. ISS crew closed radial hatches and activated Safe Haven in Soyuz and Dragon.
  - The risk to ISS of a penetrating collision has increased by 2X compared to pre-satellite breakup levels. Was previously 1/50,000 orbits, however, is now between 1/33,000 to 1/25,000 orbits.
  - Normal ISS operations are continuing; we operate and manage in an environment with increasing orbital debris and have procedures for monitoring and, if necessary, taking action for potential debris conjunctions.

Utilization Summary

Exploration Capabilities Development Technology Demonstrations: FY21 Accomplishments

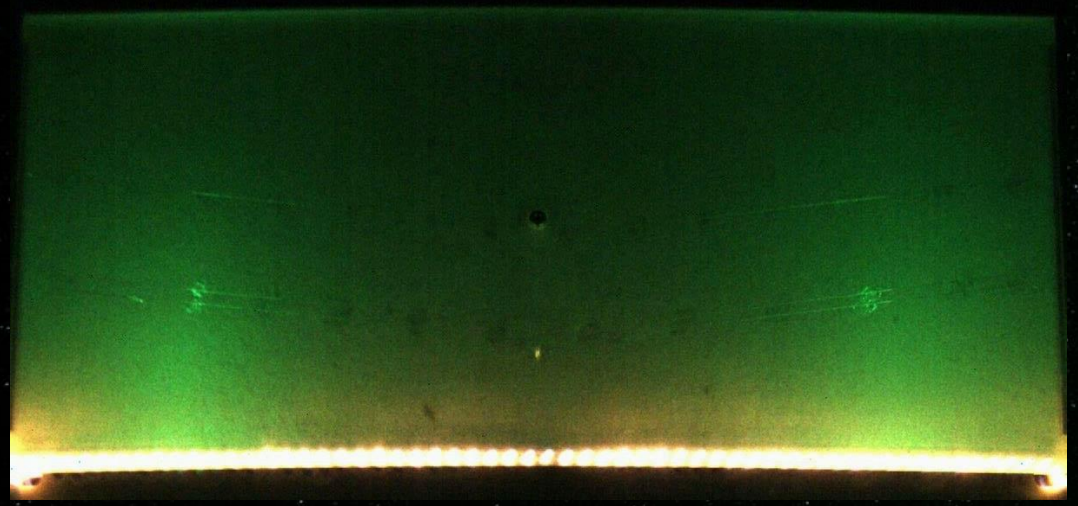


Above: Mark Van de Hai installing 4-Bed CO2 Scrubber in the US Laboratory

Right: Space Suit Evaporation Rejection Flight Experiment (SERFE)

Below: Brine Processor Assembly installed in March 2021

Exploration Capabilities Development Technology Demonstrations: FY21 Accomplishments



Polymethyl Methacrylate (PMMA) Sample
10.2 psia
26.5% O2
Air Flow 20 cm/s
10x actual speed

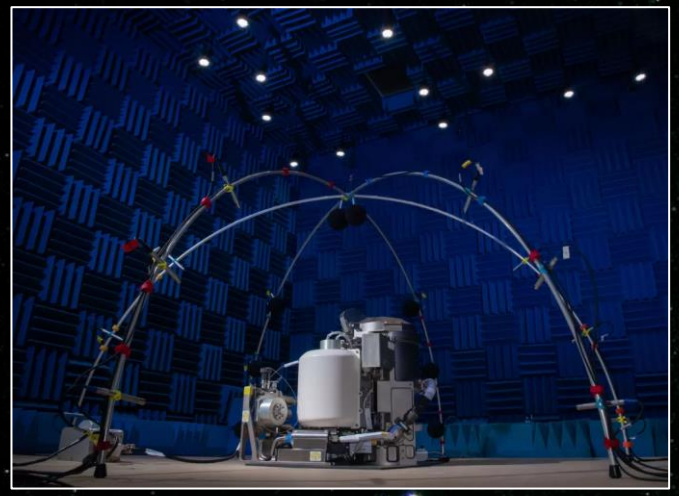
Below and Left: the fifth Spacecraft Fire Safety Experiment (Saffire-V) flown on NG-14

Cotton Sample
10.2 psia
26.5% O2
Air Flow 20 cm/s
10x actual speed

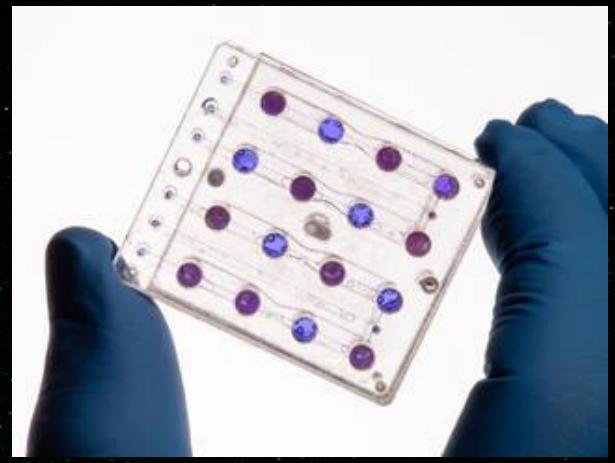
Below: Airborne Particulate Monitor

Below: RFID Enabled Autonomous Logistics Management (RFID)

Exploration Capabilities Development Technology Demonstrations: FY22 Hardware



Left and Below: Universal Waste Management System (UWMS)



Left: BioSentinel

Left: Alternate Fecal Container (AFC)

Metrics – Agency Priority Goal (APG)

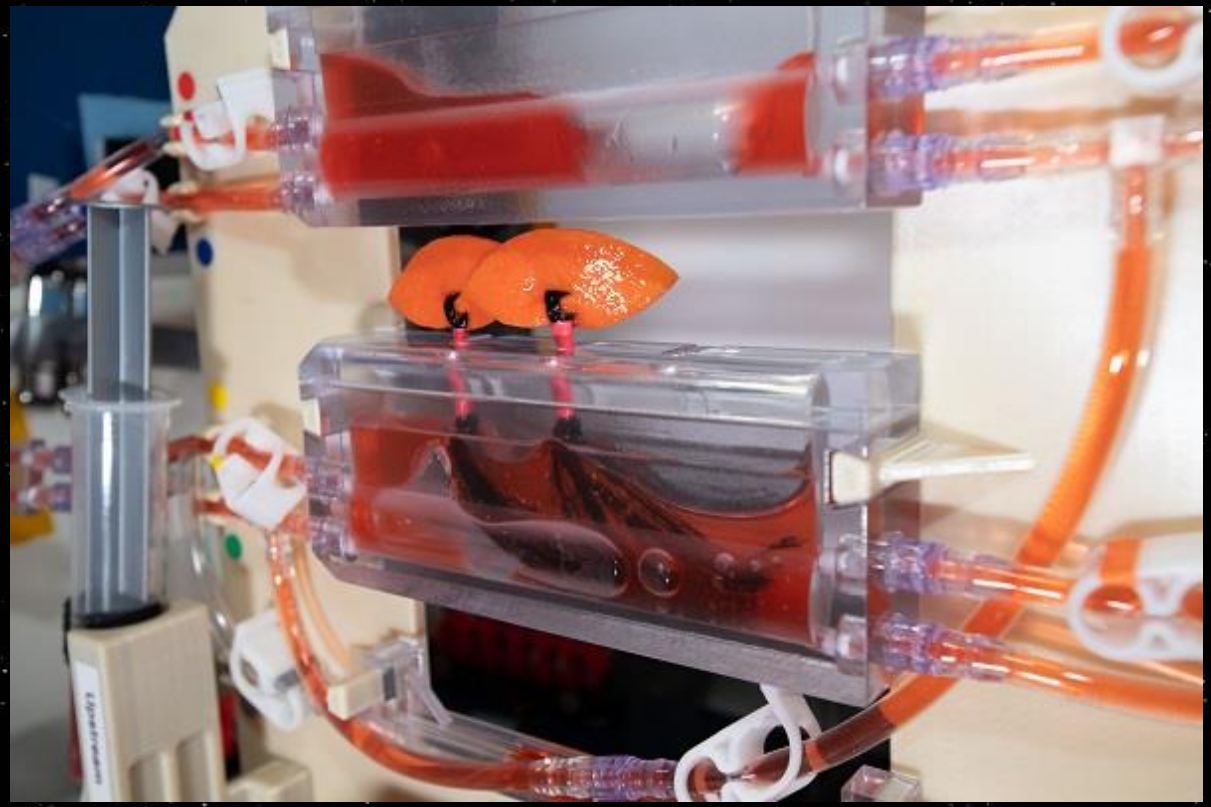
Initiate at least five technology demonstrations on the International Space Station to advance deep space exploration.
Status: GREEN

FY21 Initiated (7)	FY22 Delivered (3)	FY22 To Be Delivered (5)
• Spacesuit Evaporation Rejection Flight Experiment (SERFE) (Initiation began FY21, Q1)	• Universal Waste Management System (UWMS) (Delivered FY21, Initiated FY22)	• Spacecraft Atmosphere Monitor (SAM) Unit 2
• Airborne Particulate Monitor	• Alternate Fecal Container (AFC)	• Exposed Root On-Orbit Test System (XROOTS)
• RFID-Enabled Autonomous Logistics Management-2 (REALM-2)	• BioSentinel	• Urine Processor Assy (UPA) Purge Pump & Separator
• Spacecraft Fire Safety (Saffire) V, initiation following NG-14 departure		• Hydrogen Sensor Demo for Oxygen Generation Assembly (OGA)
• Brine Processor Assembly (BPA)		• Advanced Gas Analyzer (AGA)
• 4-Bed CO2 Scrubber		
• Water Processor Assembly (WPA) Catalytic Reactor (Initiated in FY21, returned on SpX-22 for TT&E)		

2021 Utilization Highlights

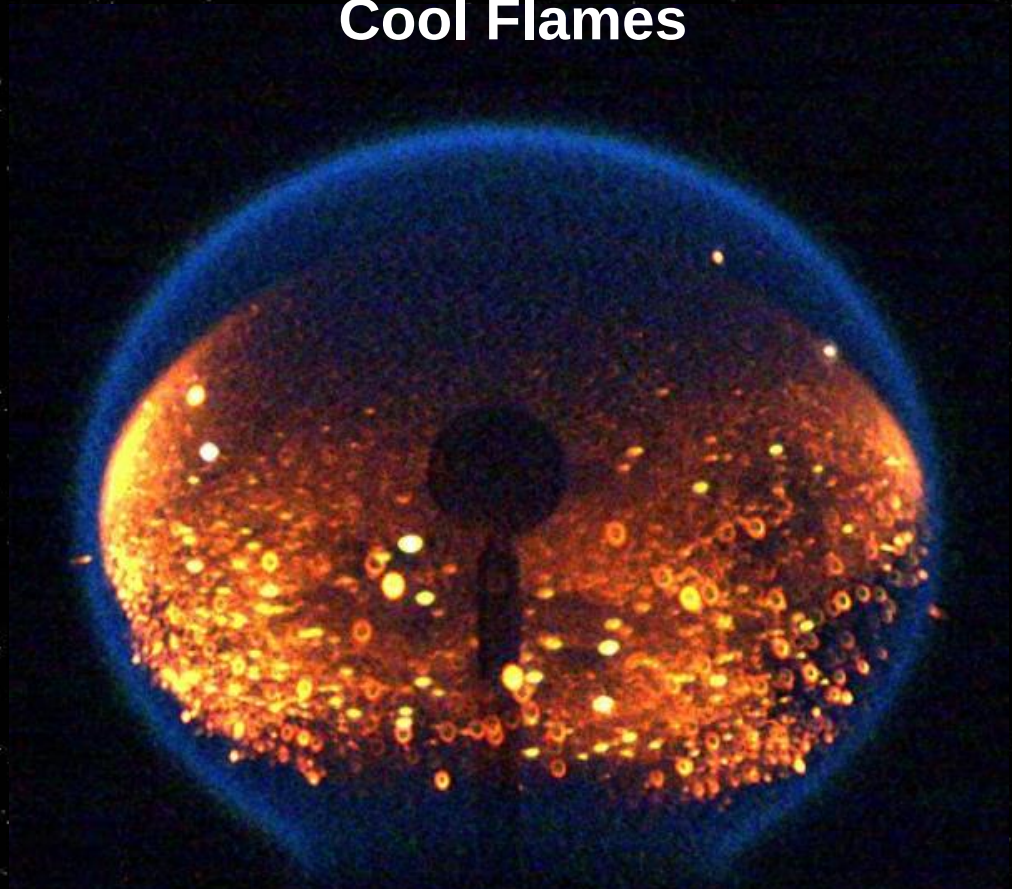
Science

Fluid Physics



This investigation demonstrates passive measures for controlling fluid delivery and uptake in plant growth systems. Reduced gravity creates challenges in providing adequate fluid and nutrition for plant growth. The study examines using other physical properties to replace the role of gravity.

Cool Flames



Cool Flames Investigation with Gases study, aims to better understand flames that burn at extremely low temperatures. During Crew-2's mission, combustion researchers achieved a **first for cool flames in space - burning gaseous fuels**

2021 Utilization Highlights

Science

Alpha Magnetic Spectrometer

The AMS actively looks for evidence of **cosmic dark matter, and large-scale distributions of cosmic antimatter** (eg., antimatter stars, galaxies). ISS continues to provide EVA and robotic servicing and repair of the AMS, enabling the extension of its science mission well beyond the originally-planned 3-year mission.

Use of AR in Cold Atom Lab (CAL)

NASA's Cold Atom Lab (CAL) is the first quantum science laboratory in Earth orbit, hosting experiments that explore the fundamental behaviors and properties of atoms. In July, the CAL team successfully demonstrated using an AR headset to assist astronauts with upgrade activities.

2021 Utilization Highlights

Enabling Exploration

Chile Peppers Harvesting

Both Crew-2 and Crew-3 harvested the space station's first crops of chile peppers for the **Plant Habitat-04** experiment. This plant experiment was the longest in the history of the space station at 137 days. Studies like this one could help enable viable and sustainable crop production for future missions as humans explore the Moon and Mars.

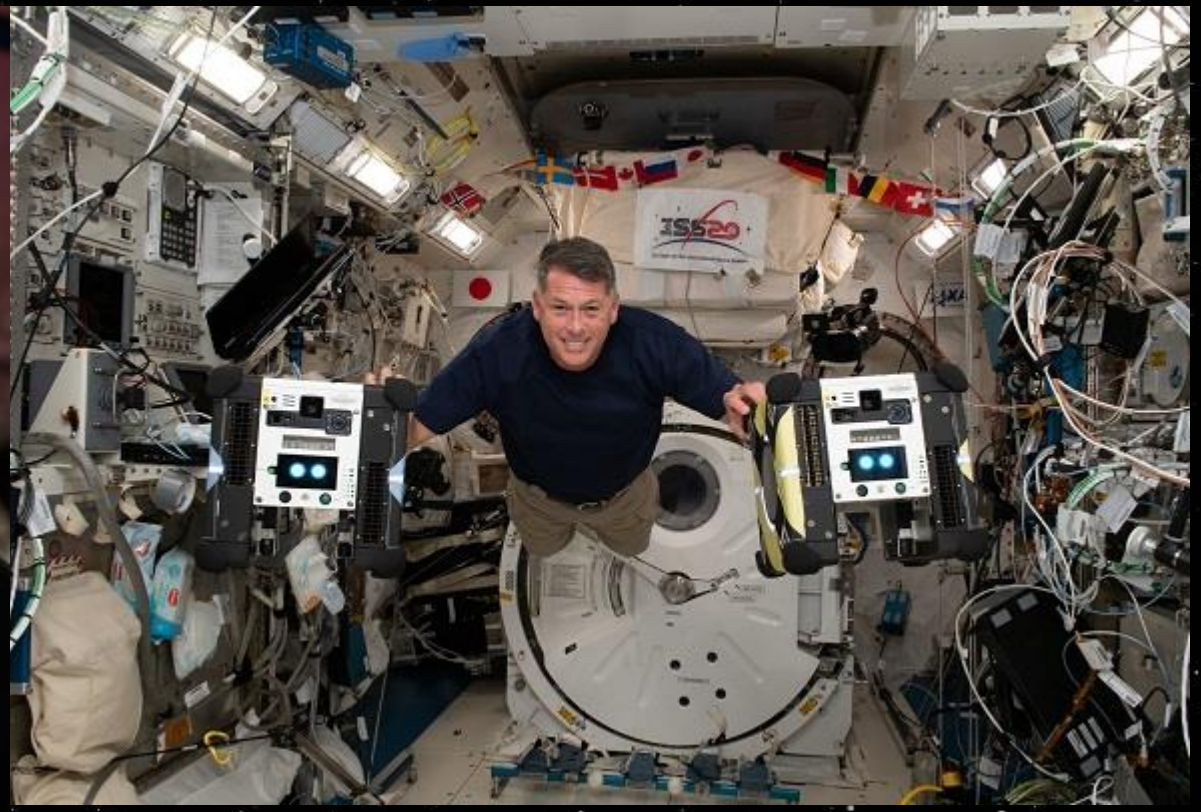
2021 Utilization Highlights

Enabling Exploration

Space Agriculture

Extra Dwarf Pak Choi were grown for a **Veggie** study that explores space agriculture to sustain astronauts on future missions to the Moon or Mars. During his mission, Hopkins performed the **first plant transplant** in space.

Robotic Partners



Shane Kimbrough is pictured inside the Kibo laboratory module with the **Astrobee** free-flying robotic assistants. He monitored the cube-shaped robotic free-flyers as they tested automated rendezvous techniques.

2021 Utilization Highlights

Benefits to Humanity

Storm Spotting

The **Crew Earth Observations** activity records how the planet is changing over time, from human-caused changes, such as urban growth and reservoir construction, to natural dynamic events, such as hurricanes, floods, and volcanic eruptions.

Protein Crystal Growth

The biotechnology study seeks to demonstrate new methods for producing high-quality protein crystals in microgravity and identify possible targets for drugs to treat diseases on Earth.

2021 Utilization Highlights

Benefits to Humanity

Cardinal Heart

This study analyzes how changes in gravity affect cardiovascular cells at the cellular and tissue levels. It could provide new understanding of heart problems on Earth, help identify new treatments and develop better screening measures to predict cardiovascular risk prior to spaceflight.

Kidney Stones

3D kidney cell experiments study the effects of microgravity on formation of microcrystals in kidney tubules. Results could help design better treatments for kidney stones and bone loss for astronauts and osteoporosis for people on Earth.

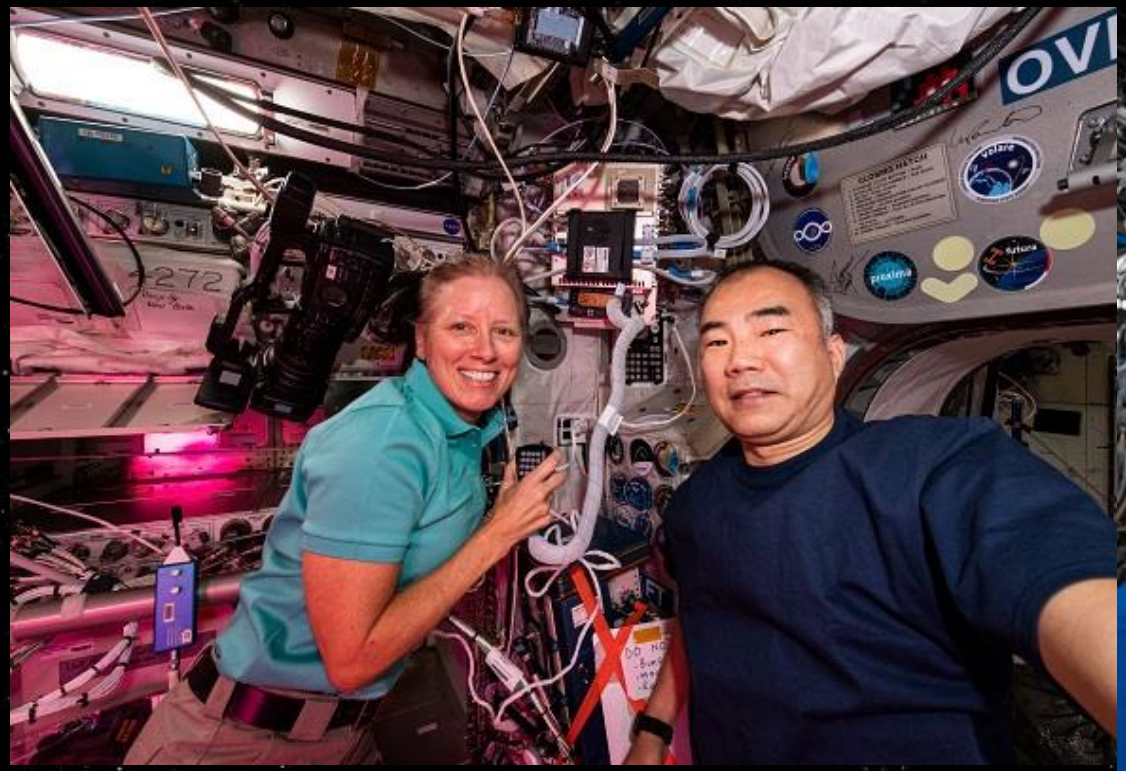
Cardinal Muscle

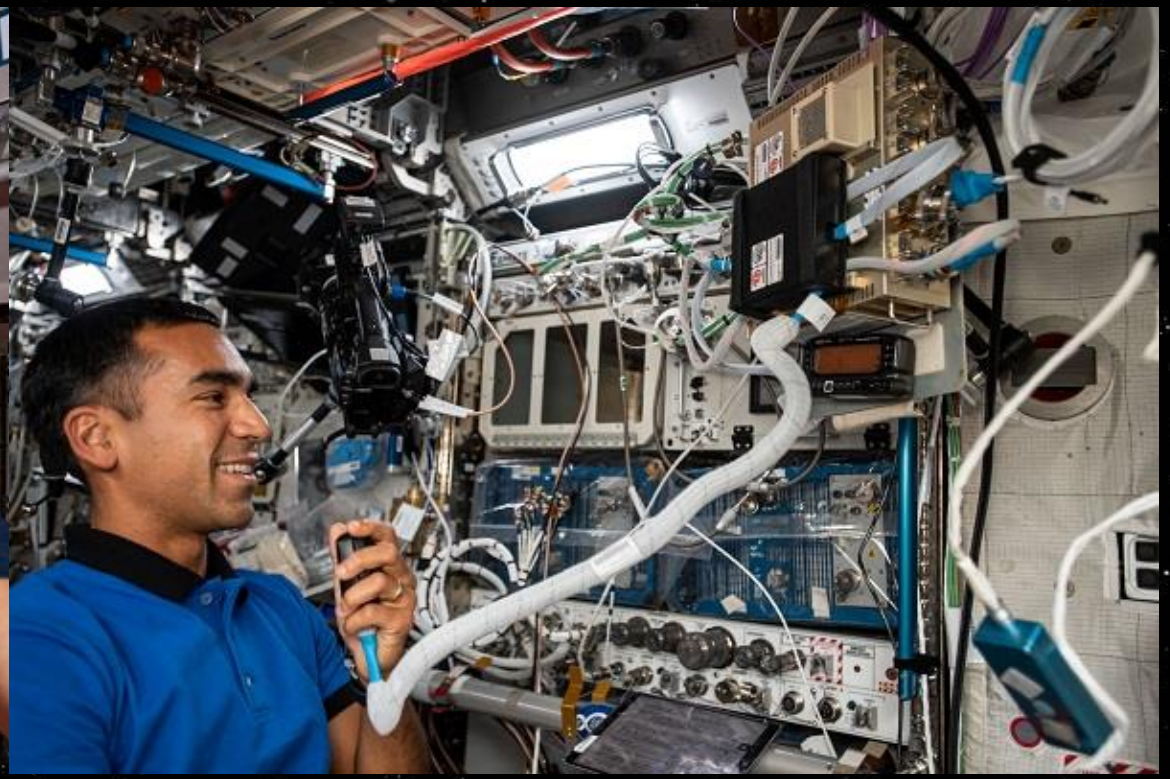
This study tests whether such engineered tissues cultured in space could provide a model for studying muscle loss and assessing possible therapeutics prior to clinical trials.

2021 Utilization Highlights

STEM

Amateur Radio on ISS (ARISS)

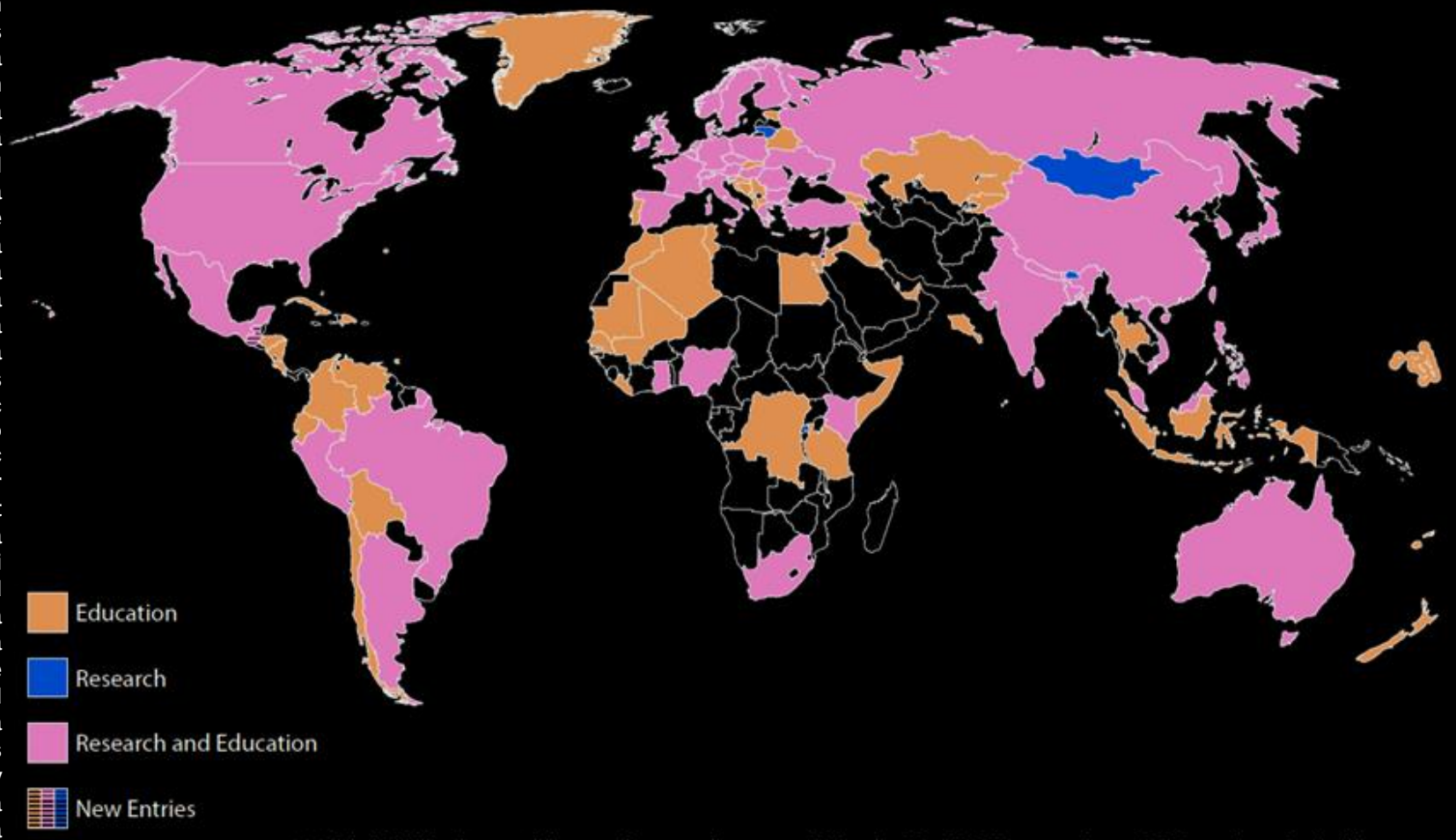




Left: NASA astronaut Shannon Walker and JAXA (Japan Aerospace Exploration Agency) astronaut Soichi Noguchi pose for a photo during an Amateur Radio on International Space Station (**ARISS**) ham radio session with students at Hisagi Junior High School, Zushi, Japan. Right: NASA astronaut Raja Chari spoke with students from Colegio Pumahue in Chile. The program's goal is to spark student interest in mathematics and science and inspire the next generation of explorers. Selected students learn about the station, radio waves, and other topics and prepare questions before their scheduled call.

International Participation on ISS

Albania
Algeria
Argentina
Armenia
Australia
Austria
Bangladesh
Belarus
Bermuda
Bhutan
Bolivia
Bosnia
Brazil
Bulgaria
Chile
China
Columbia
Costa Rica
Croatia
Cuba
Cyprus
Czech Republic
Democratic Republic of the Congo
Dominican Republic
Ecuador
Egypt
Estonia
Fiji
Finland
Georgia
Ghana
Greece
Greenland
Guatemala
Honduras
Hungary
India
Indonesia
Iraq
Ireland
Israel
Jordan
Kazakhstan
Kenya
Kuwait
Kyrgyzstan
Lebanon



109 highlighted countries and areas have participated in ISS Research and Education Activities

Belgium
Canada
Denmark
France
Germany
Italy
Japan
Netherlands
Norway
Russia
Spain
Sweden
Switzerland
United Kingdom
United States

*New participating country

Liberia
Lithuania
Luxembourg
Macedonia
Malaysia
Maldives
Mali
Marshall Islands
Mauritania
Mexico
Monaco
Mongolia
Montenegro
Morocco
Nepal
New Zealand
Nicaragua
Nigeria
Peru
Philippines
Poland
Portugal
Qatar
Republic of Malta
Republic of Korea
Republic of South Africa
Romania
Rwanda*
Senegal
Serbia
Singapore
Slovakia
Slovenia
Somalia
Sri Lanka
Taiwan
Tanzania
Thailand
Trinidad and Tobago
Tunisia
Turkey
Ukraine
United Arab Emirates
Uruguay
Vatican City
Venezuela
Vietnam

ISS Research Statistics

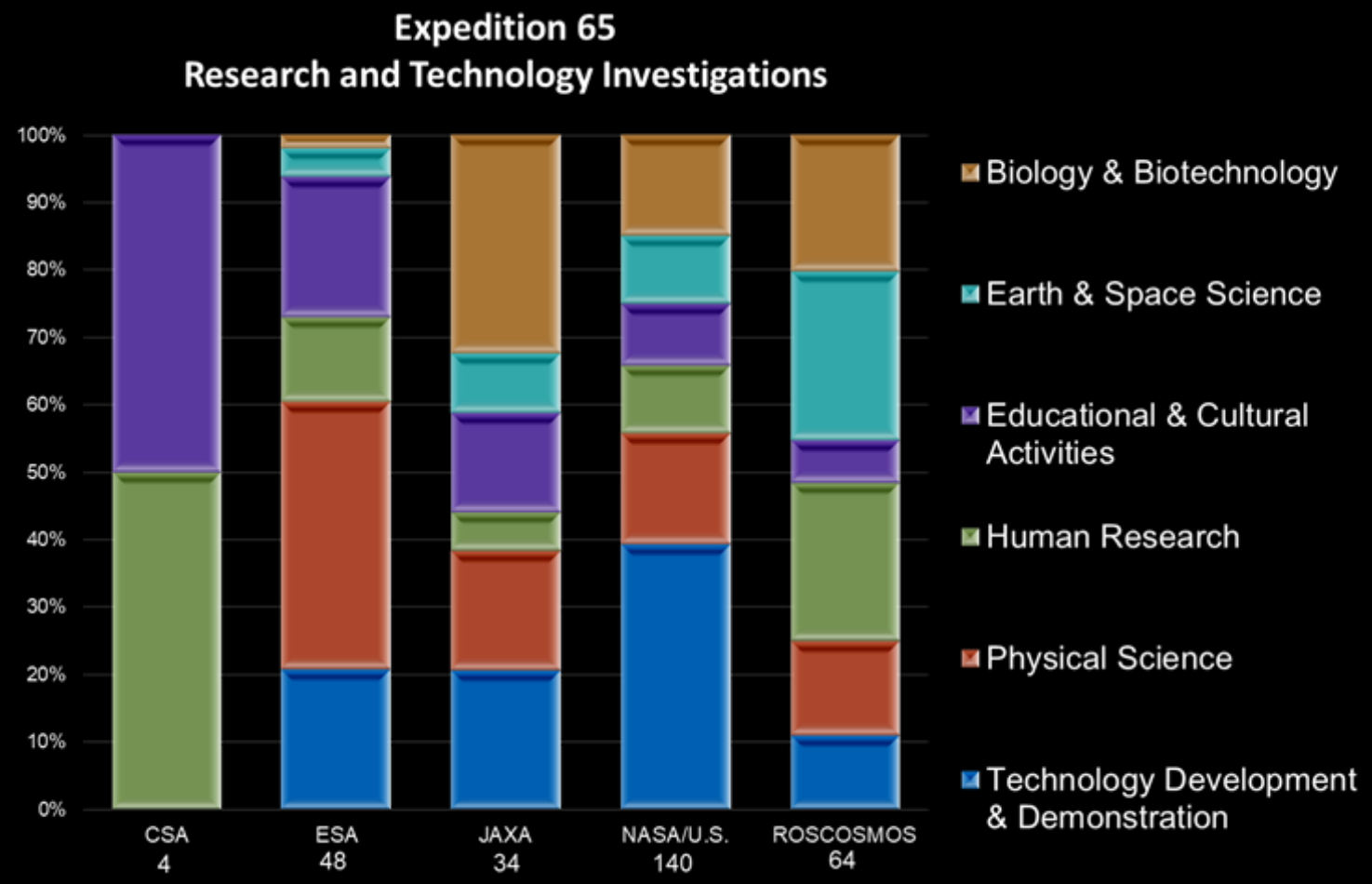
Investigations for 65: 290

- 140 NASA/U.S.-led investigations
- 150 International-led investigations
- 81 New Investigations
  - 0 CSA
  - 24 ESA
  - 11 JAXA
  - 43 NASA/US
  - 3 ROSCOSMOS

MCB Approved Statistics Exp. 0-62

- 3040 Investigations
- 4418 Investigators Represented
- 109 Countries/Areas with ISS Research and Education Participation
- Over 2377 Scientific Results Publications (Dec 1998 – Nov 2021)

Estimated Number of Investigations Expedition 0-65: 3202*



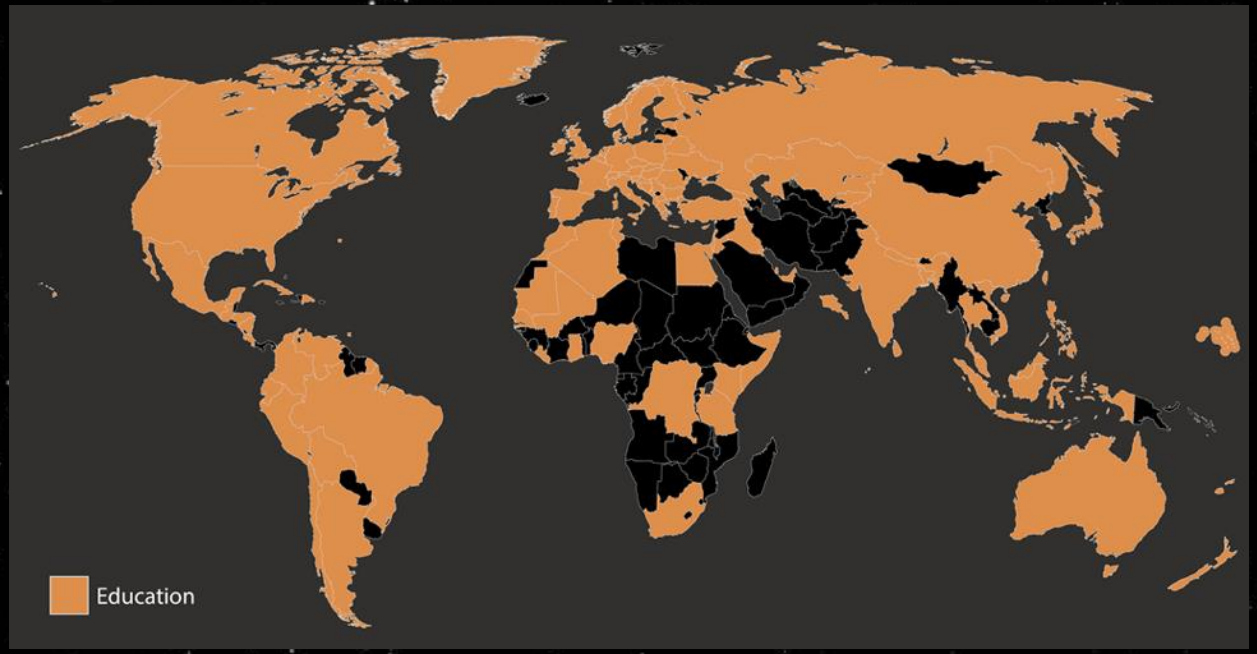
*Pending Post Increment Adjustments

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

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

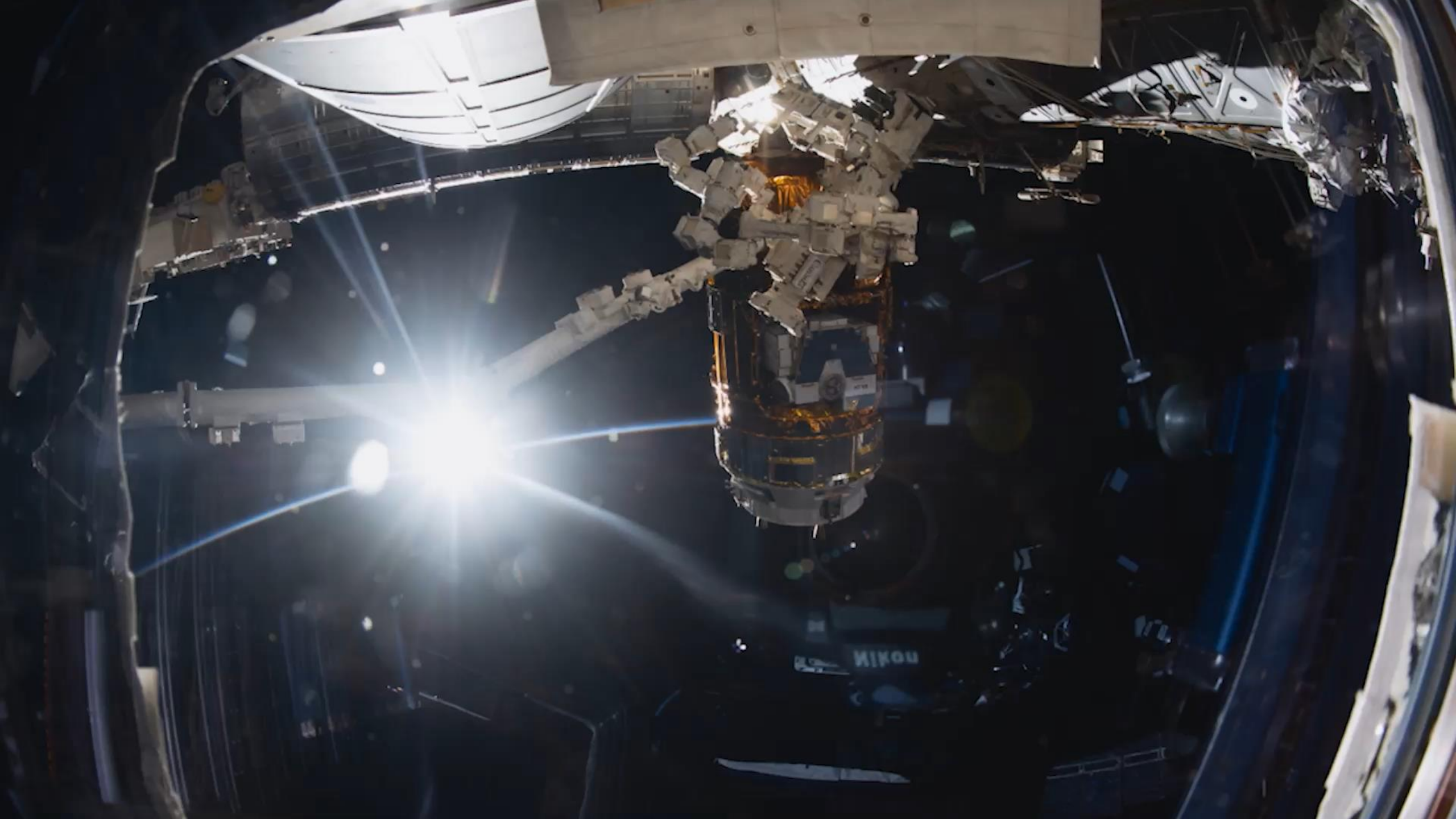
- **88 payloads delivered in FY21, second most in single year (despite COVID)**
- **85% of total costs for selected projects were externally funded**
- **Beginning to see more demand than resources available**
- **NASA-CASIS partnership is strong**
- **NASA studying potential future models of a national laboratory in LEO**

ISS Extension and Transition

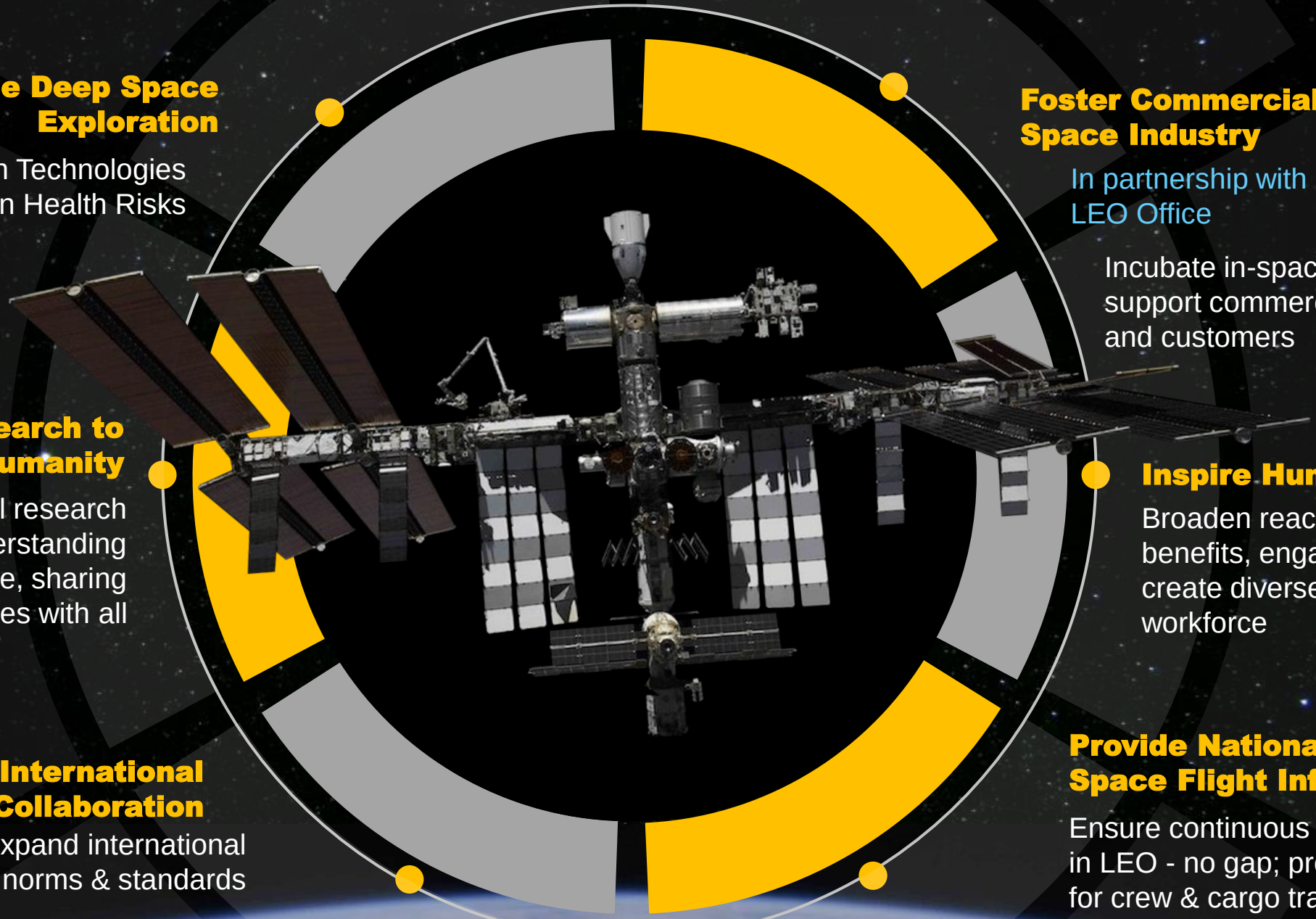
ISS Extension Through 2030

- On December 31, 2021, the White House announced a decision to extend operations of the ISS through 2030*
- Extension through 2030 will allow time to complete critical exploration development activities while bringing new commercial LEO capabilities online
- The ISS International Partners are working with their respective governments to extend through 2030
- There are no technical constraints to operating through 2030

* https://blogs.nasa.gov/spacestation/2021/12/31/biden-harris-administration-extends-space-station-operations-through-2030/



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

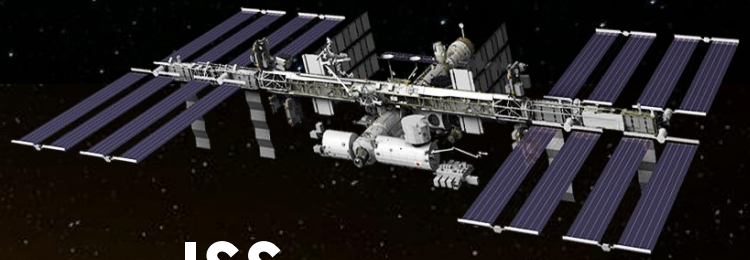
Lead International Collaboration

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

Utilization Transition from ISS to CLD (notional)



Users	ISS	CLD
International Partner Utilization	Through ISS Intergovernmental Agreement (IGA) and bilateral agreements	Bilateral government to government agreements and arrangements directly with industry
NASA Technology Demonstration	Long-duration microgravity testing of exploration systems (ECLSS, Crew Health Systems, Food Production, etc.)	Accommodation for ongoing subset of testing, possible incorporation into CLD designs
NASA Human Research	HRP risk reduction plans - multiple subjects for varied durations	Ongoing research with NASA crew and possibly private astronauts, exploration analogs
NASA Science	Biological, Physical, Earth, Planetary decadal-driven science	Purchase accommodation for ongoing decadal-driven science; transfer hardware or purchase commercial facility services
Other Government Agency Research	Through ISSNL or NASA collaboration (NIH, NSF, DoD, others)	Through LEO National Lab
In-Space Product Manufacturing	NASA in-space production + ISSNL	Development through LEO National Lab ; commercial production business to business
Commercial Tourism, Marketing	ISS Private Astronaut Missions, Commercial Use Policy, reimbursement of resources	Business to business

Transition Indicators

Indicators	2030 Forecast/Status
At least one Commercial LEO Destination (CLD) capable of meeting ongoing NASA needs in LEO	Current plan allows for two-year overlap between CLD and ISS deorbit
Health and status of the ISS	ISS structural analysis projects no issues through at least 2030
Emergence of non-NASA markets for CLD services to ensure CLDs are sustainable	Under demand stimulation initiatives, several promising focus areas
ECLSS integrated testing on ISS has achieved exploration reliability targets	Current plan projects targets achieved by the end of 2030
Remaining HRP risk reduction activities can be completed on CLD with two NASA crew	Majority of risks requiring ISS should be complete; remaining requirements for CLD under evaluation
Model and agreements in place for ongoing international partnerships in LEO on CLD	Beginning discussions with partners on areas of mutual interest
Commercial crew and cargo providers have continuity; reduced prices	Multiple crew and cargo providers; competition drives pricing

Summary

- ISS Extension through 2030 announcement completed
- ISS is healthy and technical sound to operate through 2030
- Plan for transitioning from ISS to commercial capabilities is in progress
- Technology demonstrations required for exploration are on track for completion by end of 2030
- **The decade of results is now underway**


National Aeronautics and
Space Administration
NASA
NASA
Learn more about the space station at
NASA.GOV/STATION