National Aeronautics and
Space Administration

Advancing Technologies for Human Exploration:

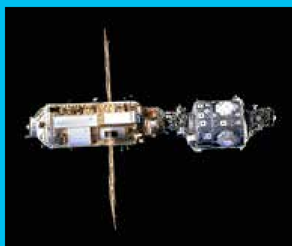
Successes and Future Plans for Using ISS as an Engineering Testbed

Robyn Gatens,

Deputy Director, ISS Division

Some Assembly Required

1998



Zarya/Unity

2001

Destiny

2007

Harmony

2008

Columbus

JEM

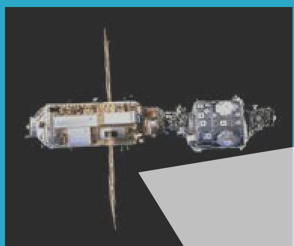
2010

Tranquility

Assembly Complete

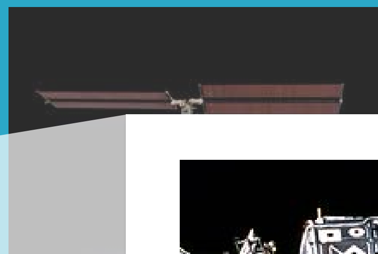
Life Support Systems through Space Station History

1998



Zarya/Unity

2001



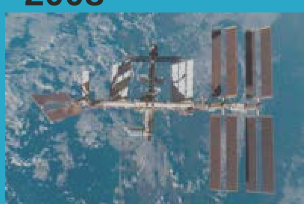
Destin

Some
bly
red

2007

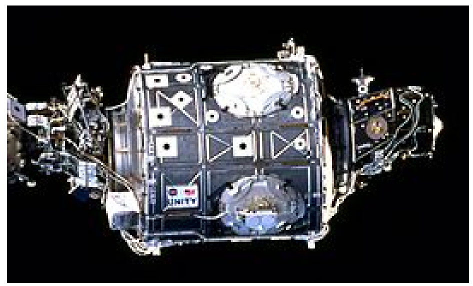
Harmony

2008



Columbus

JEM

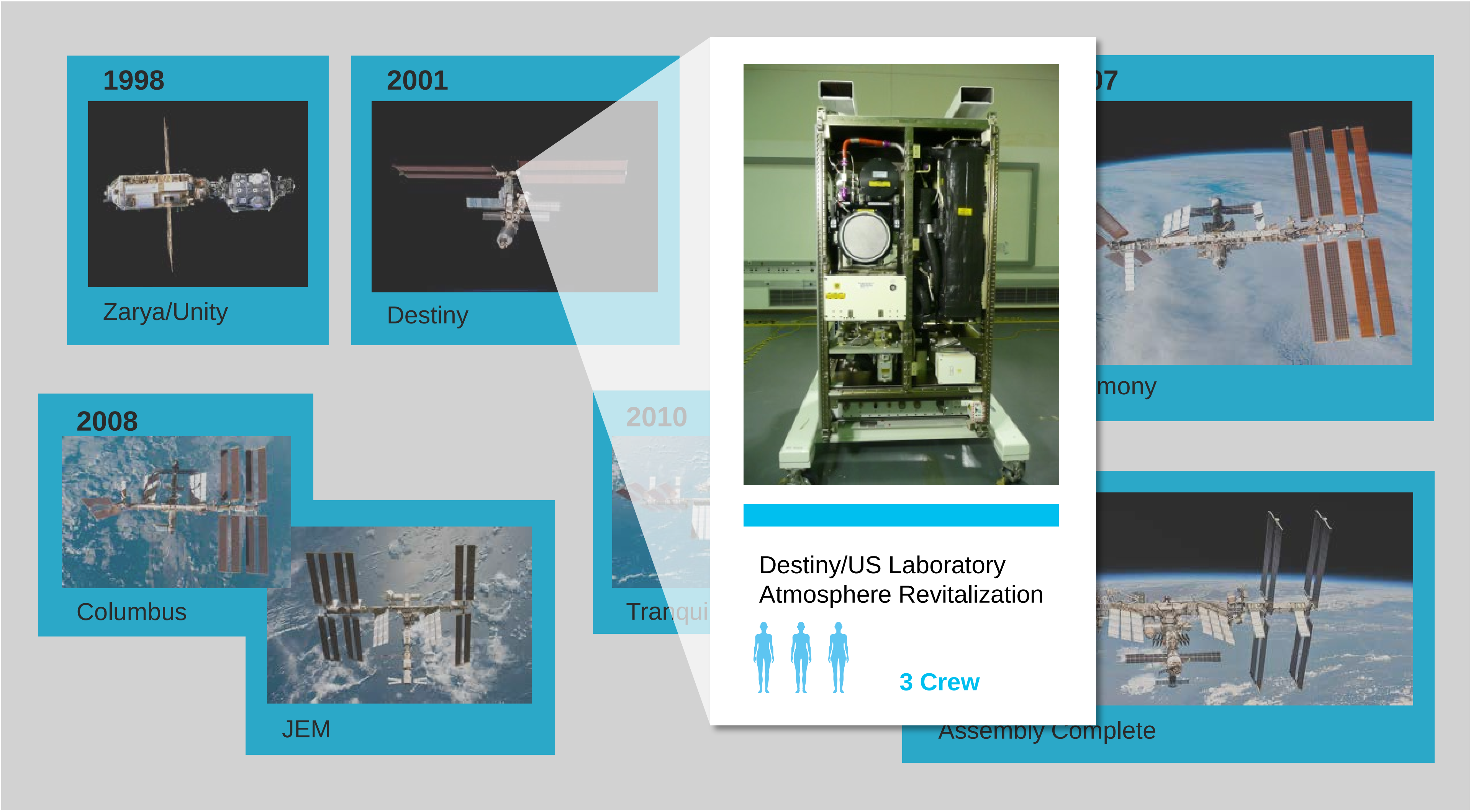


Node 1 Unity Module
Ventilation/Filtration

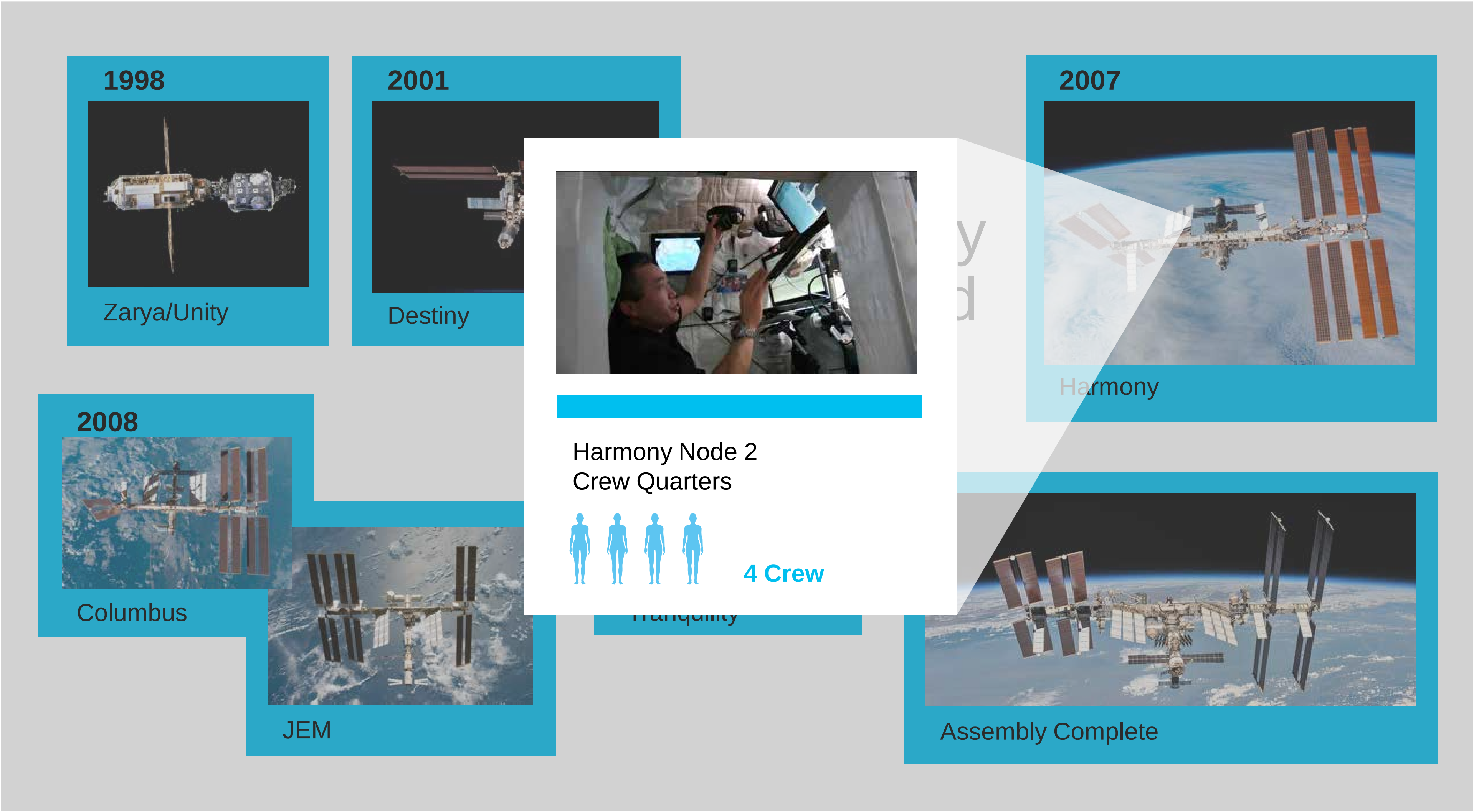
0 Permanent Crew

Assembly Complete

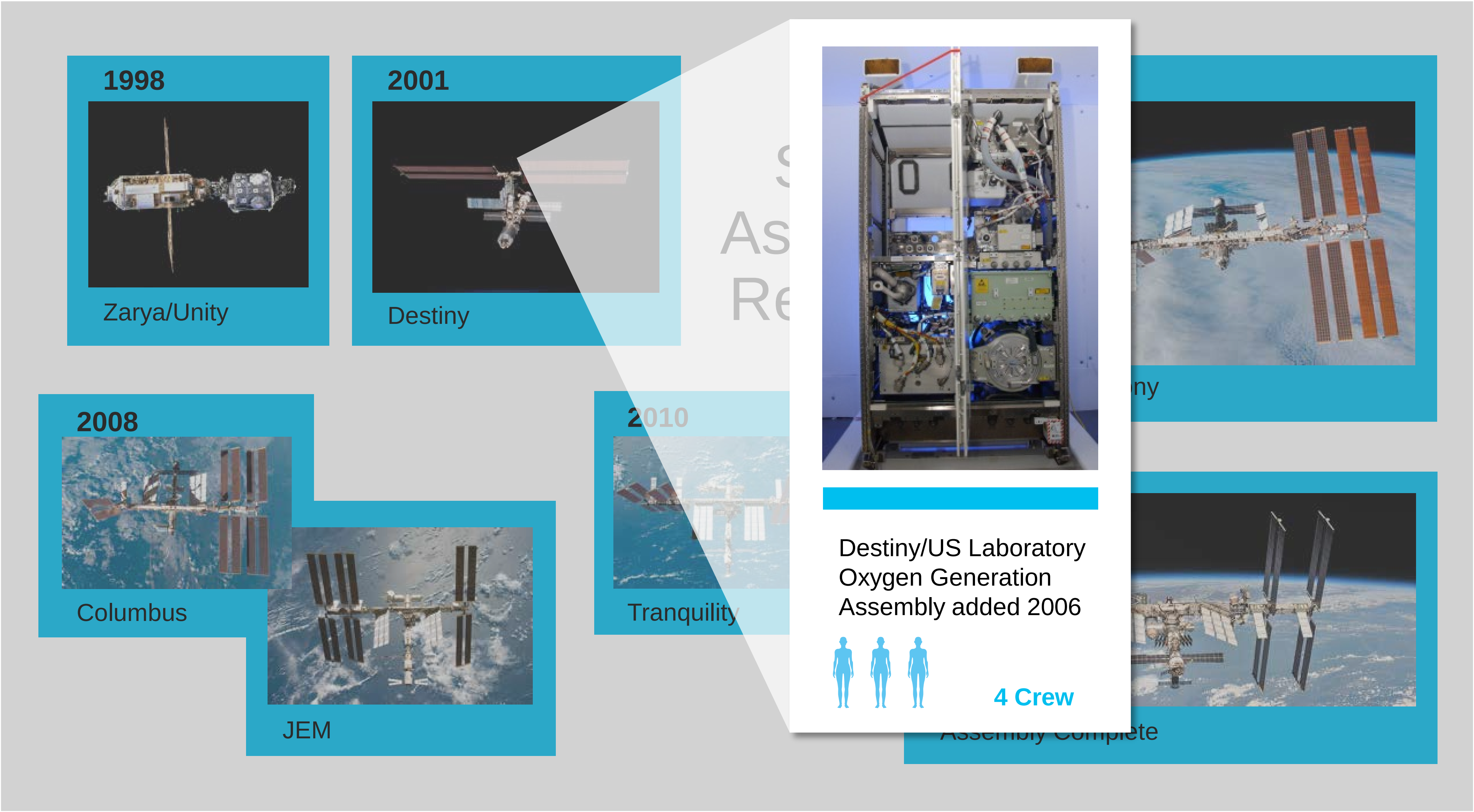
Life Support Systems through Space Station History



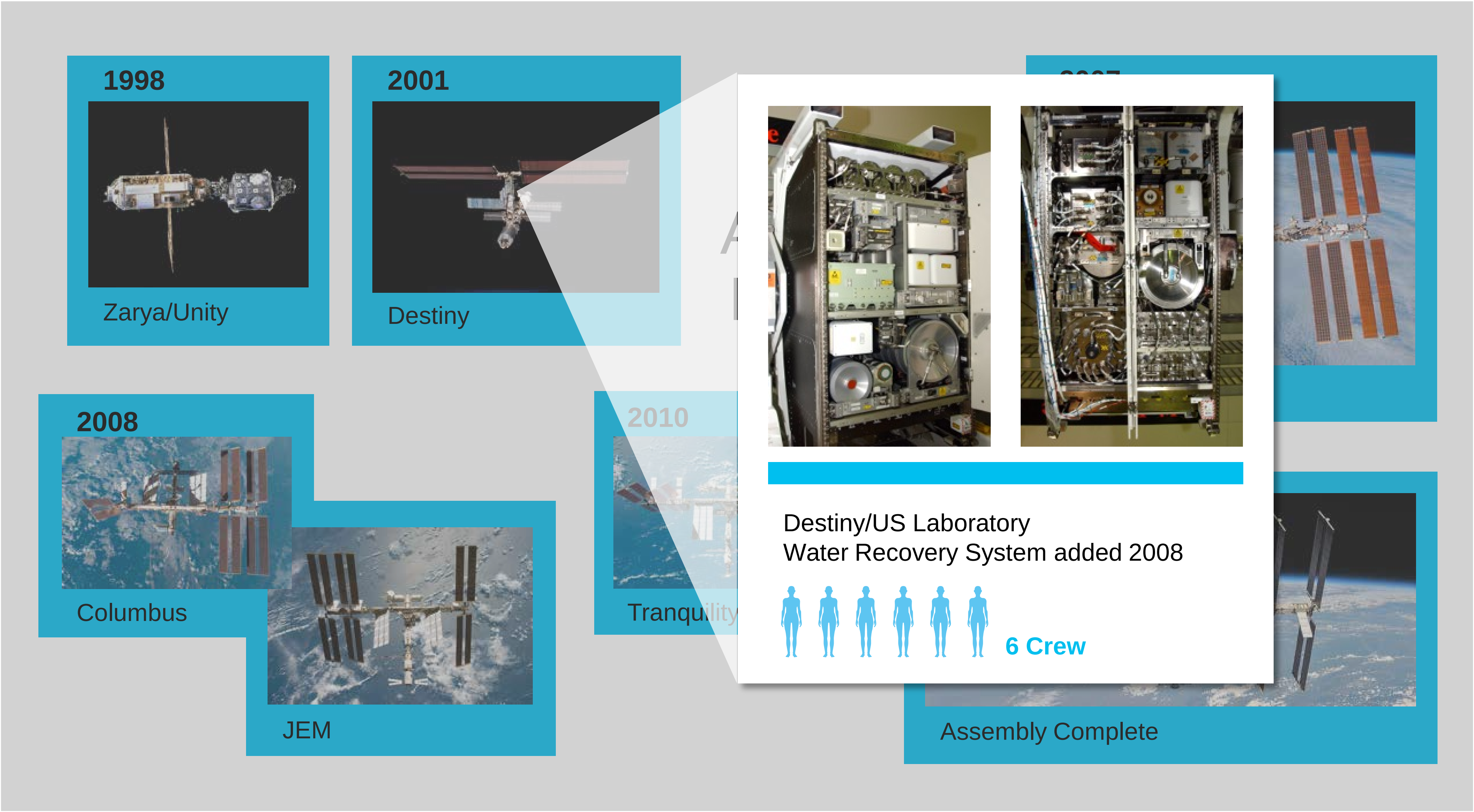
Life Support Systems through Space Station History



Life Support Systems through Space Station History



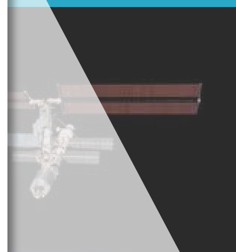
Life Support Systems through Space Station History



Life Support Systems through Space Station History

Tranquility Node 3
OGS & WRS relocated here; Sabatier added 2010
Double toilet stall 2019

6 Crew



Some Assembly Required

2007

Harmony

2010

Tranquility

Assembly Complete

The Unique Environment of Space Station

Over **2,800** experiments and technology demonstrations and counting

Expeditions 0-58, December 1998 to March 2019

Microgravity Environment

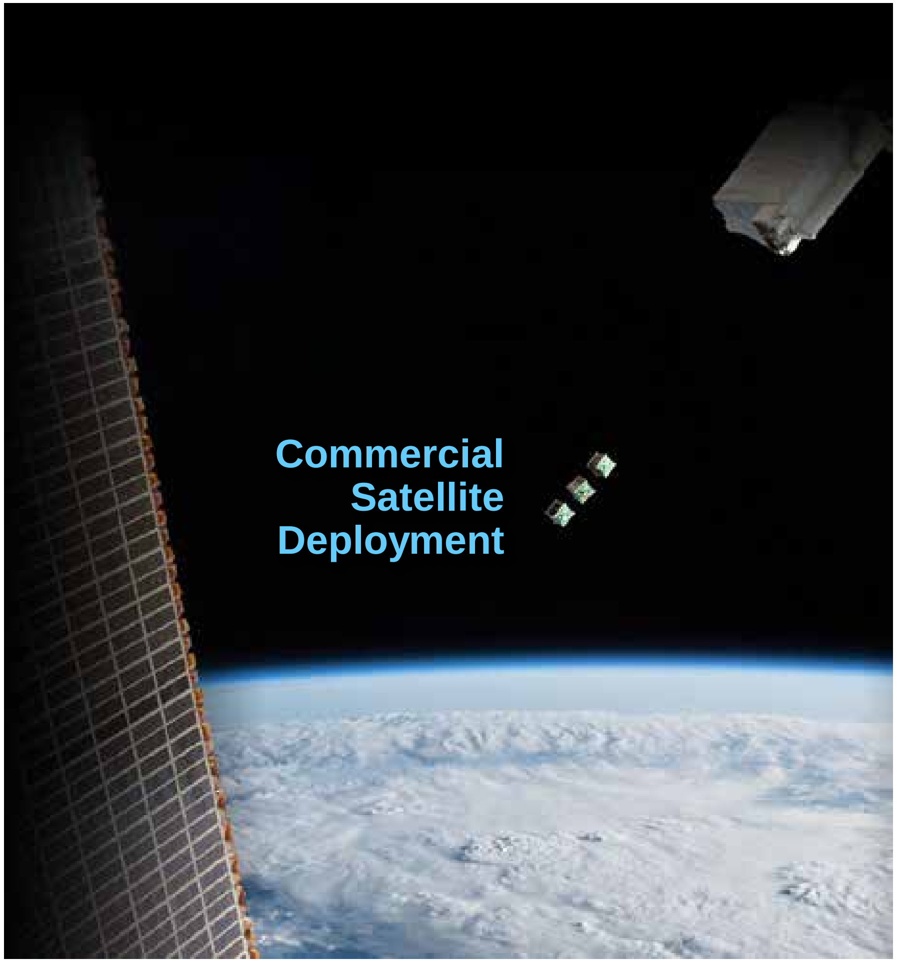
Extreme Space Environment

Low-Earth Orbit Vantage Point

Continuously Crewed

20 Years on the International Space Station

Technology Demonstrations Areas



- Materials, Structures and Manufacturing
- Human Health, Life Support and Habitation
- Fire Protection
- Radiation
- Space Power and Energy
- Robotics, Telerobotics, and Autonomous Systems
- Communications and Navigation
- Thermal Management
- EVA
- Operations Process and Procedures
- Entry, Descent and Landing

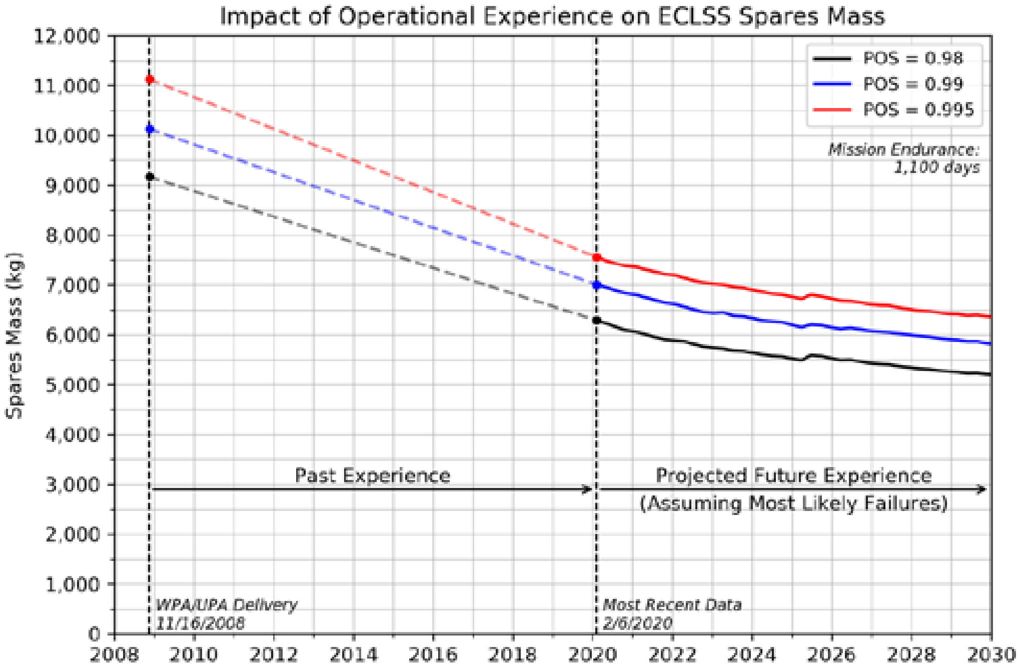
20 Years on the International Space Station

Lessons Learned from the Space Station

ISS provides the most relevant environment & interfacing systems for simultaneously validating human/system interactions, micro-g effects, and long-duration environmental exposure effects

- Urine processor calcium precipitation
- Workmanship/design problems that manifested over long period of on orbit operation
- Biomass buildup, release and downstream clogging in micro-g
- Siloxane compounds in cabin & impact on water system
- Carbon Dioxide Removal Assembly sorbent material degradation/dusting
- Cabin heat exchanger coating degradation over time caused by contamination and dryout cycles
- Effects of cabin CO_2 levels on Internal Thermal Control System fluid chemistry
- Contaminant propagation through system (Sabatier poisoning)

ISS Experience Reduces ECLSS Mass for Future Missions



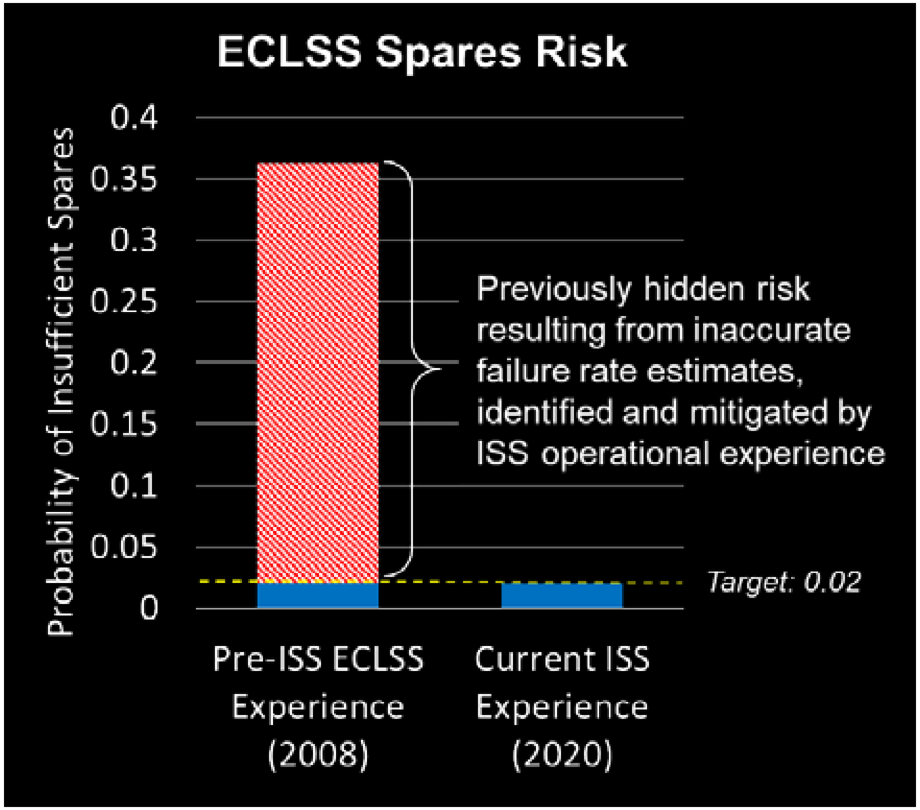
- Future Mars-class human exploration missions will require lower ECLSS logistics mass due to ISS experience, system investments, and testing
- Operational experience yields critical data to improve failure rate estimates by correcting under- and overestimates

- Reduced uncertainty allows risk coverage with more optimized spares allocations and fewer spares, *lowering logistics mass by ~30%*
- Because NASA has not established safety goals for future deep space human exploration missions, a range of POSs has been provided

ISS20
20 Years on the International Space Station

ECLSS spares allocated to achieve a reasonable range of Probability of Sufficient (POS) spares for a 1,100-day Mars-class mission using initial, current, and projected future failure rate estimates.

ISS ECLSS Experience Increases Future Mission Crew Safety



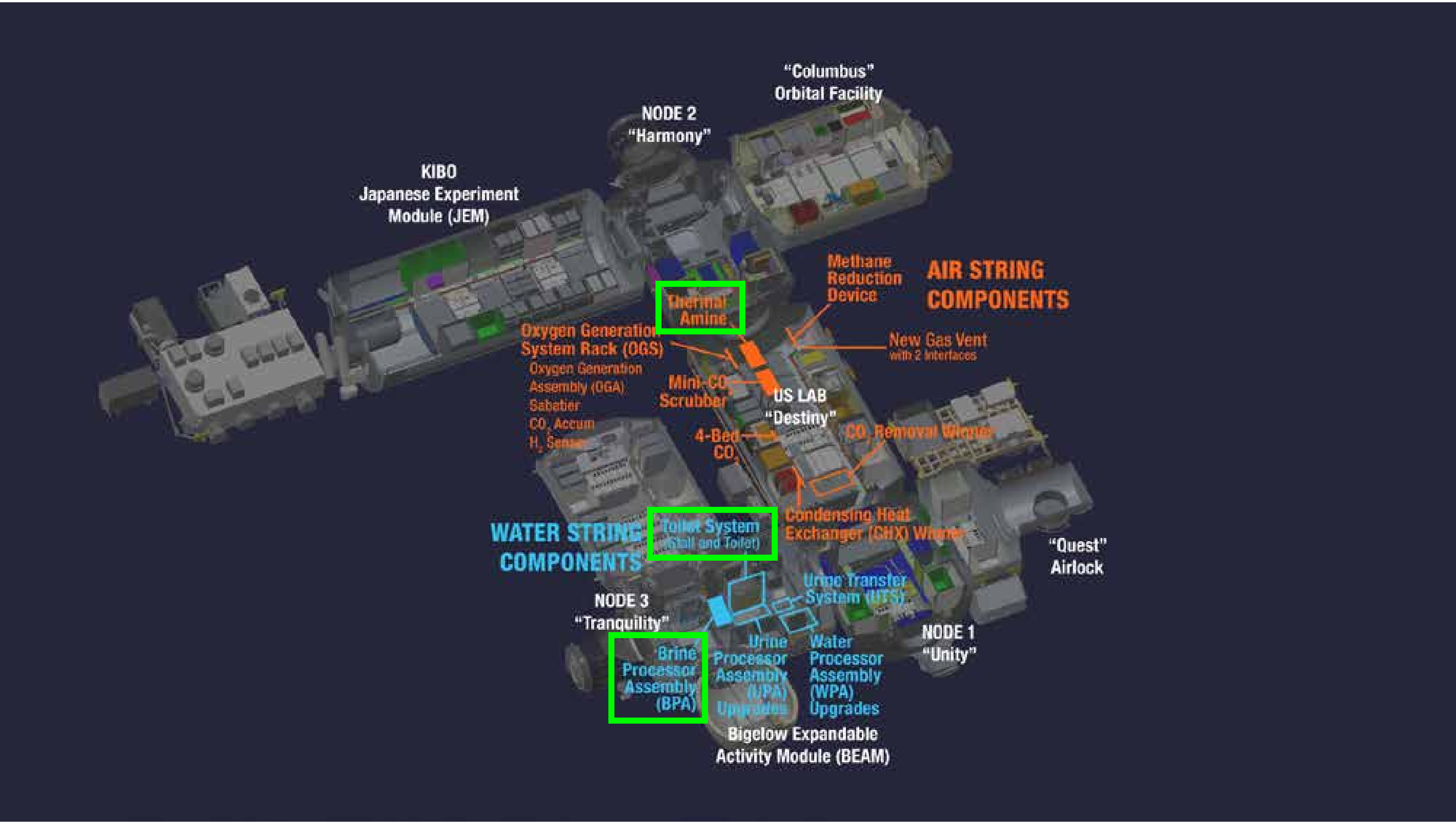
- Future long-duration Mars-class Human exploration missions will be safer due to ISS past and future ECLSS-CHP operational experience and system investments
- Operational experience yields critical data to improve failure rate estimates and help identify and mitigate risks associated with underestimates
- Reduced uncertainty allows risk coverage with fewer and better optimized spares, increasing ECM crew safety from an ECLSS perspective ~17 times relative to pre-ISS experience

Using today's ISS ECLSS ORU reliability estimates, we now know that Mars mission spares allocations created using initial reliability estimates were not optimized and would have resulted in a significant amount of hidden risk. ISS experience over the past decade has corrected those estimates and helped mitigate that risk.

20 Years on the International Space Station


From Low-Earth Orbit (LEO) to the Moon and Mars
DEVELOPING EXPLORATION CAPABILITIES
Mars-Class Transportation
Gateway
Notional
Commercial Platform
International
Space Station (ISS)
Advanced Communications
Advanced Propulsion
Automated In-Space Assembly
Fire Detection, Suppression and Cleanup
Medical Autonomy, Human Health, and Food Systems
Long-Duration Environmental Control and Life Support Systems (ECLSS)
Autonomous Environmental Monitoring and Vehicle Operations
In-Space Manufacturing
Next Generation Spacesuits
Radiation Monitoring and Protection
Entry Descent and Landing (EDL) Including Precision Landing
Earth Surface
Lunar Surface
Mars Surface
Cryogenic Fluid Management
In-Situ Resource Utilization (ISRU)
Sustainable Power
Earth-Independent Crew Operations with Communications Delay
Autonomous Egress/Post Landing Operations

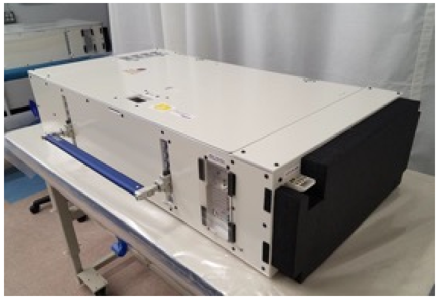
Life Support Systems on the Space Station



Life Support Systems:

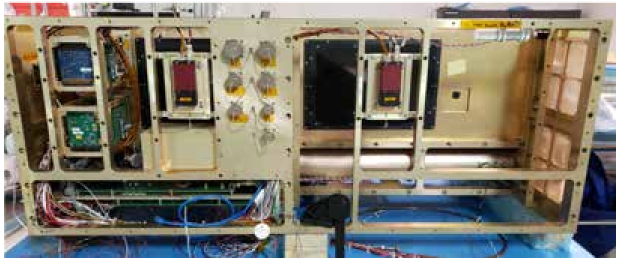
Thermal Amine Scrubber

Brine Processor Assembly (BPA)

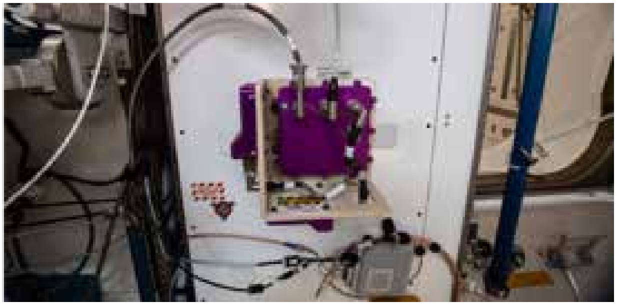


Universal Waste Management System (UWMS)

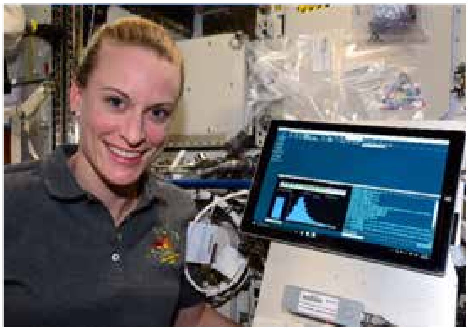
Fire Safety:
Saffire Experiments



Radiation:
Hybrid Electronic Radiation Assessor (HERA)



Environmental Monitoring:
- MiniON DNA Sequencer,
- Aerosol-Sampler-Particulates
- Spacecraft Atmosphere Monitor (SAM)



Crew Health and Performance:

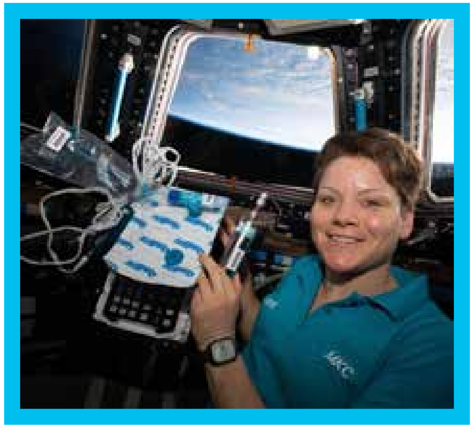
- Exercise Device (ESA's E4D)
- EVA Suits (Z2.5 pictured)
- Food Systems (VEGGIE pictured)

Logistics Reduction:

- RFID Enabled Autonomous Logistics Management (REALM-2)
- In-space Manufacturing
- Heat Melt Compactor for Trash Processing

NASA's Future LEO Demand

Human Research



Technology Demonstrations

Crew Accommodations & Training

Science

Physical & Biological Research

National Lab Services

20 Years on the International Space Station

National Aeronautics and
Space Administration

Thank you for participating!

Learn more at

nasa.gov/station