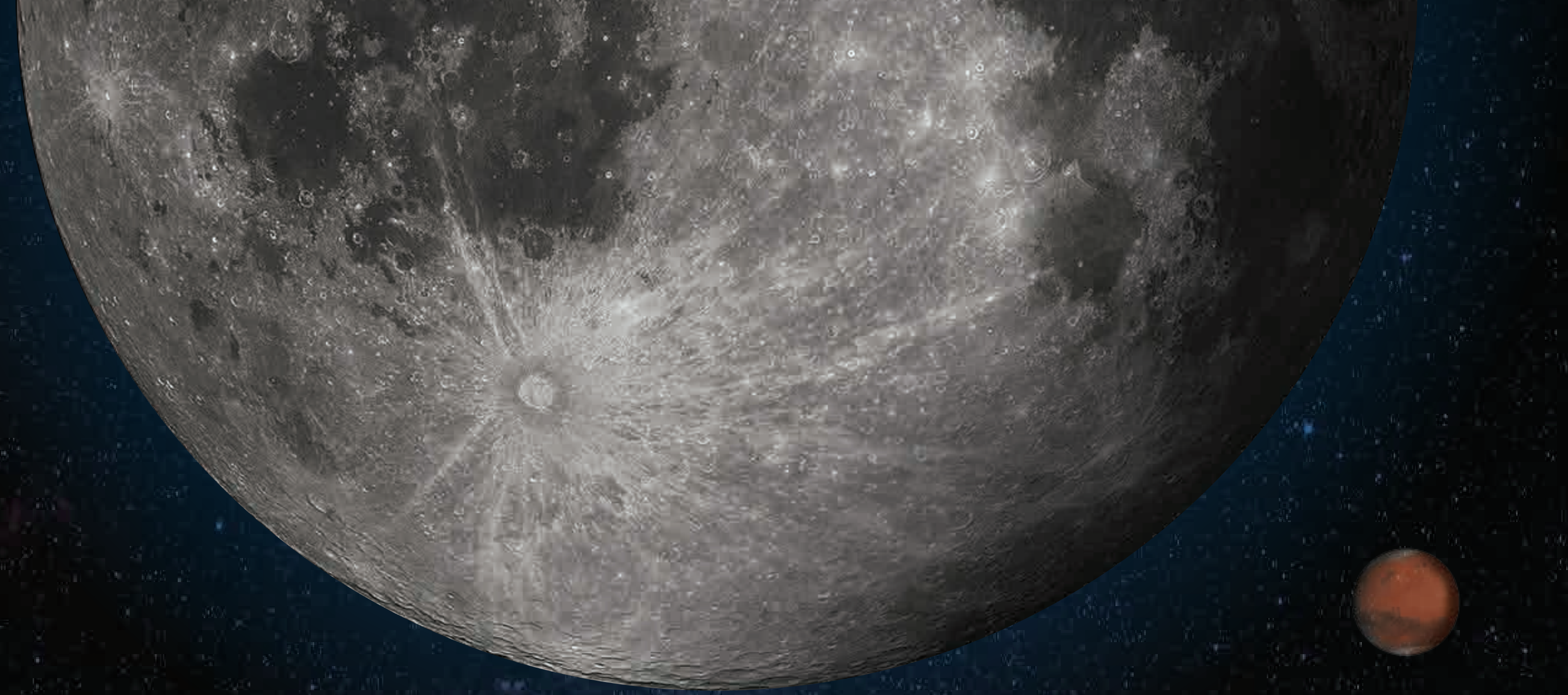


BENEFITS FOR

EXPLORATION

INTERNATIONAL SPACE STATION

INTRODUCTION - *As space travel has expanded in distance, duration, and capability, each mission has provided advances to enable the next. Experiments on space shuttle missions and the Shuttle-MIR expeditions demonstrated capabilities and reduced risk to International Space Station (ISS) construction and operations. Through Shuttle-MIR operations and experiments in human research, and as a test bed for space technologies, processes and operations, shuttle-MIR enabled the ISS Program.*

Today, the ISS is providing knowledge in human research, experience in long-duration spacecraft operations, and is serving as a testbed for technology demonstrations of new capabilities and upgraded vehicle systems, which are enabling future missions.

SPACE STATION: THE FIRST EXPLORATION MISSION

The ISS is the first exploration mission, enabling more distant and longer-duration exploration missions in the future – well beyond low-Earth orbit.

Long-duration, distant exploration missions will require capabilities beyond the currently available technologies and avoidance of the potentially negative effects of the space environment on the health and performance of humans working in that environment. Testing those new capabilities and mitigating human health risks aboard the ISS helps to reduce exploration risks and their associated financial costs.

The ISS program and its international partners have made advances toward an exploration mission beyond low-Earth orbit through three broad approaches:

- Using ISS as a testbed for exploration missions by maturing operational processes, demonstrating advanced technologies and maturing vehicle systems, proving their effectiveness prior to being used on more distant missions
- Conducting investigations that seek ways to mitigate the risks to the human crew
- Experimentation to increase engineering and operational knowledge while developing and validating engineering models

A TESTBED FOR FUTURE EXPLORATION

The unique environment and operations of the ISS as a long-duration spacecraft make it exceptionally positioned to operate as a testbed for exploration missions. Demonstrating a new technology for the first time on a mission that requires this performance is a risky approach for the crew and completion of the mission. Demonstrating the performance of these technologies first on the ISS, where they are not required for safety of the crew or vehicle operations, proves their performance without risking the crew or mission prior to their use in an operational spacecraft.

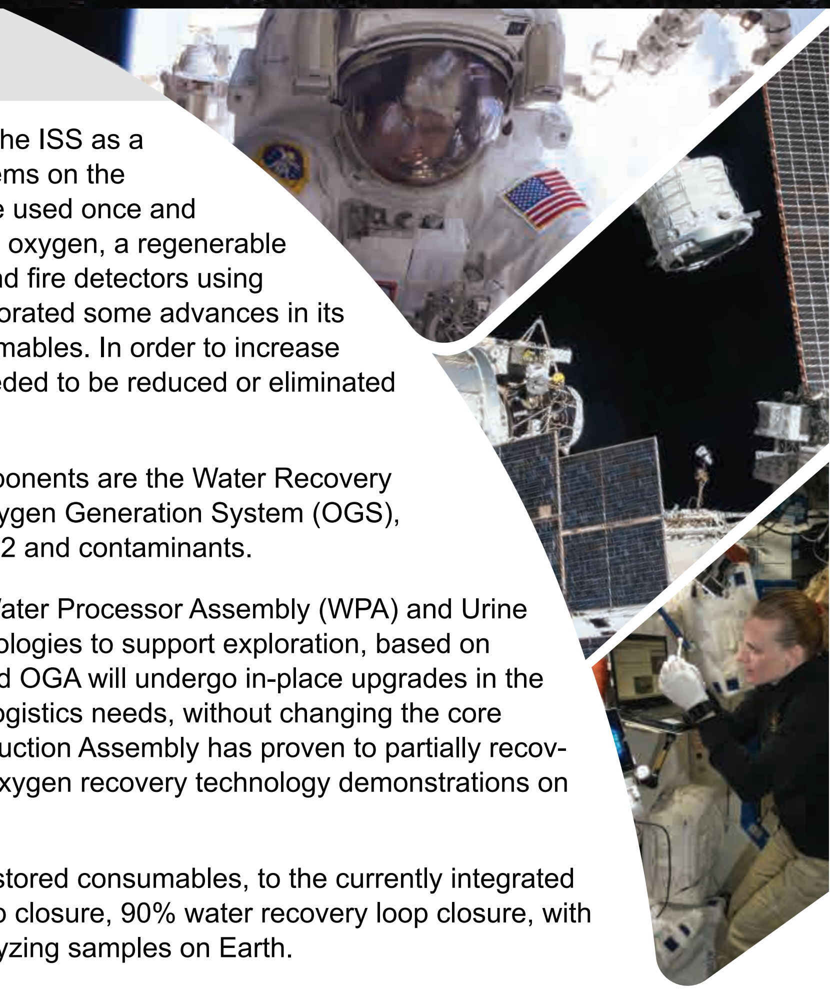
Technology and systems demonstrations aboard the ISS provide the best means to prove in-space operational maturity of new technologies for:

- System performance in the space and crewed-spacecraft environment
- Flight and ground crew training and operational procedures
- Systems and mission operational processes and procedures
- Logistics needs as driven by operations in the spacecraft environment
- Safety incorporated into operations and design features
- Interoperability in the space systems infrastructure.

Since its start, the ISS program has demonstrated large steps toward exploration: operating a long-duration spacecraft, the first regenerative life support system, continuous distributed operations with international partners, interface standards and many additional practices and systems.

Through the experience of ISS operations, the vehicle systems and operational processes have become less reliant on resupply and communications from earth through logistics reduction in addition to increased system capabilities and reliability.

ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEMS (ECLSS)



One important example of technology demonstration using the ISS as a testbed is the ECLSS. Prior to the ISS, the life support systems on the Mercury, Gemini, and Apollo spacecraft were designed to be used once and discarded. The ECLSS on Skylab featured stored water and oxygen, a regenerable molecular sieve for carbon dioxide and humidity removal, and fire detectors using ultraviolet light detection. Although the Space Shuttle incorporated some advances in its life support system, it still relied heavily on the use of consumables. In order to increase the time crews could stay aboard the ISS, consumables needed to be reduced or eliminated using regenerative systems.

The regenerative ECLSS aboard the ISS, whose main components are the Water Recovery System (WRS), Air Revitalization System (ARS) and the Oxygen Generation System (OGS), reclaims and recycles water and oxygen while removing CO_2 and contaminants.

The Oxygen Generation Assembly (OGA) and the WRS's Water Processor Assembly (WPA) and Urine Processor Assembly (UPA) have proven as adequate technologies to support exploration, based on performance experience aboard the ISS. The WPA, UPA and OGA will undergo in-place upgrades in the near future in order to enhance maintainability and reduce logistics needs, without changing the core technologies. Additionally, the Sabatier Carbon Dioxide Reduction Assembly has proven to partially recover oxygen from CO_2, and will form the basis for enhanced oxygen recovery technology demonstrations on the ISS in the future.

The ISS has advanced the ECLSS technology from mostly stored consumables, to the currently integrated ECLSS that performs at 42% O_2 recovery from CO_2 air loop closure, 90% water recovery loop closure, with six months of spares and, when needed, returning and analyzing samples on Earth.

Near-future ISS system upgrades and demonstrations aim to prove higher resource recovery with enhanced maintainability and reduced logistics needs.

SPACE STATION AS A HUMAN RESEARCH PLATFORM

The Human Research Program (HRP) was developed because of NASA's refocus on exploration in early 2004. The program uses research findings to develop procedures to reduce the potential negative effects of the space environment on the health and performance of humans working in that setting. With the goal of returning to the Moon and traveling to even farther destinations, HRP is using ground research facilities, the ISS, and simulated environments to develop these procedures and to further research areas that are unique to the Moon, Mars and other destinations.

The development of the HRP content has been formulated around the management architecture that describes evidence as forming the basis of the existence of a risk to the human system, gaps in our knowledge about characterizing or mitigating the risk, and the tasks to be carried out in order to produce the deliverables needed to close the gaps and reduce the risk.

As deliverables and new evidence are generated, a reassessment is made of the progress of risk reduction.

SPACE STATION'S CONTINUING BENEFITS TO EXPLORATION

These accomplishments are the initial returns of an ongoing process to mitigate spaceflight risks to the human crew and demonstrate through in-space operations the technologies and systems that will be used in exploration missions. Many additional efforts are in process and will provide results in the coming years. Major areas of focus include: Human Health and Performance; Environmental Control and Life Support Systems (ECLSS); Spacecraft Fire Safety; Exploration Communications; Crew and Spacecraft Autonomy; and Radiation Monitoring and Protection.

The ISS partners have demonstrated and practiced how to conduct an exploration mission aboard the ISS, already proving required capabilities for future missions. Continuing to take advantage of the ISS for exploration is a valuable investment in human spaceflight's future.

For more information on any of the experiments providing benefit to exploration, or any ISS research, visit the Space Station Research and Technology Experiments page:
https://www.nasa.gov/mission_pages/station/research/experiments_category

Investigations

- Carbon Dioxide Removal Assembly (CDRA)
- Urine pre-treatment
- Oxygen Generation Assembly (OGA)
- Distillation Assembly (DA)
- Sabatier
- ISS Insitu Environment Monitoring
- Amine Swingbed
- Biomolecule Sequencer
- Microbial Sensor
- Personal CO2 monitor
- Radiation Environment Monitor
- European Crew Personal Active Dosimeter (EUCPAD)
- WISENET
- Microflow
- Radi-N2
- Active Area Dosimeters (J-TEPC)
- Environment Monitor (JEM WIS)
- Roll-Out Solar Array
- Forward Technology Solar Cell Experiment (FTSCE) on MISSE 5 and 7
- ISS Li Ion Batteries
- Tele-Robotics
- International Docking Adapter (IDA)
- METERON / SUPVIS-JUSTIN
- METERON / HAPTICS
- Flying Camera Robot (Int-Ball#1)
- Mobile Procedure Viewer (MobiPV)
- Crew Autonomous Operations
- NICER/Sextant Navigation
- Orion Optical Navigation
- Cognitive Radio
- Disruption Tolerant Network (DTN)
- Common Communications for Visiting Vehicles (C2V2)
- SpaceBorne Computer
- SPHERES-VERTIGO
- Automated Rendezvous and Docking Sensor
- ISS Logistics Reduction
- RFID-Enabled Autonomous Logistics (REALM)
- Bigelow Expandable Activity Module (BEAM)
- Phase Change HX
- Zero Boil-Off Tank (ZBOT)

Human Health and Performance Investigations

- The International Space Station Sprint Exercise Protocol for Maintenance of Health
- Compression Garment
- Vertebral Ultrasound
- Bone Health
- Decompression Sickness Prevention Protocols
- Disturbance of Balance
- Biomarkers for Eye Changes
- Immune Dysfunction
- Advanced Food System Products
- Cognition
- Spacecraft Assessment Tools (SOLV)
- The Integrated Medical Model (IMM)
- Flexible Ultrasound

Radiation Environment, Physics, and Transport Tools