



## Analog Missions and Field Tests

NASA is actively planning to expand human spaceflight and robotic exploration beyond low Earth orbit. To meet this challenge, a capability driven architecture will be developed to transport explorers to multiple destinations that each have their own unique space environments. Future destinations may include the moon, near Earth asteroids, and Mars and its moons.

NASA is preparing to explore these destinations by first conducting analog missions here on Earth. Analog missions are remote field tests in locations that are identified based on their physical similarities to the extreme space environments of a target mission. NASA engineers and scientists work with representatives from other government agencies, academia and industry to gather requirements and develop the technologies necessary to ensure an efficient, effective and sustainable future for human space exploration.

NASA's Apollo program successfully conducted analog missions to develop extravehicular activities, surface transportation and geophysics capabilities. Today, analog missions are conducted to validate architecture concepts, conduct technology demonstrations, and gain a deeper understanding of system-wide technical and operational challenges. These analog missions test robotics, vehicles, habitats, communication systems, in-situ resource utilization and human performance as it relates to these technologies.



*The in-space habitat with crew transportation and space exploration vehicles during a near Earth asteroid mission.*

## Extreme Environments

To prepare astronauts and robots for the complex challenges of living beyond low Earth orbit, NASA conducts exploration analog missions in comparable extreme environments here on Earth and in space. NASA continues to add mission locations to suit advancing requirements and enhance the experiments to provide NASA with data about strengths, limitations and validity of planned human-robotic exploration operations. Current locations include the desert, volcanic, arctic, lake, ocean and low Earth orbit environments.

## **Desert Research and Technology Studies**

### *Environment: Desert*

NASA's Desert Research and Technology Studies (RATS) team evaluates technology, human-robotic systems and extravehicular equipment in the high desert near Flagstaff, Ariz. The research and development prototypes provide a knowledge base that helps scientists and engineers design, build and operate better equipment, and establish requirements for operations and procedures.

The Arizona desert has a rough, dusty terrain and extreme temperature swings that simulate conditions that may be encountered on other surfaces in space. Additionally, its remote location presents realistic communication scenarios. Some examples of technologies the Desert RATS team has evaluated include high fidelity prototype hardware, space-suit equipment, robots, rovers, habitation modules, exploration vehicles, surface mapping and navigation techniques, and power and communication systems.



*Two rovers are connected to the Habitat Demonstration Unit during field tests in Arizona.*

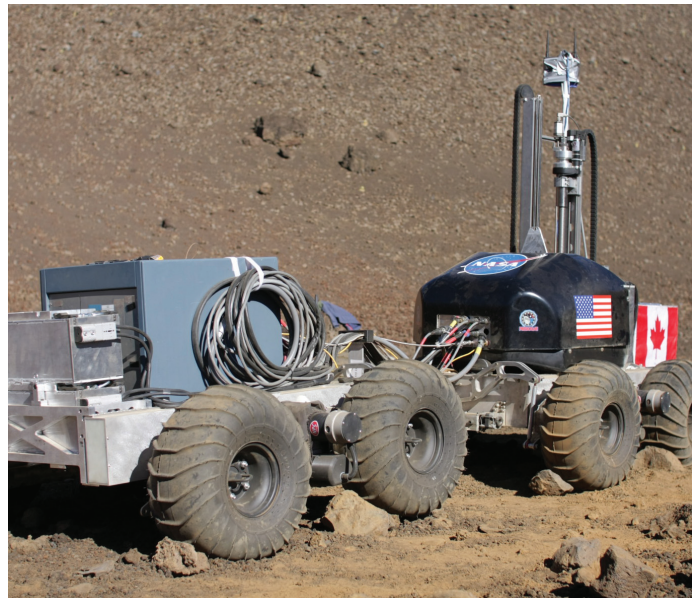
## **In-situ Resource Utilization Demonstrations**

### *Environment: Volcano*

The terrain, rock distribution, soil materials and permafrost at Mauna Kea, Hawaii, provide an ideal setting for testing hardware and operations not available in laboratories or NASA centers.

NASA conducts analog missions at Mauna Kea in collaboration with partners such as the Pacific International Space Center for Exploration Systems and the Canadian Space Agency. Together they perform in-situ resource utilization demonstrations, a necessary element in NASA's exploration architecture. Technologies that could be used to look for water ice in lunar or planetary environments are also evaluated.

In-situ resource utilization is a process that harnesses local resources for use in human and robotic exploration, such as end-to-end oxygen extraction, separation and storage from the volcanic material. Resources that could be used include regolith (or surface material), minerals, metals, volatiles, water, ice, sunlight, vacuum and thermal gradients.



*NASA and its international partners test equipment on a remote and cold volcano during field tests in Hawaii.*

## **Haughton Mars Project**

### *Environment: Arctic*

Haughton Crater is located on Devon Island, Canada, and is accessible only by aircraft from Resolute Bay, Cornwallis Island, Canada. The crater's rocky arctic desert setting, geological features and biological attributes provided an optimal setting to gather requirements for possible future robotic and human missions to Mars.

During the Haughton Mars Project, scientists and engineers from NASA, the Mars Institute, and the SETI Institute perform multiple representative lunar science and exploration surface activities using existing field infrastructure and surface assets. Science and operational concepts are demonstrated, including extravehicular activity traverses, long-term hi-data communication, complex robotic interaction, and on-board rover and suit engineering.



*The Haughton Mars Project research station located on Devon Island, Canada.*



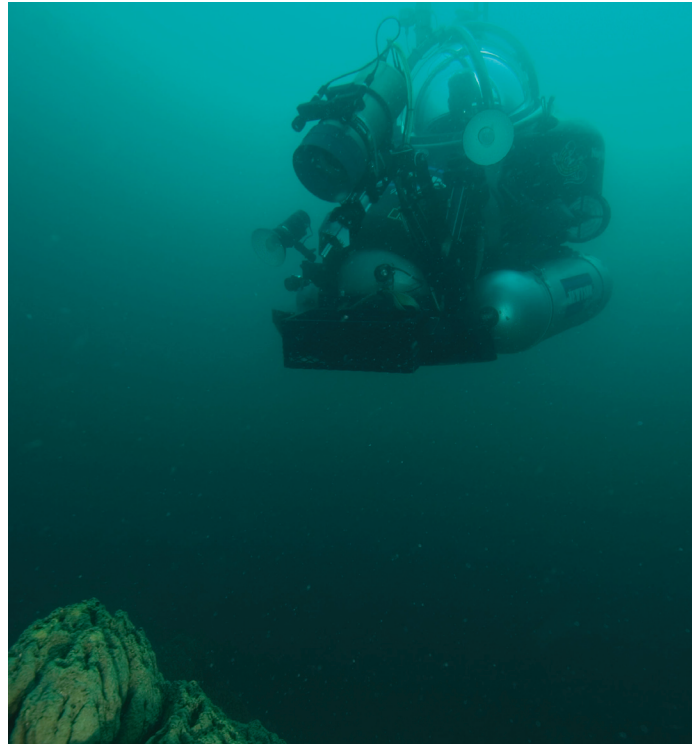
## **Pavilion Lake Research Project**

### *Environment: Lake*

The Pavilion Lake Research Project is an international, multi-disciplinary, science and exploration effort that seeks to explain the origin of the freshwater microbialites that grow in Pavilion and Kelly Lakes in British Columbia, Canada. Fossil microbialites are some of the earliest remnants of life on ancient Earth.

The microbialites in Pavilion and Kelly Lakes are relevant to our understanding of ancient microbialites that were once common and diverse on early Earth. Earth scientists and astrobiologists can apply findings from this research to the search for life in our solar system and beyond.

NASA conducts this analog mission because it is in a critical science research location that provides a challenging setting to test and develop research and exploration methods for future site surveys and science data collection. Scientists use submersible vehicles and methods to explore that are similar to how a robotic precursor mission would explore a near Earth asteroid. The process refinements for traverse planning and science data collection will help improve techniques for future space exploration missions and scientific research.



*The Deep Worker submarine searches for microbialites during field tests in British Columbia, Canada.*

## **NASA's Extreme Environment Mission Operations**

### *Environment: Ocean*

One of the most extreme environments on Earth is the ocean. Not only is the ocean harsh and unpredictable, it also provides many parallels to the challenges of living and working in space.

The Florida Keys National Marine Sanctuary, home of the National Oceanic and Atmospheric Administration's underwater laboratory Aquarius, serves as the test site for NASA's Extreme Environment Mission Operations project, known as NEEMO. The isolation and real hazards of this laboratory's environment make it an excellent site for testing space exploration concepts.

Similar in size to the International Space Station's living quarters, Aquarius is the world's only permanent underwater habitat and laboratory. The 45-foot-long, 13-foot-diameter complex is 3.5 miles off the Key Largo coast. A surface buoy provides connections for power, life support and communication to the habitat that sits about 62 feet below the surface.

Long-duration missions, lasting up to three weeks, provide astronauts the opportunity to simulate living on a spacecraft and execute undersea extravehicular activities. During these activities they are able to test advanced navigation and communication equipment and future exploration vehicles. These tests cultivate an astronaut's understanding of daily mission operations, and create realistic scenarios for crews in close quarters to make real-time decisions.



*An astronaut stands in front of an exploration vehicle mockup during field tests off the coast of Florida.*

## International Space Station Testbed for Analog Research (ISTAR)

### *Environment: Low Earth Orbit*

The International Space Station (ISS) offers a unique platform to test future exploration systems and operations because it provides a long-duration, zero-gravity space environment and the opportunity to evaluate many factors not available in other analog missions. NASA will use the ISS as a test site for long-duration missions to identify the risks and challenges to astronaut health and safety, prepare for crew autonomous operations needed for handling communication time delays, exercise ground elements training and technology development, and evaluate new exploration systems and capabilities as they become available.

ISTAR will challenge the astronauts to work progressively longer periods unassisted by mission control—just as would be expected on a mission to Mars or a near Earth asteroid. Future ISTAR missions could last as long as six months and would use ISS confinement and zero-gravity to simulate crew activities during long-duration flights and crew arrival at an exploration destination.

One example of space station research examines how humans and robots work together to overcome technical challenges. These human-robotic partnerships will be tested with the addition of Robonaut 2 (R2) at the ISS. The conditions in the space station will provide an ideal test setting for robots to work in close proximity to humans, while also working in a zero gravity environment. The plan is to evolve the system with new software uploads and subsystems, such as legs or mobility aids, to eventually allow R2 to work outside of the space station. This evolution will allow R2 handlers to better understand how the system will work in the vacuum of space, helping them prepare for future space missions.



*Robonaut 2, now onboard the International Space Station, shakes hands with an astronaut.*

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NASA's plans to extend the human presence beyond low Earth orbit will require many technological advances and a greater understanding of how to use the systems to explore effectively. To meet these challenges, scientists and engineers must conduct hands-on analog tests and research here on Earth and the International Space Station.

NASA has not yet confirmed the technologies that will be used in future space exploration missions, but with the successful testing of analog systems and procedures in simulated and extreme environments on Earth and the International Space Station, humans move one step closer to a sustainable human presence in space.

For more information about NASA analog missions, please visit: <http://www.nasa.gov/exploration/analog>

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NF-2011-04-534-HQ

