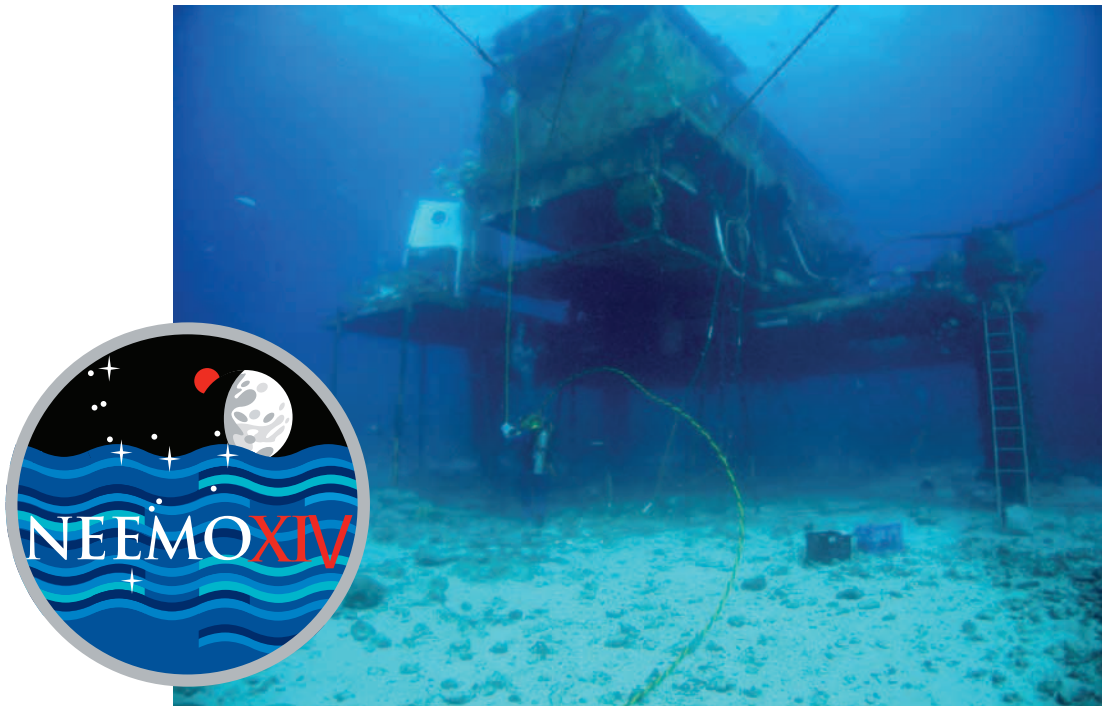


NASA Extreme Environment Mission Operations Project (NEEMO) 14

NASAfacts



Space exploration presents many unique challenges to humans. In order to prepare astronauts for these extreme environments in space, NASA engineers and scientists use comparable environments on Earth. One of the most extreme environments is the ocean. Not only is the ocean a harsh and unpredictable environment, but it has many parallels to the challenges of living and working in space.

The NASA Extreme Environment Mission Operations project, known as NEEMO, sends groups of astronauts, engineers, doctors and professional divers to live in an underwater habitat for up to three weeks at a time. These crew members, called aquanauts, live in Aquarius, the world's only undersea laboratory, located 3.5 miles off the coast of Key Largo, Fla.

Most underwater activities are accomplished by traditional scuba diving, but divers are limited to specific amounts of time because of the risk of decompression sickness (often called the “bends”). Based on the depth and the amount of time spent underwater, inert gases such as nitrogen will build up in the human body. If a diver ascends out of the water too quickly, the gases that were absorbed can create bubbles within the diver’s body as the surrounding pressure reduces.

A technique known as saturation diving allows people to live and work underwater for days or weeks at a time. After twenty four hours at any underwater depth, the human body becomes saturated with dissolved gas. Therefore, the diver can accurately predict exactly how much time is needed to

decompress before returning to the surface, which limits the risk of decompression sickness. By living in the Aquarius habitat and working at the same depth on the ocean floor, NEEMO crews are able to remain underwater for the duration of their mission.

Aquarius

Aquarius provides NASA a convincing analog to space exploration. Much like space, the undersea world is a hostile, alien place for humans to live. NEEMO crew members experience some of the same tasks and challenges underwater as they would in space. For example, working in space and underwater environments requires extensive planning and sophisticated equipment. Working underwater also has a strong benefit to NASA because the aquanauts can be weighed out to simulate different gravity environments.



Aquarius is owned by the National Oceanic and Atmospheric Administration (NOAA) and managed by the University of North Carolina at Wilmington (UNCW) via the NOAA Undersea Research Center (NURC) in Key Largo, Florida. The laboratory is located in the Florida Keys National Marine Sanctuary and is on the ocean floor next to deep coral reefs 62 feet below the surface.

The Aquarius system has three elements: a life-support buoy at the surface, the habitat module and a base plate that secures the habitat to the ocean floor. The Aquarius habitat has about 400 square feet of living and laboratory space. This size is similar to that of the Zvezda Service Module of the International Space Station, which has served as the living quarters for Expedition crew members.

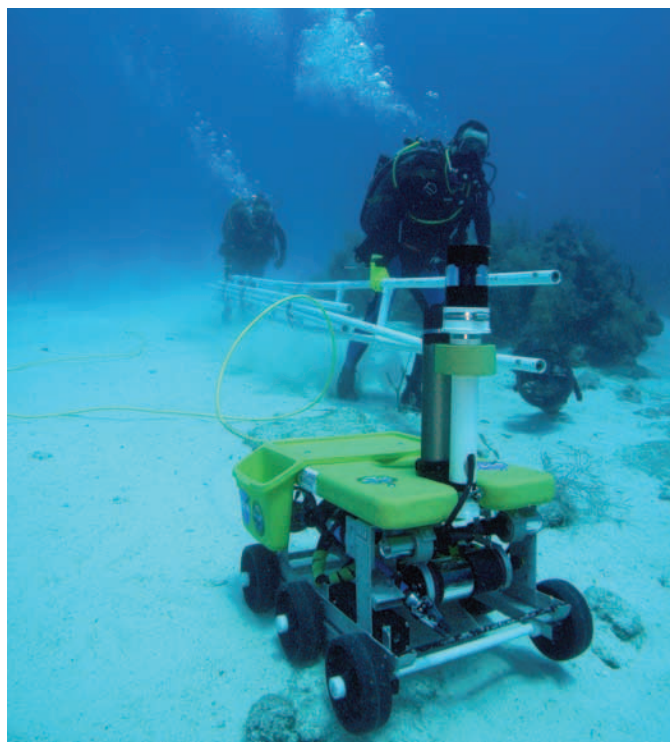
While underwater, NEEMO participants are able to simulate living on a spacecraft such as the International Space Station or to test extravehicular activities for future space missions. NASA sent its first set of NEEMO

aquanauts to Aquarius in October 2001. The crew size varies from three to four, with UNCW engineers providing support.

NEEMO 14 Mission Objectives

Extravehicular Activities

One of the biggest challenges in astronaut training is learning how to perform tasks in low gravity environments. Buoyancy, which is the ability of an object to float in liquid, such as water, is the reason that aquanauts are able to simulate low gravity. Normally, the crew members would be positively buoyant, meaning that they would float in the water. However, by wearing diving equipment and weighted backpacks, aquanauts are able to work on the ocean floor with only minimal positive buoyancy. This way, NEEMO missions can include practicing extravehicular activities (EVA) and imitate “spacewalks” to test concepts for mobility in low gravity.



The NEEMO 14 mission will provide crew members with multiple opportunities to simulate interaction with future exploration vehicles. The vehicles used on these dives are similar to the actual size of landers and rovers being developed by NASA. As aquanauts interact with these developing technologies, they can provide information and feedback to NASA engineers.

Rover Testing

- Practice off-loading a rover from a lander
- Testing different hatch opening sizes
- Evaluate suit ports on rover

- Test the mechanics developed for transferring an incapacitated crewman
- Evaluate the overall mock-up design, in terms of equipment, crew support, and effects of the environment

Lander Testing

- Test ladder angles, positioning and size, for exiting and entering a lander
- Evaluate fall protection systems and safety rails
- Simulate the delivery of a small payload
- Run through uploading of incapacitated crew
- Analog mock-up davit crane testing
- Test overall aspects of mock-up design

Exploration Traverse

- Perform exploration to various underwater sites
- Test workability of Mission Control Center support

Education and Public Outreach

- Engage students, educators, and the general public in NEEMO activities via social media, interactive education events, and media interaction

Crewmember Health

Crewmember health is of utmost importance when planning for space exploration, especially for long duration missions. Since the first NEEMO mission, a key focus for every aquanaut crew has been physiological and psychological health. Studies have included how their environment affects sleep and the body's immune system, growth of bacteria within the habitat, nutrition, and exercise-related studies.

In addition, coping with medical emergencies without a hospital or trained doctor can be a difficult and dangerous task. Aboard the space station and during long duration missions in the future, crew member health and mission success may depend on the crew's ability to deal with emergencies without the help of a doctor. Because of its physical and psychological isolation on the floor of the Atlantic Ocean, Aquarius provides the most accurate stresses needed to validate new telemedicine in an extreme environment.

NEEMO 14 will perform the following studies:

Behavioral Health and Performance Studies

- Cognitive Performance and Stress in a Simulated Space Environment
- Effects of High vs. Low Autonomy on Space Crewmember Performance



- A Scheduling and Planning Tool in NEEMO 14 – A Simulated Space
- Measures of Team Cohesion, Team Dynamics, and Leadership in a Simulated Environment
- Sleep/Wake Measures in a Space Analog Environment

Human Health Countermeasures (HHC) Studies

- Advance Extravehicular Activity (EVA) Exploration Activities Study to Assess Human Performance Responses in Partial Gravity Environments
- Immune Assessment During a Short-duration Spaceflight – Analog Undersea Mission

Kennedy Space Center Studies

- CASPER (Cardiac Adapted Sleep Parameters Electrocardiogram Recorder) Monitoring During NEEMO 14 Expedition aboard Aquarius Undersea Habitat
- Continuous Real-time Hemodynamic Noninvasive Monitoring During NEEMO 14 Expedition aboard Aquarius Undersea Habitat

By conducting these studies in and outside of Aquarius, NASA's scientists and engineers can provide for the health and safety of astronauts and others involved in long duration, extreme environment endeavors.

Communications

The physical and psychological isolation of the Aquarius habitat closely mirrors the isolation that can occur during space exploration. Communication between astronauts and Mission Control is highly important, but during future long duration missions, there will be times where this communication may not be available. Therefore, crews must be able to work independently from the mission control team.

NEEMO missions offer the opportunity to test new techniques for telecommunications. Aquanauts and engineers work to develop new ways to interact with researchers from a remote laboratory location, much like they do with the space station. In addition, they have tested new communication technology for use when a space walking crew is working at a significant distance from the laboratory.



Strong emphasis is placed on exercising team building and leadership skills among the NEEMO crews, which enables them to continue working efficiently when they are unable to communicate with a mission control center. It is important to practice the plans, procedures and training that are vital to long duration exploration missions when there is the possibility of less direct communication with mission control.

NEEMO Teams and Key Personnel

In addition to the participants in NEEMO saturation dives, teams of technicians and scientists work above the surface. They monitor Aquarius’ systems and stay in contact with the underwater crew.

Surface Support Team

The Surface Support Team includes the NEEMO project lead, the mission lead, and the dive medical officer and support personnel. This team resides at the National Undersea Research Center, or NURC, during the mission and training. Overall responsibility and authority for NASA objectives during NASA missions resides with the NEEMO mission lead on this team.

Aquanaut Crew

This team consists of the four aquanaut personnel from NASA that go into “saturation,” living aboard Aquarius for the duration of the dive. This typically includes three astronauts and a medical doctor, engineer, or scientist.

Habtechs

Two NURC employee/aquanauts accompany the NEEMO crew into saturation. Their primary responsibilities are the operation of the Aquarius on-board systems and the safety of the aquanauts.

Watch Desk

The watch desk is the NURC version of NASA’s Mission Control Center. It is located onshore and is staffed by a team of two employees 24 hours a day during the mission. Watch desk personnel are primarily responsible for the overall safety of the mission, monitoring the telemetry of the facility and approving all of the aquanaut dive plans. The watch desk lead is the ultimate authority on safety issues such as storm evacuation, medical emergencies, habitat system contingencies and dive plan approval.

Principal Investigators

These individuals are responsible for developing much of the science conducted by the aquanauts. They monitor the mission from a remote control center or in some instances from the NURC facilities. They periodically interface with the crew real-time during the mission to facilitate the science needs.

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