NEEMO – NASA's Extreme Environment Mission Operations: On to a NEO! M. S. Bell[1], P. J. Baskin[2], W. L. Todd[3] [1]Jacobs@NASA/Johnson Space Center, MC: KT, Houston, TX 77058, mary.s.bell@nasa.gov, [2] Wyle Integrated Science and Engineering, Houston, TX 77058, [3] United Space Alliance, Houston, TX 77058.

Mission Operations: During NEEMO missions, a crew of six "Aquanauts" lives aboard the National Oceanic and Atmospheric Administration (NOAA) Aquarius Underwater Laboratory – the world's only undersea laboratory located 5.6 km off shore from Key Largo, Florida. The Aquarius habitat is anchored 62 feet deep on Conch Reef which is a "research only zone" for coral reef monitoring in the Florida Keys National Marine Sanctuary. The crew lives in saturation for a week to ten days and conducts a variety of undersea EVAs (Extra Vehicular Activities) to test a suite of long-duration spaceflight Engineering, Biomedical, and Geoscience objectives. The crew also tests concepts for future lunar exploration using advanced navigation and communication equipment in support of the Constellation Program planetary exploration analog studies. The Astromaterials Research and Exploration Science (ARES) Directorate and Behaviorial Health and Performance (BHP) at NASA/Johnson Space Center (JSC), Houston, Texas support this effort to produce a high-fidelity test-bed for studies of human planetary exploration in extreme environments as well as to develop and test the synergy between human and robotic curation protocols including sample collection, documentation, and sample handling. The geoscience objectives for NEEMO missions reflect the requirements for Lunar Surface Science outlined by the LEAG (Lunar Exploration Analysis Group) and CAPTEM (Curation and Analysis Planning Team for Extraterrestrial Materials) white paper [1].

The BHP objectives are to investigate best measures and tools for assessing decrements in cognitive function due to fatigue, test the feasibility study examined how teams perform and interact across two levels, use NEEMO as a testbed for the development, deployment, and evaluation of a scheduling and planning tool. A suite of Space Life Sciences studies are accomplished as well, ranging from behavioral health and performance to immunology, nutrition, and EVA suit design results of which will directly support the investigation of open questions and operational concepts that will enable NASA to continue its plan for planetary exploration. To date, 14 NEEMO missions have been conducted utilizing crews comprised of a mix of four astronauts, scientists, and engineers with two NOAA operations specialists assigned to manage life support systems 24/7 during the mission.

The Science Platform: Aquarius is used by marine scientists to study coral reefs because saturation diving maximizes "bottom time" for a research diver. ARES uses "coral science" as a proxy for "planetary science" to train aquanaut/astronauts to use their cognitive and analytical skills for data collection and documentation on the ocean floor in a manner similar to planetary surface operations (Fig. 1).

Fig. 1. Two crewmembers on EVA to photodocument and record the location, health, and size of a coral mound.

Exploration traverses are planned as EVA's operating with directions from the IV (IntraVehicular) aquanaut as well as autonomously. Both operations scenarios are time-lined to capture the efficiency of different operations protocols and any accompanying variances in the quality of science returns. Certain EVA's are structured to combine

the special skills of human explorers with robotic field assistants to determine what kinds of sample collection and documentation tasks should be accomplished robotically to optimize activities best done by the aquanaut/astronaut (Fig. 2).

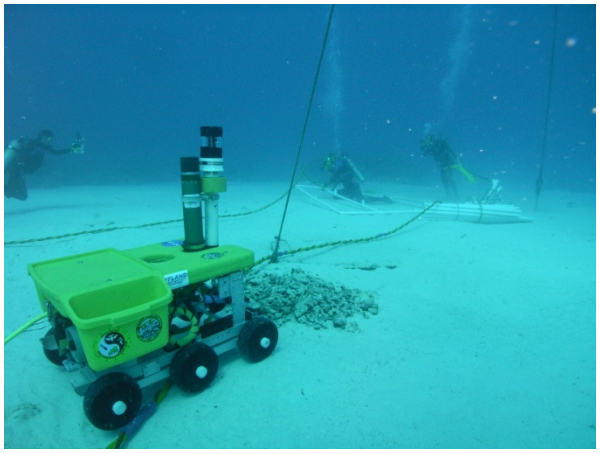

Fig. 2. Aquanauts and robotic field assistant with pancam on EVA to explore the synergy between humans and robots during geologic field operation. The ROV provides situational awareness for Mission Control.

In addition to geoscience EVA's, remote robotic sample manipulation technologies are demonstrated using a six-degree of freedom micromanipulator designed by Oceaneering for the ARES Advanced Curation Facility. Advanced curation sample handling protocols are tested and refined in the Aquarius habitat laboratory space.

Operations in an Extreme Environment: Aquanauts remain isolated from the outside world for the duration of their mission because saturation diving techniques require a lengthy decompression before surfacing is allowed. The isolation, surrounded by an extreme environment, is important for studies related to behavior and physiology (Fig. 3) and as a space analog for working and training under environmental conditions that are similar to many of the challenges faced in outer space. In particular, the NASA Aquarius experience is used to help build crew and mission control communication skills and techniques. NEEMO is therefore an important team building exercise for improving astronaut training protocols.

Fig. 3. Astronaut Nicole Stott demonstrates a diagnostic ultrasound on Dr.Tim Broderick's knee during NEEMO 9.

NEEMO 15: The next NEEMO mission is scheduled for May 2011 and will include simulations for operating in a Near Earth Asteroid (NEO) environment. NEEMO has been an important platform for advancement of astronaut suit design and will continue suit testing to optimize astronaut surface operations capabilities. The aquanaut explorers will also be mapping and documenting features of the coral reef in the Carpenter Basin area that surrounds the Aquarius habitat – an activity that will provide valuable training for mapping in the extreme environment of a planetary surface as well as to provide insight into the operational constraints that will be encountered during exploration in a variety of planetary surface environments. Through Fourteen NEEMO missions, forty-five astronauts have become aquanauts and completed science operations training.

References: [1] Shearer, C. et al. (2009) Review of Sample Acquisition and Curation during Lunar Surface Activities, LEAG and CAPTEM White paper.