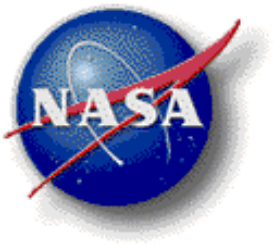
NASA NEEMO OVERVIEW DOCUMENT

NASA Extreme Environment Mission Operations 5, 6



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National Aeronautics and
Space Administration

LYNDON B. JOHNSON SPACE CENTER
HOUSTON, TEXAS

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1) Introduction

The objective of the joint underwater missions is to develop opportunities for using the "Aquarius" habitat as an analog for spaceflight and long-duration space habitation. Multiple directorates at JSC will work together with the National Undersea Research Center (NURC) to accomplish these missions during the NASA Extreme Environment Mission Operations (NEEMO) project.

NEEMO Charter:

To facilitate opportunities for NASA astronauts, scientists, physicians, MCC personnel and engineers to effectively utilize the " Aquarius" Underwater Research Facility as an analog for long-duration spaceflight, and to develop operations concepts, conduct experiments, perform space-analog tasks and sharpen team and interpersonal skills.

2) Facility Description

Aquarius is the only undersea research laboratory in the world. Owned by the National Oceanic and Atmospheric Administration and managed by the University of North Carolina at Wilmington, Aquarius operates 4.5 kilometers off of Key Largo in the Florida Keys National Marine Sanctuary. It is deployed next to deep coral reefs 20 meters below the surface. It is similar in size to the ISS service module, measuring approximately 14 meters long by 4 meters in diameter. Like its "outerspace" counterpart, Aquarius "aquanauts" explore and investigate an alien environment hostile to habitation. It provides life support systems that allow scientists to live and work underwater, in reasonably comfortable quarters while housing sophisticated research capabilities.

Aquarius aquanauts and scientists live in a "saturated" environment, equivalent to a depth of 17 meters. This allows them to work on the reefs outside the habitat for extended periods of time. Aquarius entry is gained through the wet porch, which contains an open moon pool, dive equipment storage areas, a sink and a hot water shower. There are two main compartments in Aquarius. The first, called the entry lock, contains bench space for computers and experiments, power equipment, life support controls, small view ports and bathroom facilities. The second, called the main lock, is the larger living space and includes berths for the six person crew, computer workstations, two large view ports and kitchen

facilities. The main lock also contains the life support controls so both the entry and main locks can be independently pressurized.

The facility is supported by a 10-meter life support buoy on the surface, which provides power, life support and communication requirements. There is also a shore based “mission control” which supports all Aquarius missions with 24-hour mission monitoring.

Aquarius Habitat - Key Largo, Fl.

3) Mission Specifics

3.1) NEEMO 5

Date
6/16/03-6/29/03

Duration
14 days

Training Dates
6/9/03-6/13/03

Duration of Training
5 days

3.2) NEEMO 6 (if funded)

Date
10/13/03-10/26/03

Duration
14 days

Training Dates
10/6/03-10/10/03

Duration of Training
5 days

4) Points of Contact

4.1) MOD

Bill Todd - Project Lead
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4.2) FCOD/CB

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4.3) SLSD

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4.4) Aquarius/NURC

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Craig Cooper- Operations Lead
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Email: craigbc@juno.com

4.5) Facilities/Participants

Surface Support Team (SST)- Consists of NEEMO Project lead, Mission Lead and support personnel. This team resides at the National Undersea Research Center (NURC) during the mission and training. Overall responsibility and authority for NASA objectives during the 2003 missions resides with NEEMO Mission Lead on this team.

Aquanaut Crew - This team consists of the four aquanaut personnel from JSC that will go in to "saturation"

Habtechs - Consists of two NURC employee/aquanauts that accompany the NEEMO crew into saturation. Their primary responsibility is the operation of the Aquarius on-board systems and for the safety of the aquanauts

"Watch Desk" - This is the NURC version of the MCC. It is located on-shore and is staffed by a team of two employees 24 hours/day during the mission. They 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.

Principle Investigators (PI's)- These individuals are responsible for developing much of the science conducted by the aquanauts. They will monitor the mission from the EXPOC or in some instances from the NURC facilities. They will periodically interface with the crew real-time during the mission to facilitate the science needs. This analog is much like the relationship JSC has with the MSFC scientists.

ExPOC- Team Leader, CAO, Capcom, Systems

5) Directorate Objectives

5.1) MOD/DT

1) Program management
2) Mission timeline development
3) Operations and Procedures development
4) Implement training

MOD/ExPOC

NEEMO-5

New objectives (some were partially completed during NEEMO-2):

1. Perform mission planning and oversight role, in conjunction with PI's and SST
2. Develop ops for facilitating PI interaction
3. Determine practical communication system capability when EVA crew is operating at a significant distance from the habitat
4. Perform role as EVA Mission Control for construction task
5. Provide generic EVA Mission Control support; track dive data and tank pressures from aquanauts during EVA's
6. Model Aquarius site grid into 3D bathymetrical map
7. Observe habitat and life support buoy "telemetry" transmitted via the life support buoy
8. Perform internal ExPOC objectives such as evaluating advanced software tools
9. As with all analog site operations, perform standard operational evaluation of ExPOC facility and processes

NEEMO-6

All of the previous objectives plus:

1. Perform expanded mission planning and oversight role, in conjunction with PI's and SST
2. Check dive plan for Aquanauts, in conjunction with SST
3. Monitor habitat and life support buoy "telemetry" transmitted via the life support buoy
4. Perform expanded internal ExPOC objectives such as evaluating advanced operations concepts, technologies, and software tools

5.2) FCOD/CB

1) Exercise teambuilding skills
2) Practice leadership, teamwork and self-care
3) Experience and cope with living conditions similar to those on ISS
4) Respond to challenges of achieving operational group objectives by maintaining their productivity and motivation while managing interpersonal issues that arise from an isolated environment

5.3) SA/Life Sciences

Spaceflight presents many risks to crew health, well-being and performance, many of which are still poorly understood or mitigated. Exposure to the microgravity environment for periods of days to months results in a number of physiological, psychological and behavioral changes, both during flight and after landing. Individually and combined, some of these changes have impaired the ability of crew members to carry out some of their basic duties and may place crew members at increased risk for discomfort, injury, or death. To anticipate and potentially mitigate these deleterious responses, the SLSD NEEMO Project has established the following objectives:

- Conduct evidence-based, operational investigations in a spaceflight-analog environment to evaluate, validate and certify countermeasures (CMs) designed to maintain optimal astronaut functional ability in- and post-flight.

- Perform a standardized set of integrated physiological and psychological tests, pre- and post- mission, termed the Clincial Status Evaluation (CSE) to examine candidate CM effectiveness and any intersystem effects.

- Resolve habitability and human factors issues to pre-determine effectiveness in flight.

- Validate and certify hardware necessary to determine the efficacy and efficiency of candidate CMs.

- Validate life sciences hardware and operational processes and procedures to pre-determine effectiveness in-flight.

- Perform ground and flight crew familiarization and training.

- Develop a dataset of physiological and psychological responses for comparison to future ground-analog studies.

- Formulate and maintain a metrics system for monitoring SLSD NEEMO Project success.

- Collaborate with other organizations involved in the development of an integrated program for future Aquarius missions.

6) Mission Tasks

The timeline and Mission Objective Requests for each mission is located at: http://mod.jsc.nasa.gov/dt/Schd/NEEMO/NEEMO.htm

6.1) EVAs

South Site (Pinnacle) Orientation Dive - Aquanaut team will visit the south site beginning at the pinnacle and transit toward the habitat. They should pay attention to all surroundings and become familiar with topography and excursions lines. Photo documentation of the team dive is suggested.

North East Site (Deep Transect, Gazebo) Orientation Dive - Aquanaut team will visit the north site beginning at the Deep transect and transit toward the habitat. They should pay attention to all surroundings and become familiar with topography and excursions lines. Photo documentation of the team dive is suggested.

S4 and 5th leg Site (including deep sands flats sweep) Orientation Dive - Aquanaut team will visit the deep site beginning at the ens of the S4 line by performing a very large circle sweep. They should pay attention to all surroundings and become familiar with topography and excursions lines. Photo documentation of the team dive is suggested.

Site Tagging DTO – The Aquanaut team will deploy a "NASA Tag" along the excursion lines which will systematically identify the location. These tags will eventually become the basis for an entire grid network of the Aquarius site and are used in conjunction with the Communication DTO.

Communication DTO - Aquanauts will test the power and clarity of the underwater comm system by venturing away from the habitat measuring their distance traveled and provide comm voice tests at given intervals. The aquanaut buddy pairs will transit to many areas on a certain site and provide voice checks, which will be documented and used to characterize the useful range of the communications system.

Construction Task - This exercise will come in five separate EVA's. During the first exercise the crew will be required to locate and transport pieces of the payload and the required tools, which will be located in another area. They will

then construct the base unit of the structure, which will be in the form of a stack built of PVC. For the second EVA, the buddy pair will construct the truss part. The third EVA will have the buddy team construct the antenna and connect cables. The fourth EVA will have them construct the solar array and cable connections. The fifth EVA will be waterlab teardown.

Coral Science - Aquanauts will perform tasks associated with data collection on the coral reef. This will involve the setting up of transect lines perpendicular to the excursion lines and measuring the size and health of the coral. Each coral will be photo documented and the results compiled and given to NOAA.

Night Dive - Dive at night to experience different techniques. Depart habitat during sunset and dive during nighttime conditions using specialized techniques and equipment.

Dawn Dive - Dive during sunrise experience changing environmental conditions. Depart habitat .5 hours before sunrise and witness changing conditions.

EVA Considerations:

1) Location of Dive teams
2) MCC Support
3) Priority of task
4) Skill level/difficulty
5) Chance of slip

6.2) Outreach

Educational Outreach - provide an opportunity for the crew on board Aquarius to connect with students at museum and science centers who have completed a prerequisite education challenge in order to participate in the event. The videoconference will connect up to 6 different museum/science centers to the crew on board Aquarius. To provide an opportunity for the crew on board Aquarius to connect with students from around the globe using the Internet as the medium for delivery.

6.3) Life Sciences

Actiwatch – The purpose of this MOR is to assess sleep latency and sleep efficiency using the Actiwatch® - a device used to record sleep/wake activity. The crew will wear the watch on their non-dominant hand while keeping a record of their activities, including sleep.

Bacterial Detection – The objective of this study is to analyze daily swab samples from various areas of the habitat with an automated real-time monitor of

bacterial endotoxin. These results will be correlated with advanced microbial analysis of the same samples in a laboratory following the mission.

In-suit Doppler – This MOR will evaluate the hardware developed to monitor crewmembers during and/or after EVA for nitrogen bubble formation and provide an early warning for the possibility for decompression sickness. Crewmembers will be asked to don the device immediately after returning from a dive (the device cannot be worn in the water), and wear it for 2-4 hours.

Physiologic Monitoring – The purpose of this MOR is to evaluate the usefulness of wireless medical monitoring devices inside a metal-walled habitat, and procedures that rely on such devices. The monitoring devices consist of non-invasive sensors that attach to the torso and wirelessly transmit data to a laptop.

Clinical Nutritional Assessment – The objective of this MOR is to assess the impact of the NEEMO analog on dietary intake and nutritional status, and provide preliminary information on interactions between nutritional status and immune function. Two key areas are hypothesized as being affected by this environment: stress-induced alterations in energy and protein utilization, and pressure-induced changes in bone and calcium metabolism. This is a modified version of the Clinical Nutritional Assessment Profile (MR016L) performed on station crewmembers.

Otoacoustic Emissions – This study has two purposes. The first is to evaluate otoacoustic hearing assessments as a screening tool to assess vulnerability to barometric pressure related hearing loss. Otoacoustic emissions are an objective, noise-tolerant technique and so are well suited for use in operational environments. The second is to validate the procedures and verify the repeatability of self-administered tests in an operational setting. These data are important for completing the planned otoacoustic emissions measurements on ISS successfully.

Portable Ultrasound – This MOR will evaluate the effectiveness of the SonoSite (portable ultrasound device) as a diagnostic tool for crewmembers in remote environments with minimal ultrasound training. This device will be used in a simulated medical event, during which time the crewmembers will communicate real-time with physicians in the ExPOC.

Habitability Assessment – The objective of this activity is to evaluate the Aquarius from the human factors and habitability perspective as an isolated, confined analog for ISS, and to determine the human factors and habitability requirements for such an isolated and confined analog, and identify potential enhancement for the next generation habitat.

Magic Windows – This MOR will gather information about current displays and determine additional needs and identify usability issues through a small survey

and possibly test of a procedure (medical or maintenance task) with a head mounted display and normal procedure format.

STARx - This is a software application developed for portable, hand-held devices (i.e. Palm) that is intended for use by astronauts as a therapeutic monitoring tool while on board the shuttle and for use during ISS missions. Crewmembers will be asked to evaluate the functionality and user-friendliness of STARx and ARES ™ software using the Palm PDA handheld computer.

Latent Viral Shedding in Small Isolated Groups – The purpose of this study is to study the effects of social and work stresses on viral shedding and immune function within the social context of the Aquarius habitat, and to compare those results with data from groups isolated in other extreme environments. Investigators will attempt to determine if subjects undergoing stress in a ground-based analog of space flight have the patterns of viral reactivation seen in astronauts.

Wound Healing – This MOR will evaluate the procedures written for the digital still camera used on orbit (the DCS 760) and the ability to interpret data the transmitted images from the ExPOC. The images will track the healing process of wounds incurred by crewmembers during nominal EVA/dive activities.

7) Mission Priorities:

The following is a list if the major activities scheduled for the missions. This priority will be used in the event of mission activity re-planning due to any circumstance.

CAT. 1-

South Dive (Pinnacle) Orientation Dive EVA

North East Site (Deep Transect, Gazebo) Orientation EVA

S4 Site, 5th leg (Including deep sand flats sweep) Orientation EVA

Photo/Video in and around Habitat

All Life Sciences, including

- Actiwatch
- Bacterial Detection
- In-suit Doppler
- Physiologic Monitoring
- Clinical Nutritional Assessment

Otoacoustic Emissions

Portable Ultrasound

Habitability Assessment

Magic Windows

STARx

Latent Viral Shedding in Small Isolated Groups

Wound Healing

CAT. 2-

Construction Task EVAs

Communication DTO/ Site Tagging EVAs

Coral Science EVAs

Educational Outreach Web Cast connection

CAT. 3-

Crew Habitability Assessment

Communication linkup with ISS
Dawn Dive EVA

Educational Outreach Museum/Science Center Connections

ExPOC/Aquarius Test Call

Night Dive EVA

8) Mission Objectives

Specific mission objectives are documented in the NEEMO Mission Objective Request, or MOR. These MOR's are a collection of objectives from each of the directorates, which include DTO's, DSO's, in-habitat and in-water science, daily tasks, educational outreach events and media activity. Basically, any task that is time-lined is first submitted on a MOR. Refer to all of the MOR's at http://mod.jsc.nasa.gov/dt/Schd/NEEMO/NEEMO.htm

9) Crew Composition

NEEMO 5

Peggy Whitson - CB (CDR)
Clay Anderson - CB
Garrett Reisman - CB
Emma Hwang - SLSD

NEEMO 6

TBD - CB (CDR)
TBD - CB
TBD - CB
TBD - SLSD

10) Core Crew Requirements/Prerequisites/Selection

Aquanaut selection processes will be coordinated and accomplished by individual directorates who may have additional requirements. However, all potential candidates must meet all of the following requirements. If a candidate does not possess the minimum of 25 dives, the NEEMO Project Manager will have sole authority to determine whether or not the candidate can participate. This assessment may include an evaluation of the candidate's diving skills and a waiver. In the case of other deviations from the following requirements, the NEEMO program manager will be the ultimate authority. Requirements include:

1) Candidate must be in good physical condition and be able to participate in strenuous activity.
2) Candidate must be able to successfully pass an Air Force Class 3 physical.
3) Candidate may not have had RK eye corrective surgery
4) Candidate must be comfortable in confined areas and in staying in the water for extended periods
5) Candidate must hold a minimum of Open Water Diver Certification from a
5) national agency such as PADI, NAUI or YMCA
6) Candidate must have logged a minimum of 25 dives (this requirement can be waived if assessment of diving skills is completed)
7) Candidate must be able to dedicate 3 weeks to a mission and training. Also, Candidate will have to dedicate occasional time (several days /month) prior to the mission for medical and safety training
8) Candidate must have specific knowledge or a skill set appropriate for mission and NEEMO program objectives.

11) Crew Documentation and Information

All aquanauts will be provided with a set of documents for review including a mission plan, an aquanaut guidebook, a procedures document, MOR's, science briefings and an Aquarius Operations Manual. They will also be given maps of the Aquarius site and schematics of the on-board systems. Most of these documents are located and maintained at http://mod.jsc.nasa.gov/dt/Schd/NEEMO/NEEMO.htm

12) Training Required

Each aquanaut will undergo 5 days of training at the NURC. This training will include lessons in underwater navigation, equipment familiarization, self-survival techniques, site orientation, systems overview and safety practices. Lessons may also be presented concerning science objectives and test objectives. Prior to the NURC provided training, candidates will participate in a dive training trip, receive training in O2, CPR and first aid at JSC in addition to science specific training and baseline data collection.

13) Mission Plan and Products

The mission plan is developed using Mission Objective Requests (MOR's) provided by Principle Investigators in the NEEMO Working Group. This group will review the timeline with the crew prior to the mission. The timeline will detail opportunities for EVAs, contact w/MCC, PAO and education outreach and daily housekeeping activities. This timeline will be maintained and updated real-time during the mission. Daily Summaries will be written for the crew and a Topside Status Report will be written for members of the NEEMO working group and management.

14) Detailed Test Objectives (DTO's) and (DSO's)

The in-water DTO for all of the missions will concern the field evaluation of a set of underwater facemasks and dive communication gear, which will be used for data collection and construction activities. Aquanauts will be given training on this equipment during the training period at NURC. The Principle Investigator of this DTO is Mr. Karl Shreeves, Diving Science and Technology (DSAT) (See MOR)

15) Educational Outreach and Public Affairs

Outreach events are planned and will be supported by:
NASA Educational Outreach POC - Susan H. Anderson
Distance Learning Outpost – Sherri Jurls
NASA Quest POC - Lori Keith

Public Affairs events are planned and supported by:
Public Affairs Office - Kelly Humphries