Underwater Environment Used to Simulate Moon's Gravity in Development of Next-Generation Spacesuit

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What is the optimum design for a spacesuit planned for lunar expeditions? How does the center of gravity and weight of the suit affect an astronaut's mobility, performance, and safety? How do you simulate the lunar environment on Earth?

These are all questions being answered by Johnson Space Center's Space and Life Science Directorate using a combination of facilities and analog environments with the goal of designing the next-generation spacesuits. The effort is being led by the Extravehicular Activity (EVA) Physiology, Systems and Performance Project to understand medical safety and human performance issues related to working in partial-gravity environments. The Neutral Buoyancy Laboratory (NBL) provides a safe and predictable environment for such tests. The facility is usually used for zero-gravity training to prepare for spacewalks on the space shuttle and International Space Station, but by adjusting the weight system and using specially designed hardware, astronauts are able to use the 6.2-million-gallon pool to simulate the Moon's surface and potential lunar outpost activities.

The Neutral Buoyancy Laboratory (NBL) from above.

Investigation Description

Subjects don coverall suits, a specialized backpack, and the NBL's Surface-to-Surface Diving System, which allows for two-way communication with the test conductors on the surface. Weight is added to the suits to simulate lunar gravity, and the backpack can be adjusted to simulate various center of gravity configurations. The subject then performs a series of tasks similar to what will be required when living and working on the Moon. Tasks include walking, hopping, running, shoveling lunar soil, climbing a ramp, picking up rocks, recovering from a fall, and climbing a ladder.

A unique combination of specialized equipment is used for the data collection during the study at the NBL. An underwater motion and force measurement system has been developed, using existing facility cameras, Hydroflex underwater lights, force sensors, and the coverall suits, which have been modified to add Ping-Pong balls at the subject's joints to track movement. A modified Cooper Harper rating scale is also used to assess the crew member's level of effort and comfort during each task. The motion measurement data, biomechanical modeling results, digital video, force

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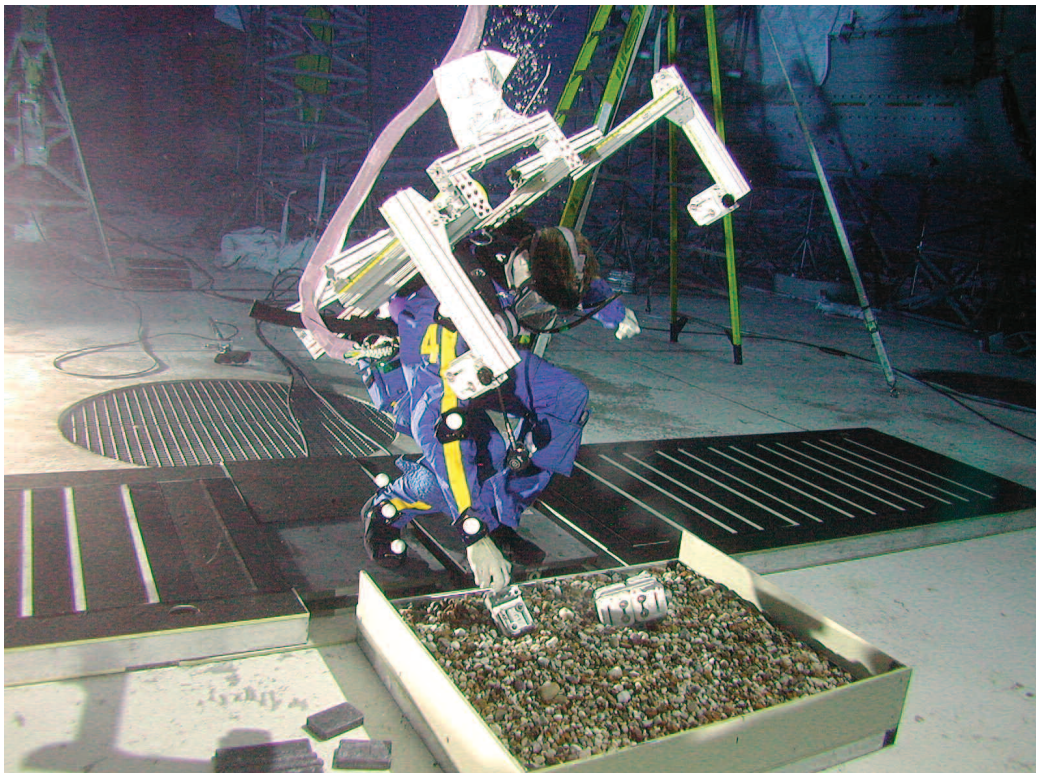
continued

Subject descends ramp at bottom of NBL.

plate, and other data will be compared with the results from ongoing studies performed at other analog environments such as NASA Extreme Environment Mission Operations missions at the National Oceanic and Atmospheric Administration's Aquarius habitat and C9 parabolic flights.

Results

The results of the NBL test will include validated biomechanics and center of gravity data as well as rationale for the optimal center of gravity location for the future lunar spacesuit. The goal of this research is to develop countermeasures, knowledge, technologies, and tools that will enable safe, reliable, and productive human space exploration during EVA activity.



Subject performs pick-up task to evaluate center of gravity impact.