Water Egress and Survival

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A requirement for the Orion crew module (CM) to splash down in the ocean brought back some old training requisites to the Johnson Space Center (JSC) Mission Operations Directorate (MOD). In typical training scenarios the crew and support personnel practice crew egress procedures under various configurations and conditions. In the past, we trained crews in full-scale trainers both in pool settings and in open water. When the new training requirement surfaced, we took a fresh look at how this might be accomplished.

Some things have changed in the past 40 years, and two notable changes are NASA's tighter budget constraints and the added availability of the JSC Neutral Buoyancy Laboratory (NBL) in which NASA astronauts train for extravehicular activities (figure 1). A study examining the cost of providing a ship that could routinely take the 18,000-lb. CM and a large test team out to sea portended significant budget challenges. Cost is clearly a big disadvantage in this scenario.

Fig. 1. *The JSC NBL.*

Another big disadvantage to training offshore is the unpredictability of the weather. Bad weather can lead to cancelled tests, and in flat water one may as well be in a pool. Astronaut's schedules are very tight in the year prior to launch, and changing them has a negative ripple effect. We thus proposed an alternative to open water testing in which a large mass located underneath the floor of the crew compartment would be manipulated to displace the center of gravity (c.g.) and generate motion in the controlled environment of the NBL. Being able to generate motion is critical in that it trains and prepares crews to perform tasks under very difficult conditions. Although the proposed concept will not produce the heave and surge found in nature, it could reliably provide very challenging conditions. The concept of an "active" trainer proved both financially appealing and practical from a training and scheduling vantage point.

NASA decided to pursue the active trainer concept by prototyping a one-quarter-scale model. The first obstacle to producing this one-quarter-scale model was a lack of data regarding how Orion would behave in the water environment. Up to this point a land landing had been nominal and was getting most of the program's attention. The one-quarter-scale model, the Water Egress and Survival Trainer-Prototype (WEST-P), was subsequently built by MOD and caught the attention of the Orion Program (figure 2).

Fig. 2. *The one-quarter-scale WEST-1.*

The Orion Program funded extensive testing of the WEST-P by the U.S. Navy at the Naval Sea Systems Command/ Carderock tow tank and by the U.S. Army at the Aberdeen Test Center large outdoor wave-generating site (figure 3). We used generated test data to make recommendations for flight vehicle sizing and placement of sea anchors, tow/ winch attach points, and flotation collars. We also assessed sea-keeping characteristics in rough waves up to 6 m high. Testing of the one-quarter-scale model showed that the WEST-P would make for a very uncomfortable ride. This suggests that rather than using a relatively large mass to manipulate the WEST-P c.g., we might use a small mass to excite motion at the resonant natural period (figure 4).

Fig. 3. *WEST-P at the U.S. Army's Aberdeen Test Center.*

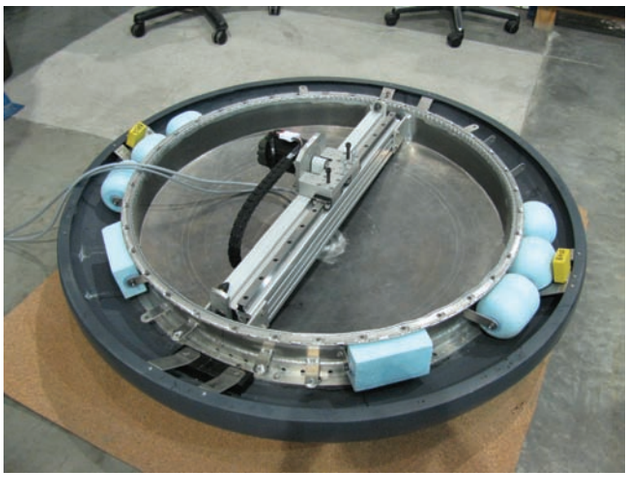

Fig. 4. *WEST-P with linear stage installed.*

The reduced component sizing and lower energy requirements of the resulting design provide benefits throughout the systems. Within the sealed, watertight test article are 24-Vdc lithium-ion batteries powering a brushless servomotor-driven linear stage controlled by a field-programmable gates arrays real-time controller using encoder slide position feedback and rotational velocity feedback from an inertial measurement unit. An ultra-mobile personal computer interfaces to the internal equipment and communicates via a wireless router to the outside world using Windows Remote Desktop.

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