First-generation Suit Port Development and Testing

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Introduction

The Lunar Electric Rover (LER), formerly called the Small Pressurized Rover, is an integral part of the current lunar surface architectures under consideration in the Constellation Program. The LER is intended to optimize human safety and performance in planetary exploration by combining a comfortable shirtsleeve, sensor-augmented environment for gross translations and geological observations with the ability to rapidly place suited astronauts on a planetary surface via the suit port. Each LER incorporates two suit ports that enable rapid egress to a planetary surface to take full advantage of human perception, judgment, and dexterity in an extravehicular activity (EVA) suit and rapid ingress to the shelter of the LER in response to solar particle events, suit malfunctions, or medical emergencies. The suit ports also enable single-person EVA operations. Figure 1 shows the 1g LER mockup.

Fig. 1. *The 1g LER mockup.*

NASA developed a two suit port deliverables in fiscal year (FY) 2008: an aft bulkhead mockup for functional integrated testing with the 1g LER mockup, and a functional and pressurizable engineering unit (EU). This included the development effort for both of the deliverables, with support from NASA Ames Research Center (ARC) for initial suit port concepts and fabrication and testing of the EU and from NASA Langley Research Center for fabrication of the aft bulkhead structure.

Aft bulkhead mockup

We integrated the suit port aft bulkhead mockup with the mockup of the LER cabin and chassis. This mockup, located on the aft bulkhead of the LER cabin structure, includes hatches, a locking (Marman) mechanism, seals, interior and exterior suit don/doff aids, and exterior platforms to accommodate different crew member heights. A lightweight mockup of the Mark III suit was tested with the suit port aft bulkhead mockup. As there are several limitations to the suit port and mockup suits, results of the suit port evaluation need to be interpreted within the context of the limitations. Figure 2 shows the aft bulkhead mockup with suits attached to the suit ports, and figure 3 shows the aft bulkhead mockup from inside the LER cabin.

Fig. 2. *Aft bulkhead mockup with Mark III mockup suits attached to suit ports.*

Fig. 3. *View of aft bulkhead mockup from inside LER cabin.*

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At the Desert Research and Technology Studies at Black Point Lava Flow, Ariz., we tested the 1g LER mockup in October 2008. Overall, the LER met all necessary objectives in terms of human performance and crew accommodations. It adequately supported EVA operations through the use of suit ports and operational support for the EVA crew member; however, redesign of the suit port mechanism controls and external alignment guides to be more easily operated could further increase performance and productivity. We found no issues with the internal cabin volume for suit donning and doffing, but minor improvements were suggested for internal access to the suit port and general operations. Test subjects showed that the suit port concept was practical, viable, and a highly efficient way to perform EVA operations from the LER.

Engineering unit

The EU is a fully functional and pressurizable unit for testing the sealing interface between the LER and the suit. It consists of a pressure vessel with an inner hatch to simulate the LER cabin at 8 psi, an interface plate representing the interface between the suit and suit port (but the suit pressure is not represented), the locking (Marman) mechanism clamping the interface plate to the pressure vessel, and the seals (inflatable seals that close up the gap between the interface plate and the pressure vessel; lip and O-ring seals that prevent leakage between the cabin volume and the interspace/exterior; and dynamic seals around the shafts of the actuators passing through holes in the walls of the pressure vessel). Suit don/doff aids are not included in the EU. Figure 4 illustrates the EU conceptual design.

The EU is being assembled at ARC for design verification and operation and functionality testing. Operation and functionality testing examines the locking and sealing interface between the suit port and the suit interface plate per the operational concept. For testing, the EU is reconfigured to simulate the different phases of suit port operations; its internal volumes are pressurized to create the pressure differences that would occur during real operations. However, testing will be at ambient, not in a vacuum chamber.

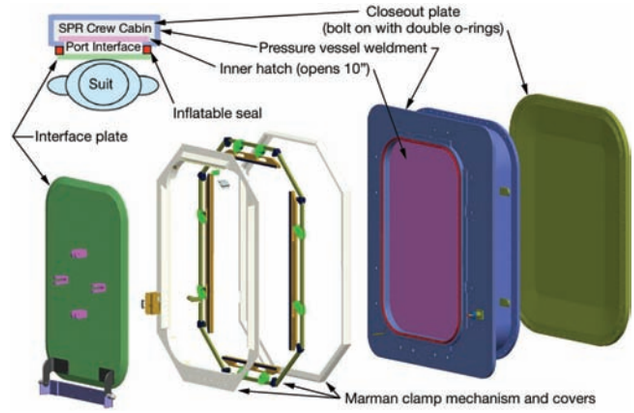

Fig. 4. *EU conceptual design.*

Figure 5 illustrates the four phases of suit port operations that will be tested. Configuration 1 represents the suit port configuration when the suit is ready for donning (cabin and interspace would be at 8 psi). Configuration 2 represents the case when the crew has donned the suit but has not depressurized the interspace or detached from the suit port (cabin and interspace would still be at 8 psi). Configuration 3 represents when the interspace has been depressurized to 0 psi, the pressure that would be achieved prior to operating the locking mechanism and detaching for an EVA. Configuration 4 represents the LER after the suit and interface plate are detached from the suit port. Pressure differentials and leak rates will be measured.

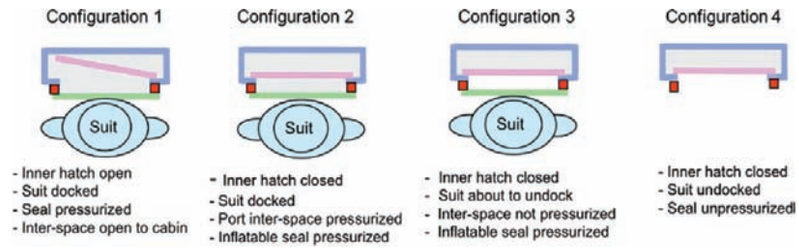

Fig. 5. *Suit port operational configurations.*

Conclusion

Testing of the suit port aft bulkhead mockup showed that with some minor modifications, the suit port concept is practical, viable, and a highly efficient way to perform EVA operations from the LER. The second-generation suit port will use electromechanical actuators to lock the suit to the suit port, thus being less fatiguing on the crew member. It will also incorporate an aft enclosure for the suits to protect them from the environment.

After operation and functionality testing is complete, the EU will undergo dust and vibration testing.

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