46th STUDENT CONFERENCE (E2)
Student Team Competition (3-GTS.4)

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DEVELOPMENT OF AN EXPANDABLE AIRLOCK FOR A MARTIAN SETTLEMENT

Abstract

With the recent expansion of space exploration industry, there is an opportunity to develop technologies and structures to sustain human life on other planets. Our team has researched and designed a functional, expandable airlock with assembly and testing currently underway for a full-scale prototype. The airlock is designed to survive in the Martian atmosphere: satisfying the pressure difference of 1 atm as well as temperatures below 173 K. A multilayered metallocene polyethylene (mPE) membrane was selected since it meets all design requirements for flexibility, sealability, and impermeability at these conditions. Physical and analytical prototyping supports the use of this commercially available product. Furthermore, an innovative system of ultra-high-molecular-weight polyethylene (UHMWPE) ropes create a lightweight flexible structure that can safely withstand 1 atm of gauge pressure. A door has been designed to distribute roughly 200 kN of force to the frames of the structure while implementing a dynamic seal. Redundancy is integrated through all major systems, including structural layers, airtight seals, and electrical sensors. Electronic airlock systems are controlled by interconnected, off-the-shelf microprocessors and sensors. In total, the expandable airlock weighs 336 kg. Improvements to the design and further areas of development are explored: Optimization of the aluminum frames, door, and base could enable significant reduction of mass in non-critical areas. The dynamic seal should be followed up with reliability testing in expected environmental conditions. Lastly, improved floorboards would ideally fold into a smaller area, and passive actuators would be designed to work at worst-case temperatures without constant heating. Overall, our team's work demonstrates a practical approach to create expandable airlock modules, which could find use on initial human expeditions to Mars. Through research and development of pioneering space technologies, future generations will be increasingly prepared for Mars missions and establishing other permanent space habitats.