30th IAA SYMPOSIUM ON SPACE AND SOCIETY (E5)
Space Architecture: Habitats, Habitability, and Bases (1A)

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NASA CENTENNIAL CHALLENGE:THREE DIMENSIONAL (3D) PRINTED HABITAT, PHASE III COMPETITION OUTCOMES

Abstract

NASA's Centennial Challenges program uses prize competitions with the singular goal of accelerating innovation in the aerospace industry. Competitions in the Centennial Challenges portfolio have previously focused on advancements in space robotics, bioprinting, astronaut suit design, small satellites, and solar-powered vehicles. NASA's 3D Printed Habitat Centennial Challenge represents a partnership between NASA and the non-profit Bradley University, with co-sponsors Caterpillar, Bechtel, Brick and Mortar Ventures, the American Concrete Institute, and the United States Army Corps of Engineers: Engineer Research and Development Center to spur development in additive construction technologies.The challenge asks teams to design and construct a Martian habitat using indigenous materials and large scale 3D printing systems. Phase I of the competition, held in 2015, was an architectural design competition for habitat concepts that could be 3D printed. Phase II, completed in 2017, asked teams to develop feedstocks from indigenous materials and polymer recyclables and demonstrate printing systems to manufacture these feedstocks into test specimens to assess mechanical strength. This paper will discuss the phase III competition, focusing on technology outcomes that can potentially be infused into both terrestrial and planetary construction applications.The phase III competition was divided into two sub-competitions: 1) virtual construction, where teams created a high fidelity building information model (BIM) of their 3D-printed habitat design and 2) the construction competition, which required teams to 3D print a foundation and subject samples to freeze/thaw testing and impact testing (level 1), produce a habitat element and complete a hydrostatic test (level 2), and additively manufacture a 1/3 scale habitat onsite in a head to head competition at Caterpillar's Facility in Peoria, Illinois over the course of three days (level 3). While the phase II competition focused primarily on development of novel feedstocks and robotic printing systems, phase III emphasized the scale-up of these systems and autonomous operation (demonstrating the capability to operate systems on precursor missions prior to the arrival of crew or terrestrially in field operation settings where human tending of a manufacturing system may be limited).

The phase III virtual construction levels yielded a number of novel habitat designs, including both modular habitats and vertically-oriented habitat concepts and the construction competition has also challenged teams to autonomously place penetrations and interfacing elements in additively manufactured structures.The paper will emphasize potential applications for the new materials and technologies developed under the umbrella of the competition and in Earth-based applications such as disaster response and infrastructure improvement.