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PROTOTYPING MARSHA:
DISCOVERIES, SURPRISES AND LESSONS IN ADDITIVE HABITAT CONSTRUCTION

Abstract

If we are to permanently settle Mars, we must be able to construct homes larger than entry, descent and landing (EDL) limits allow. In addition to the addressing challenges common to all pressurized structures, homes on Mars must be designed around human occupants, whose mental health and performance is mission-critical. To achieve adequate space for sustained well-being, in-situ additive manufacturing using locally sources materials will be needed.

On Febraury 1st 2019, AI SpaceFactory was one of only four teams awarded among six who submitted entries to Phase 3.3 of the NASA 3D Printed Habitat Challenge, placing 2nd overall on the basis of 3D-printed samples that were tested for their ability to hold a seal, for strength and for durability in temperature extremes. The team has been awarded 109, 000*byNASAtodate*.

In contrast to other teams, which used concrete as their construction material, AI SpaceFactory opted to formulate a novel polymer that leverages in-situ resource utilization (ISRU) technologies. The material is a blend of chopped basalt fiber, abundant on Mars in the form of volcanic rock deposits, and polylactic acid, a biopolymer (non-petrochemical) that can be recycled from mission waste and generated biologically from agricultural waste. Our polymer was tested by a third-party lab and proven to outperform concrete in all relevant metrics including superior tensile and compressive strength, superior durability under extreme temperatures and higher ductility. It also promises superior cosmic radiation absorption and thermal resistance.

Once validated, it was only nine weeks until AI SpaceFactory progressed from basic tests to successfully printing, in 24 hrs, a large upright cylinder (2m(d) x 1.5m(h) at t=25mm) designed to hold twelve-hundred gallons of water. The final product included prefabricated wall penetrations robotically placed and sealed "on the fly", an early global example of this feat.

Along with way, lessons were learned that merit the attention of industry technologists in the quickly maturing field of in-situ construction. Among them are insights about the inter-relationship between robot speed, tool speed, material temperature, bead size, auger speed and dimensional stability. In finished prints, the strength of inter-layer bond proved critical, yet inconsistent. Accidents led to discoveries that illuminate possible low-level solutions to challenges such as shrinkage and geometric distortion, which plague thermoplastics in particular. While some flagship challenges of additive construction remain unresolved, the team's efforts hint at promising, lasting solutions.