Tubular Truss Additive Manufacturing Lunar Utility Tower

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1. Introduction

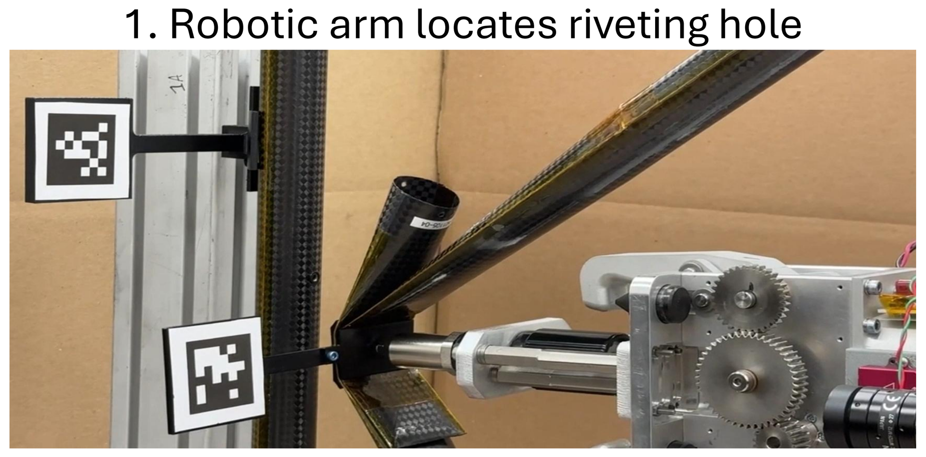
Summary. Tubular Truss Additive Manufacturing (TTAM) provides a robotic assembly solution for constructing large structures on the lunar surface and in orbit. TTAM utilizes a robotic riveting mechanism and Opterus's Trussed Collapsible Tubular Masts (TCTMs) and Recirculating Belt Deployers (RBDs) to autonomously deploy and assemble trusses.

Material Composition. The TCTM booms are constructed with High-Strain Composite (HSC) materials, made from fiber-reinforced polymers, which have a greater strength-to-weight ratio and a lower coefficient of thermal expansion than metal-based alternatives. HSC materials enable TCTM to be rolled and stowed with exceptional packaging efficiency; enough material to assemble a 100m truss can be packaged into a volume less than $1m^3$.

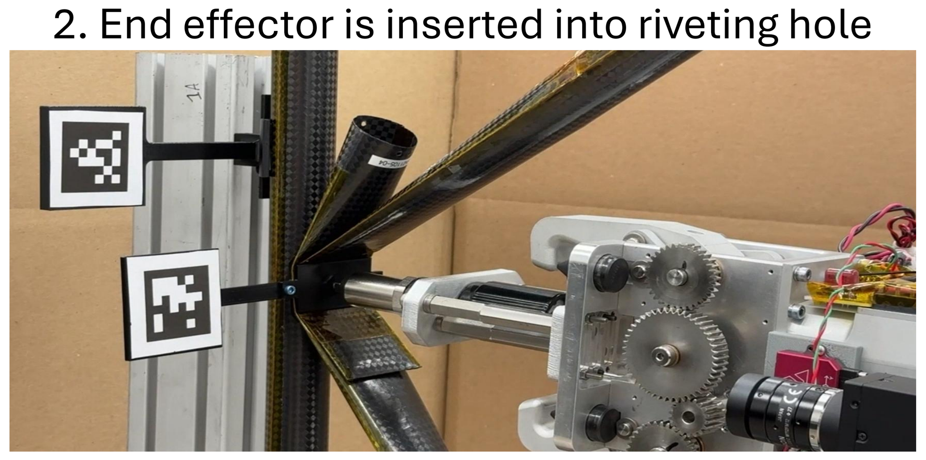
Performance. Opterus TCTMs are thin-walled collapsible tubes that provide truss-like strength and stiffness while maintaining extremely high packaging efficiency and low manufacturing costs. By joining TCTMs into a truss, the structural efficiency increases further, significantly outcompeting similar architectures in stiffness, strength, and mass efficiency. A baseline architecture has been developed, and the design is customizable to suit specific applications and capabilities. The TCTM cross-sections and truss dimensions are scalable to support various loads and lengths.

2. Deployment Process

1. Robotic arm locates riveting hole



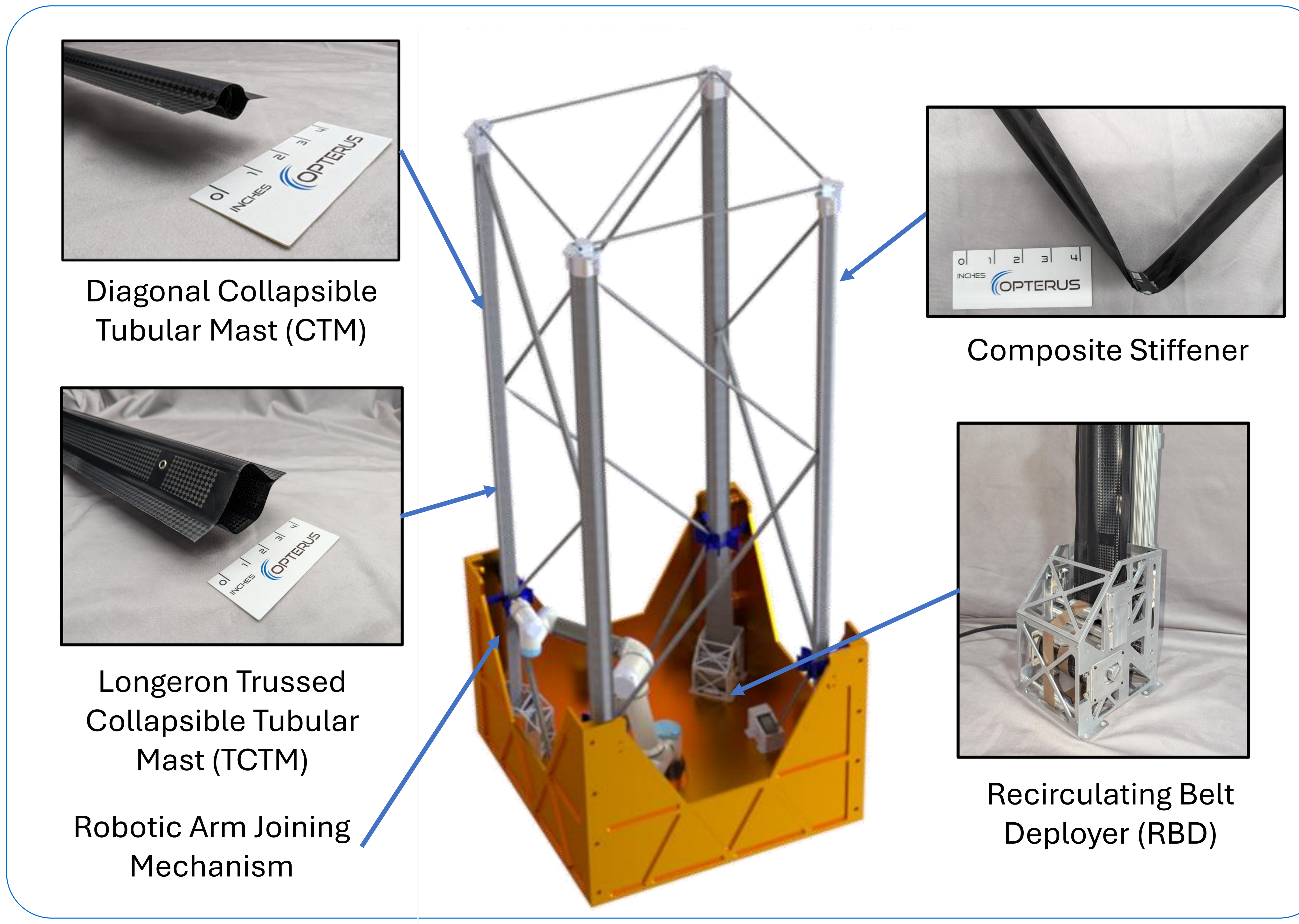
2. End effector is inserted into riveting hole



3. Robotic arm guides diagonal to junction and rivet is engaged

Robotic Assembly. TTAM uses low-power RBDs to unfurl longeron and diagonal TCTMs and a robotic mechanism to join the trusses with rivets. During the TCTM manufacturing process, holes are placed incrementally along the length of the booms. The edges of the holes are reinforced with composite stiffeners on the diagonal booms and metal grommets on the longeron booms to prevent the composite fibers from fraying and provide a rigid backing for the rivet clamping force. As booms deploy, the robotic mechanism identifies hole locations with visual tags, limit switches, or conductive strips and inserts rivets using its end effector. Because of the compliant nature of the TCTMs, the robotic arm can correct alignment errors between the diagonal and longeron booms by adjusting the diagonal boom position.

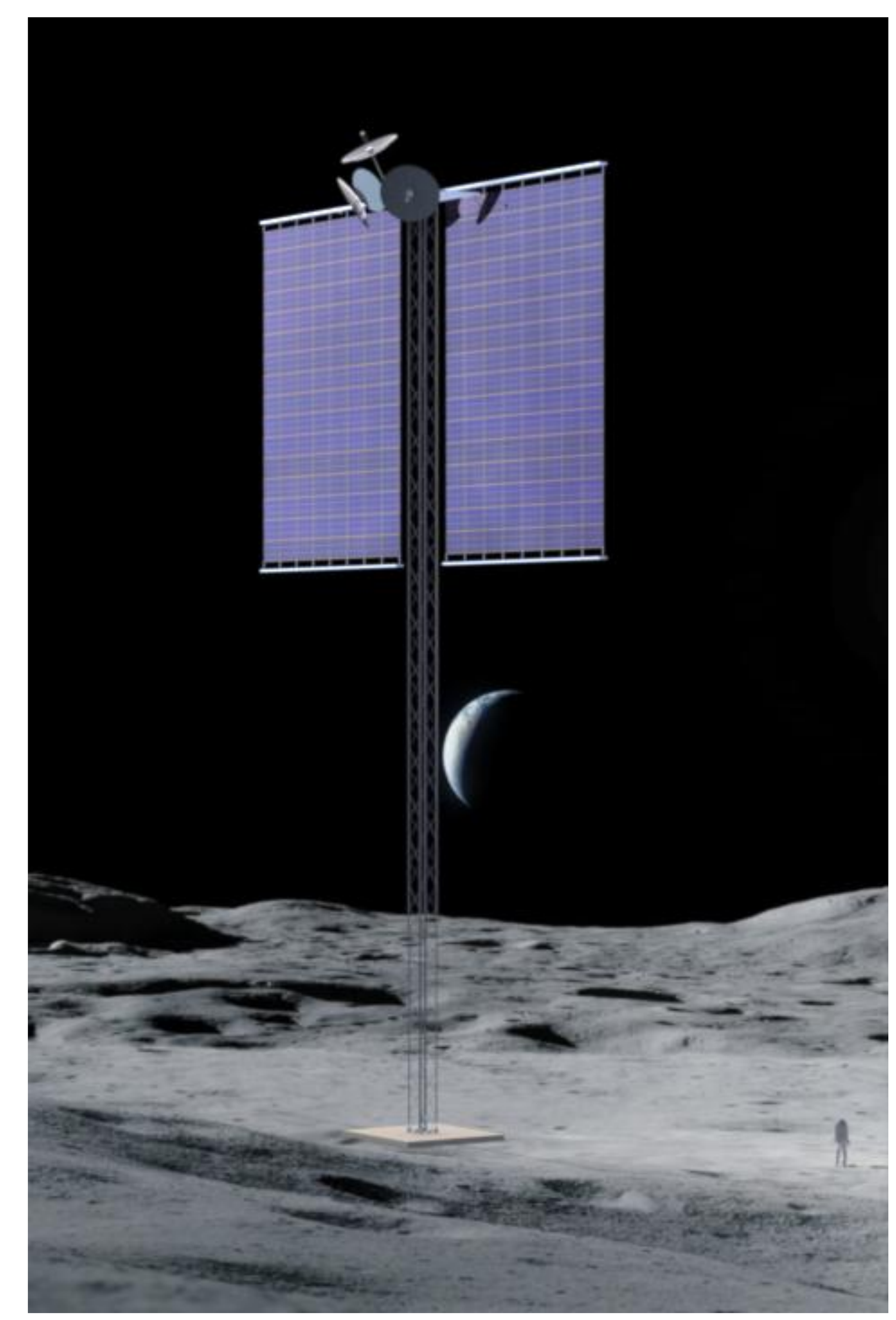
Demonstrations. In collaboration with the NASA Jet Propulsion Laboratory robotics team, the riveting process was successfully demonstrated in a laboratory environment. This demonstration utilized visual identification methods and a robotic end effector to align the riveting holes on the diagonal and longeron booms and apply a rivet.



3. Applications and Outfitting

Impact. Once assembled, a TTAM tower can support various equipment, including photovoltaic arrays for power generation, communication and power beaming systems, light-reflecting mirrors for heat directing and spotlighting, and research equipment such as imaging and sampling instruments.

Development. Concepts for a fully outfitted tower have been generated. Electrical wiring can be co-cured into the TCTM laminate or threaded through the hollow cross-section. The composite materials have a near-zero coefficient of thermal expansion and provide thermal protection to the wiring, preventing excess expansion and contraction along the tower's height. Additionally, removable fasteners or magnets can be used at truss junctions to enable the truss to retract for servicing and relocation.



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