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Author: Dr. Clyde Webster
Crest Robotics, Australia

Mr. Albert Rajkumar
University of Adelaide, Australia
Dr. Jan Golembiewski
Australia
Mr. Gregory Hunter
Australia

PIONEERING AUTONOMOUS EARTH-BAGGING CONSTRUCTION FOR A SUSTAINABLE LUNAR FUTURE

Abstract

This paper introduces 'Charlotte,' a spider-like robotic system developed by Crest Robotics in partnership with Earthbuilt Technologies and brought to space by the Lunar Construction Collective (LCC). Designed to autonomously construct protective earth-bagged structures on the lunar surface, Charlotte leverages in-situ resource utilization (ISRU) by using lunar regolith, minimizing reliance on Earth-supplied materials. By automating earth-bagging, a construction method historically limited to human labor, Charlotte lays the groundwork for sustained lunar exploration by providing scalable infrastructure essential for robotic storage, supply depots, and future human activities on the Moon.

With its early history in military applications, the strategic use of earth-bagging lies in its simplicity, efficiency, and sustainability. It enables rapid creation of robust, radiation-resistant storage areas and shelters using unprocessed regolith and geotextile encasement, eliminating the need for material processing or energy-intensive operations. As the regolith remains unprocessed, the material can be reclaimed and reused, making earth-bagging ideal for semi-permanent structures that can be adapted or relocated as mission needs evolve. These initial storage and staging structures are crucial for early robotic missions, offering protection from the extremes of the lunar environment, and helping to mitigate exposure to dust created during lunar activities. Establishing such logistics hubs reduces operational risks and ensures that more complex systems, like mass-scale 3D printers for human habitats, can be safely deployed and maintained.

At the core of Charlotte's capability is the Earthbuilt Extruder, enabling continuous regolith extrusion and compaction for rapid construction. The robot's adaptive locomotion system ensures reliable operation on uneven lunar terrain. Charlotte is a concert of capabilities from LCC members including an MP Space space-rated battery system, a dynamic Ethercat-based control backbone from Arbite Robotics, and advanced AI-enabled state-estimation from Deneb space that facilitates high autonomy and precision. Charlotte directly supports the vision of NASA's Moon-to-Mars Planetary Autonomous Construction Technologies (MMPACT) team by providing critical storage and staging infrastructure for mass-scale robotics, fundamental to building complex human habitats. To advance this goal, the LCC will formalize partnerships at IAC 2025 with commercial entities collaborating with NASA's MMPACT initiative. This aligns Charlotte with the Moon-to-Mars infrastructure roadmap, positioning it for interplanetary applications, including Mars exploration.

Supported by the NSW Government's Space+ Program, this research targets TRL6, with a fully operational prototype to be unveiled at IAC 2025, providing the global space community with an exclusive

preview of Charlotte's capabilities in enabling sustainable, autonomous lunar construction and scalable storage solutions.