Unlocking the Value of the Moon with New, Innovative Solutions. Matthew Kuhns, Vice President of Research and Development at Maten Space Systems, 1570 Sabovich St, Mojave, CA, 93501 (Contact: mkuhns@masten.aero)

Introduction: The Moon offers a tremendous amount of value for humans right here on Earth. The first samples brought back from the Moon during the Apollo era changed the way we thought about the solar system, the history of Earth, and our place in the universe, and there's still so much science to uncover. From an environmental perspective, the Moon offers an abundance of resources, such as water, oxygen, and rare-Earth metals, that can be used to produce fuel, support manufacturing needs, and unlock new commercial applications. And from an economic standpoint, the global space market is expected to exceed $1 trillion and drive millions of high-paying jobs.

The Moon is also the gateway to our solar system. It has a harsh environment that we have to solve for before we can explore further into the solar system.

So how do we unlock the value of the Moon and beyond? We must find solutions to mitigate hazardous lunar dust, survive the cold lunar night, navigate the lunar surface, and utilize lunar resources. Masten Space Systems is playing a key role in building new, innovative technologies to solve these pressing challenges and unlock the value in space for humans on Earth.

Mitigating Lunar Dust: Razor-sharp regolith caused by robotic and human landers is a major challenge for the future of space exploration. This dust can damage landers, payloads, surrounding infrastructure, and even pose a hazard to astronauts. Masten is solving this challenge with an in-Flight Alumina Spray Technique (FAST) that creates instant landing pads by injecting ceramic particles into a rocket engine nozzle and building up a coating over the regolith prior to landing. This approach minimizes harmful dust particles and enables more landing locations for complex lunar, Mars, or asteroid missions.

Following a Phase 1 NASA Innovative Advanced Concepts (NIAC) award, Masten spent the last year studying and advancing the FAST concept in collaboration with Honeybee Robotics, Texas A&M University, and the University of Central Florida. Masten can share the latest data from our research that proves the solution is feasible in the lunar environment.

Surviving the Lunar Night: Temperatures on the Moon can reach as low as low as -232°C (or -387°F) during the lunar night, causing spacecraft systems, rovers, and payloads to fail. Masten's Nighttime Integrated Thermal and Electricity (NITE) System solves this challenge by delivering heat and power through the oxidation of metals using propellant margin from the lander's propulsion system. The NITE System autonomously operates when temperatures fall below a specified threshold, enabling landers and payloads to extend mission operations for at least 12 months.

Masten is on track to finalize the NITE heat generation subsystem by mid-2022 following a NASA SBIR Phase II award and can share the latest test results.

Navigating the Lunar Surface: Unlike Earth, the Moon isn't equipped with GPS so lunar spacecraft and assets are essentially operating in the dark. Masten's lunar position, navigation, and timing (PNT) solution proposes to fix that with surface-based sensors that can be deployed from a spacecraft into a dedicated sensor array on the Moon. With functionality similar to GPS, the autonomous network can enable navigation and location tracking for spacecraft, assets, and future astronauts on the lunar surface or in lunar orbit.

Masten is currently developing the network prototype following a Phase II SBIR contract through the Air Force Research Laboratory's AFWERX program. The PNT technology will soon be tested aboard Masten's rocket-powered lander, Xodiac, to demonstrate payload integration and beacon operations in a terrestrial environment, enabling a path towards lunar demonstration.

Extracting Lunar Ice: Usable as drinking water, rocket fuel, and other vital resources, lunar ice is critical to maintain a sustained presence on the Moon and allow future missions to Mars and beyond. Masten's Rocket Mining System can autonomously extract more than 420,000 kg of water per year. It uses a series of rocket plumes under a pressurized dome to fluidize ice particles and a vacuum-like system to store the water. The full system can be attached to a rover and delivered via Masten's lunar landers.

The Rocket Mining System was recently selected as one of the winners of NASA's Break the Ice challenge. Masten aims to continue developing the full system in 2022.