National Aeronautics and Space Administration

*Masten is working with NASA to test potential solutions for mitigating the hazards of rocket engine blasts*

# Small Business Technology Enables Safer Lunar Landings & Longer Lunar Missions

## Challenge

As humanity takes to the stars with renewed vigor, all eyes are on the Moon and Mars. For NASA, the Moon is both a target and a stepping stone: the Artemis missions will land the first woman and the first person of color on the Moon, while also exploring new areas of the lunar surface and establishing a long-term presence. Ultimately, NASA aims to jumpstart a lunar economy and leverage the lessons learned to send astronauts to Mars. To achieve these ambitious goals, NASA is collaborating with commercial partners, including small businesses.

Two key challenges to solve are safe landings on the Moon and surviving the lunar night. For large spacecraft, landing involves firing a rocket engine onto the surface to slow down. This runs the risk of plume impingement and scouring—creating a large crater and ejecting material from the surface that could damage both the vehicle and any assets it is landing near, such as a future lunar base. One proposed solution is to construct landing pads on the Moon. Identifying the right materials to create these landing pads is part of an active area of high temperature materials research, robotic construction, and landing and launch pad testing for NASA.

### Project

- Testbed for Studying Lunar Blast Effects
- Metal Oxidation Warming System for Surviving the Lunar Night

### Mission Directorates

- Science
- Space Technology

### Follow-on Success

More than $4 million in NASA funding related to SBIR developments, and more than $2 million in revenue attributed to I-Corps learnings

### Snapshot

Masten Space Systems leveraged NASA SBIR/STTR solicitations to identify and respond to challenges establishing a sustainable presence on the Moon. The company partnered with the program to study the effects of rocket engine plume impingement and blast during lunar landings and launches, and to develop a metal oxidation warming system (MOWS), resulting in $2.8 million in funding from NASA Tipping Point to enhance the capability of the MOWS. Masten participated in the NASA SBIR/STTR I-Corps training program to help identify commercial uses for these technologies.

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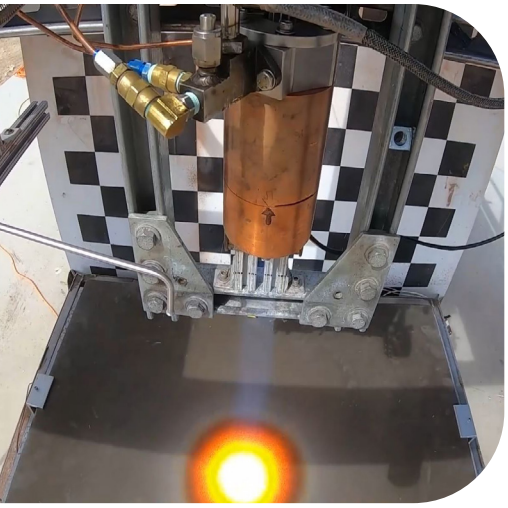


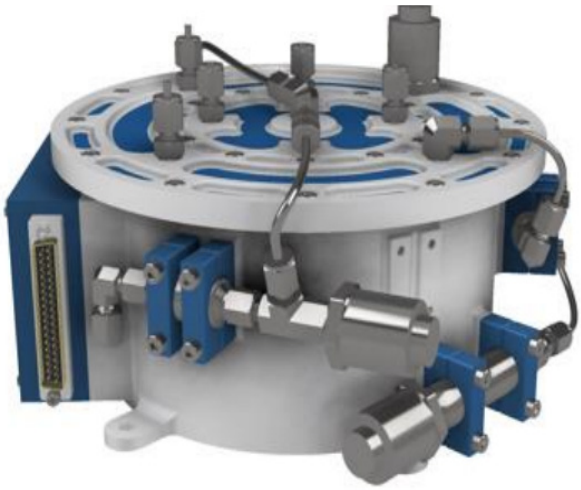
*Testing lunar landing and launch pad candidate materials on Masten's rocket engine test stand*

Once equipment arrives on the Moon, the challenge becomes keeping it operational. Despite the significant time and expense it takes to send new materials to the Moon, most equipment can only survive for a single lunar day, which is approximately two Earth weeks. When the lunar night sets in, temperatures plummet and could render equipment permanently inoperable. While nuclear heating is a proven solution, it is expensive and faces many restrictions for sustained lunar activity.

## Solution

Masten Space Systems, based in Mojave, CA, has partnered with NASA's Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) program to develop technology enabling sustainable access to the Moon for both NASA and commercial companies. Masten began its relationship with NASA when it won the 2009 Lunar Lander Challenge, part of the agency's Centennial Challenges program. One year later, the company received its first NASA SBIR Phase I contract, managed by Kennedy Space Center (KSC), to create a testbed for entry, descent, and landing that would allow groups inside and outside of NASA to study plume surface impingement effects and novel solutions for mitigating these effects.

In 2018, the NASA SBIR/STTR program put out another call for proposals related to plume surface impingement and lunar blast effect modeling for rocket landings. The agency had five potential lunar landing and launch pad candidate materials that needed to be tested on an oxygen/methane propellant rocket engine test stand. Masten received a Phase I SBIR contract to provide an environment for performing the landing and launch pad tests. NASA leveraged Masten's status as an SBIR/STTR award recipient to provide Phase III funding; under this direct sole source contract, Masten is working with KSC to characterize plume impingement on several material samples in Moon-like conditions using various mitigation strategies. The speed of the Phase III mechanism meant that Masten received these funds four months after their Phase I contract ended, even before award of their Phase II contract, managed by Langley Research Center (LaRC), to continue modeling plume effects and develop a method for scaling results between terrestrial and simulated lunar environments.



*With their NITE system, Masten aims to enable equipment to survive the extreme cold temperatures of lunar night*

Masten also received Phase I and II SBIR contracts, managed by Marshall Space Flight Center (MSFC), to develop a Nighttime Integrated Thermal and Electricity (NITE) system that creates chemical reactions to deliver heat and power through the oxidation of metals using propellant margin from the lander's propulsion system. The company's ultimate aim is to create a modular technology that would enable customers to outfit their equipment with a heat and power system to survive the lunar night or operate in a shadowed region of the Moon. Shortly after award of the Phase II contract, Masten received $2.8 million from the **NASA Tipping Point** program to further advance the technology readiness level of the system and test it in a lunar environment.

## Business Impact

As of October 2021, Masten has received 9 NASA SBIRs, 1 NASA STTR, and 3 NASA Tipping Point awards, along with contracts from several other NASA programs and initiatives. These include NASA Innovative Advanced

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>
> – Matt Kuhns
> VP of R&D for Masten

Concepts (**NIAC**), NASA **Flight Opportunities**, Commercial Lunar Payload Services (**CLPS**), and Lunar Cargo Transportation and Landing by Soft Touchdown (**Lunar CATALYST**).

According to Masten, seizing opportunities to learn from their customers has been key to the company's growth. This sentiment was echoed by Will Johnson, NASA Heat Transfer Engineer at MSFC, who works with Masten on MOWS: "They're very good at doing industry research to understand not only NASA's needs, but the industry as a whole." Masten CEO Sean Mahoney recounted one year when none of their five NASA SBIR proposals were selected for award. Despite initial frustration and disappointment, the feedback the company received on the proposals and the knowledge gained by going through the proposal process ultimately helped pave the way for Masten's future. In fact, the company reviews feedback for every proposal—including ones selected for award—to help guide their approach to successfully executing the contract.

Masten attributes business success to the Innovation Corps (**I-Corps**) training program, which the company enrolled two teams in during Phase I contract periods. I-Corps is offered in partnership with the National Science Foundation (NSF) and guides firms through a customer discovery process to develop an effective business plan. Matt Kuhns, the company's VP of Research & Development, remarked, "Why did we get a Phase III? We listened to I-Corps and changed our approach to selling this as a service. We can trace going to I-Corps and changing our business plan to pulling in $2 million in contracts, commercial and government."

Masten has used the yearly NASA SBIR/STTR solicitation as a reliable framework and funding source to test and refine the company's ideas and focus on the most pressing issues facing NASA and the commercial space industry. Doing so has allowed the company to leverage their time and resources to the fullest to build a successful business.