

*With NASA STTR support, Parabilis' hybrid upper stage with ACE configuration performed successful hot fire demonstrations for CubeSat launches*

## Hybrid Upper Stage Provides a Safe, Green, and Cost-Efficient Solution for CubeSat Launches

### Challenge

Rocket launch propulsion systems are critical technologies for many of NASA's missions. The largest classes of launch propulsion systems use either solid or liquid propellants, but these have operational and cost challenges. Liquid systems have oxidizer and fuel in separate tanks, where the propellants are mixed, ignited and then expanded through a nozzle, producing thrust. Liquid rocket propulsion systems are advantageous for performance but are costly due to complexity and can explode if the propellants inadvertently mix. Solid systems contain pre-mixed oxidizer and fuel, both in solid form, and are advantageous for high thrust, but once the propellants burn it is difficult to stop the operation until the propellant is gone, and controlling the thrust level in flight is difficult. Solid rocket motors can also explode if the solid fuel grain cracks.

With orbital and deep space missions planned for the foreseeable future, NASA seeks unconventional and novel improvements to rocket systems.

### Solution

Parabilis Space Technologies (Parabilis)—a small business specializing in propulsion systems and vehicles, small satellite systems and buses, and systems integration—came to NASA's attention through the Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR) Program. In 2015, soon after the company's formation, Parabilis received an STTR award in collaboration with the Utah State University (USU), as well as an SBIR award, marking the beginning of its

#### Project

Hybrid upper stage propulsion system with Aft-injection, Center Exhaust (ACE) configuration for launching CubeSat class payloads

#### Program

Small Business Technology Transfer (STTR)

#### Post-Phase II Success

More than \$4M in post-Phase II and follow-on funds from NASA and the Air Force

#### Snapshot

Parabilis Space Technologies developed a hybrid upper stage that combines the benefits of traditional liquid and solid propulsion systems while reducing risk and cost. Hybrid technology is safe, green, and cost-efficient, making it versatile, especially for CubeSat launches, and Parabilis' ACE configuration makes the system more compact. Parabilis received additional funding from NASA and the U.S. Air Force to develop this technology beyond the Phase I and II STTR accomplishments

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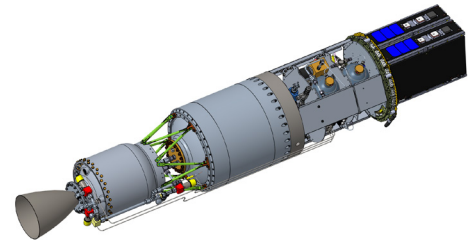
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partnership with NASA. The Phase I STTR award focused on delivering a low-cost, high-performance hybrid upper stage to launch CubeSat class payloads and led the company and university to receive a Phase II award to continue development.

Parabilis has since worked with five out of ten NASA centers on a variety of technologies and topics outside of the hybrid propulsion system, including thrusters and additive manufacturing. The company's STTR award to develop the hybrid propulsion system originated at the NASA Marshall Space Flight Center (MSFC) for Phase I and was transferred to the NASA Armstrong Flight Research Center (AFRC) at the beginning of Phase II. NASA Propulsion Engineer Daniel Jones has been at AFRC for more than 20 years and has overseen the progress of several SBIR and STTR contracts, including Parabilis' work on the hybrid upper stage.

"Although hybrid rocket propulsion is not new, Parabilis offers a unique and innovative approach to launching satellites with their system," says Jones. "Cost is a big advantage of this technology because it will be crucial to the success of any business providing launch services for small payloads. And safety is the other key advantage. Parabilis has a unique design that offers a greater level of safety than traditional propulsion systems, and they have a lot of experience working with different propellants."

Parabilis' upper stage launch system boasts benign "green" propellants with the company's Aft-injection, Center Exhaust (ACE) configuration, which makes the system compact and reduces complexity, enabling a variety of applications. As a result of the Phase II STTR funding, the hybrid upper stage with its ACE configuration performed a successful series of hot fire demonstrations



*Parabilis' hybrid upper stage is less complex than traditional systems, enabling a variety of applications*

in May 2019. In these tests, the system proved to be capable of delivering the thrust level required for the delivery of CubeSats.

## Business Impact

The successful demonstrations led Parabilis to receive a Phase II Sequential STTR award—with which hot fire testing will continue with NASA AFRC through 2020—and opened the door to working with the U.S. Air Force. The funding from follow-on NASA and Air Force contracts totals more than \$4M, but according to Parabilis CEO Dave Streich the early funds from Phase I were just as impactful to the company as the follow-on awards.

"SBIRs and STTRs basically enabled us to fund the start of this company. They became the basis for building our company. We did not have to get outside capital or debt—we were able to fund ourselves from a very early stage," says Streich.

More than just funding, Streich also acknowledges the SBIR/STTR Program enabled the company to gain credibility through its partnership with NASA. As Parabilis begins to target commercial markets, Streich says that the relationship with NASA and the resulting work with Air Force brings validation needed to break into the commercial market.

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Having NASA's support is of immense value to us. We are thrilled to have earned that support and we're very happy we've been able to execute our programs. Without the SBIR/STTR program this would have been a much more difficult road for us to travel.

– David Streich, Parabilis  
CEO