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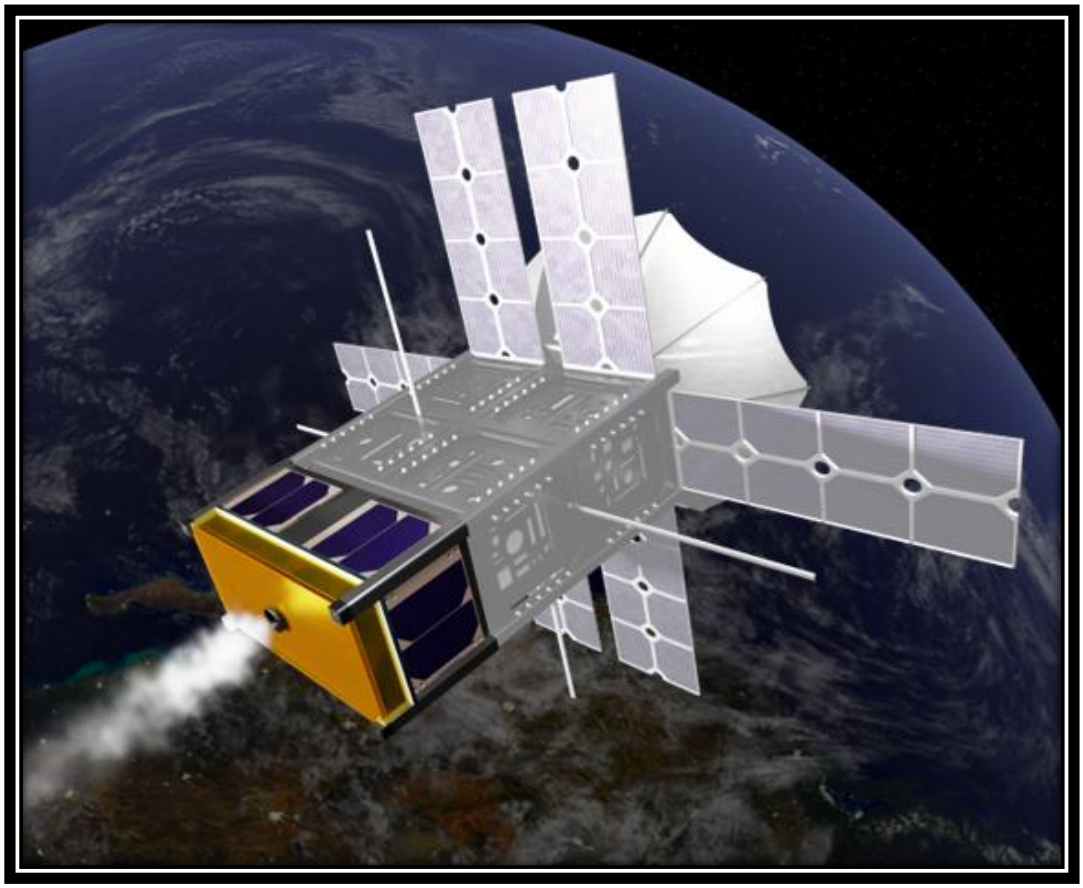

ThermaSat propelling a 4U CubeSat with no power draw from the payload *(illustration by Nathan Blaylock of Howe Industries)*

Steampunk in Orbit

Howe Industries delivers the steam powered ThermaSat™ propulsion design to the National Science Foundation

Scottsdale, AZ – January 4, 2021 - Since their introduction in 1999, CubeSats have made a dramatic mark in space, widely used for technology demonstrations, earth sensing, telecom and other missions. But their full potential has been held back by the lack of a good propulsion solution.

That's about to change, thanks to a breakthrough engine design which Howe Industries has submitted to the National Science Foundation (NSF). Among many benefits, this will bring the impact of global warming into much closer view.

Of the 2700 CubeSats (and other nanosatellites) that have been created to date, less than 10% have their own means of propulsion. This leaves them at the mercy of gravity and atmospheric drag until soon falling to earth (even if fully functional).

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"The problem with existing propulsion options is twofold," according to Dr. Troy Howe (PhD), Howe Industries CEO. "On the one hand, these systems require substantial power to operate, siphoning energy from the primary payload.

"And then there are the more 'energetic' propulsion systems (typically scaled down from use on much larger satellites). These rely upon toxic, highly pressurized or even explosive liquids, such as hydrazine. This is problematic as most CubeSats share a ride to orbit and launch providers are leery of endangering their other, often more valuable cargo. While deployment from the International Space Station (which is common for CubeSats) precludes any satellite propulsion which likewise might pose a risk to the station and personnel.

"The ThermaSat steam engine overcomes these obstacles while fulfilling other must-have requirements for a successful CubeSat propulsion system", concludes Dr. Howe.

Quite simply, the ThermaSat propellant is plain water. But unlike in a traditional steam engine, there's no boiler. Rather, the water is flashed into superheated steam in the instant before being shot out of the nozzle. Even better, the self-sufficient, plug-n-play ThermaSat requires no power from the satellite; nor are there bulky, protruding reflectors to obstruct the mission objectives. (In the illustration above, the extended solar panels are for powering the satellite payload).

With only two moving parts, the engine has the benefit of being simple and reliable. And though smaller than a loaf of bread, the ThermaSat will deliver 1,800 Newton-seconds of total impulse - or 203 seconds of specific impulse - using just a small teapot's worth of water (1 kg / 2.2lbs) This is enough propellant to maintain a CubeSat in a Low Earth Orbit of 375 km/233 miles for more than five years, representing a huge potential savings in satellite replacement.

Alternatively, the ThermaSat can enable months-long missions in a Very Low Earth Orbit of 250 km/155 miles (or even lower with extra propellant). Without propulsion, the orbit of a CubeSat at this altitude would decay in a matter of days or weeks. By being able to sustain such missions at the very edge of space CubeSats could provide higher resolution for remote sensing while dramatically decreasing communications latency (with an increase in total communications throughput). This could be particularly important during a natural disaster (or other crisis). A satellite equipped with the ThermaSat could even alter its orbit, descending to get a better look at a situation in progress. With the added benefit – if stealth is important - that the water vapor exhaust is inherently undetectable.

"The heart of the system is the unique thermal capacitor, made from phase-changing materials, which concentrates and stores the solar heat collected from just 20 square inches of exposed surface area", according to Jack Miller, R&D engineer for the ThermaSat program. "Using a combination of photonic crystals and gold-tinted mirrors the completely inert capacitor reaches a blistering operating temperature of 1,052K (1,433 Fahrenheit). This results in a specific energy comparable to a lithium-ion battery, but without the potential for explosion. The side-mounted solar panels are for the electromechanics, standby heating and as a power reserve for the payload."

In addition to station keeping, the ThermaSat can be used to raise orbits, for geolocation missions (which require formation flying) as well as for scheduled deorbiting and collision avoidance (likely to become a requirement). The system can also enable rapid constellation deployment, without relying upon variable drag. And because it requires no power from the satellite, the ThermaSat might be

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deployed as a strap-on propulsion unit when servicing/upgrading even much larger satellites. But perhaps most exciting, is the potential to enable a new class of smart, autonomous satellites able to relay data and even to 'swarm' together for specific tasks.

Howe Industries developed the ThermaSat with support provided by the National Science Foundation as part of a Phase I Small Business Innovation Research (SBIR) grant. With the design now delivered to the NSF, the company intends to pursue a Phase II SBIR to build prototypes leading to a test flight in space.

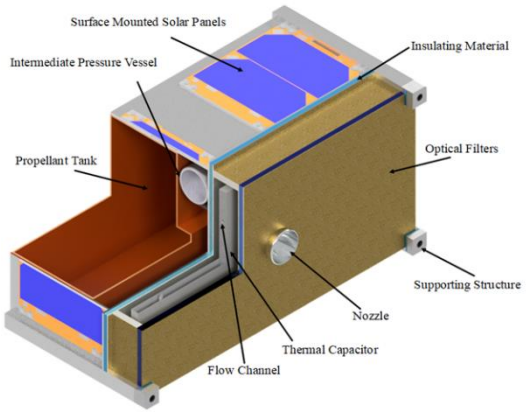
Whatever the mission, with the ThermaSat steam engine on board a satellite will unerringly maintain its course as it rides invisible tracks through space.

About Howe Industries

Dr. Troy Howe, PhD (CEO) started Howe Industries in 2015 with the mission to introduce technologies – with both space as well as terrestrial applications – that derive from their team's expertise in nuclear technologies, thermal systems and propulsion. Reflecting the company's culture of innovation and excellence, Howe Industries has been the recipient of multiple grants from federal agencies, including NASA (and NASA NIAC), DARPA, as well as the NSF. In addition to the ThermaSat, Howe has developed the solid-state, Advanced Thermoelectric Generator (ATEG), a new fuel for nuclear thermal propulsion and the Pulsed Plasma Rocket - which promises to speed astronauts to Mars in less than 3 months.

To learn more about the space-bound little steam engine with the can-do attitude, contact Marvin Weinberger marvin@thermasat.com 610-574-8450.

ThermaSat by the numbers:



- 2U standard configuration of 2000 cubic cm (.07 cubic foot) but available 1U to 4U
- Supports 4U to 16U spacecraft bus/payloads
- Standard propellant load of 1kg (2.2 pounds) distilled water, undetectable vapor exhaust
- Total wet mass of 2,445 grams (5.4 pounds)
- Operating temperature of 1,052k (1,433 Fahrenheit)
- 203s I_{sp} (highly efficient even with an inert propellant)
- Nominal thrust of 1.02N (Newtons) with a total impulse of 1,800 NS (Newtons-seconds)
- 200 m/s (meters per second) of delta-v (depending on spacecraft bus/payload mass and scalable with increased propellant)
- Minimum impulse bit of .04 (for fine control) to a max of 60,000 mNs
- Zero Watts power draw from satellite bus
- 2.3-4.6W electrical from side-mounted solar panels for electromechanics, standby heating and as a power reserve for the satellite
- Minimal RF interference
- Option to co-locate non-mission payload components (depending on configuration)