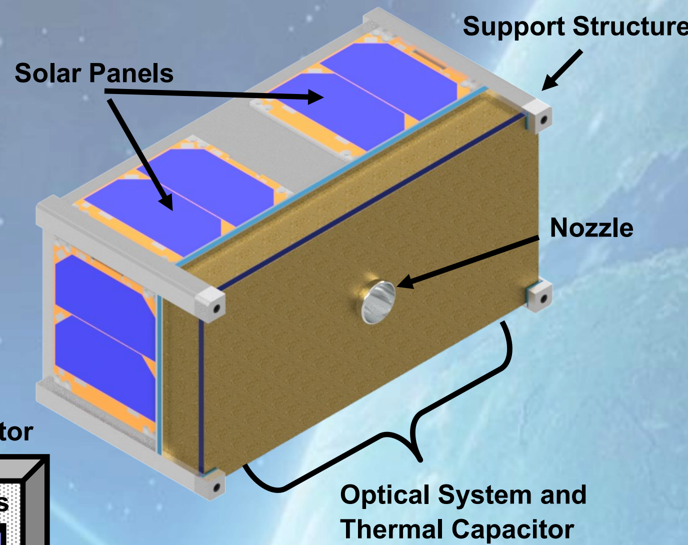
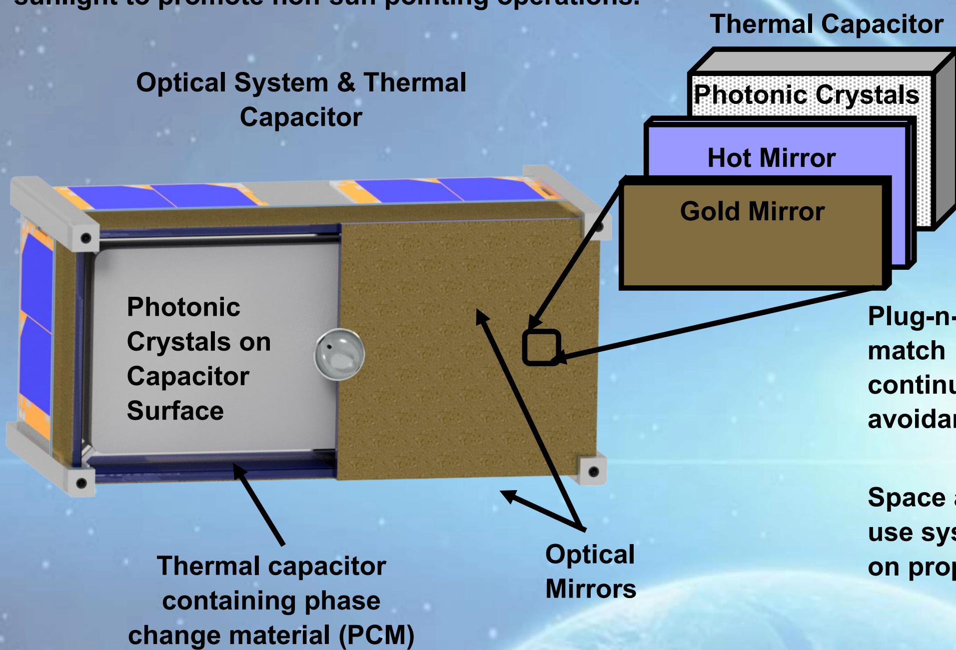
ThermaSat™

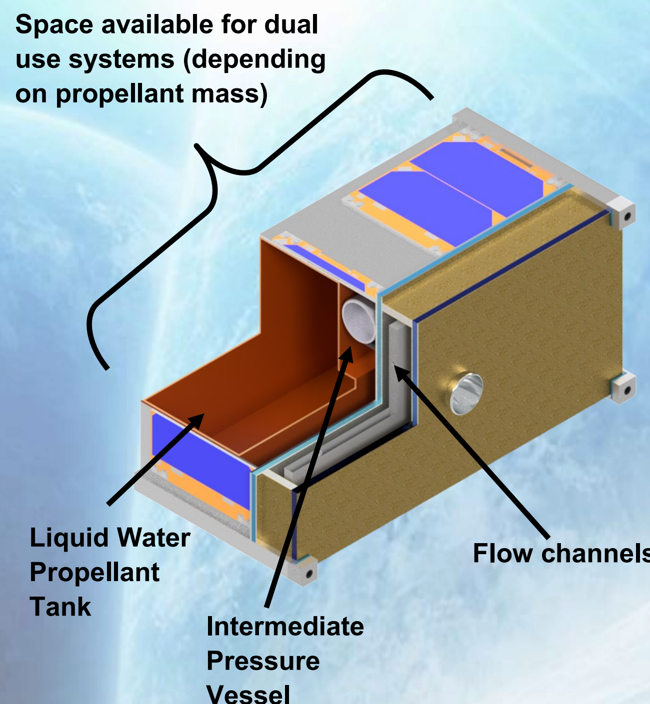
HOWE INDUSTRIES

With support from the NSF, Howe Industries is developing the novel ThermaSat™ propulsion system. This plug-n-play system uses water as a safe and non-explosive propellant, unpressurized at liftoff. Utilizing solar thermal propulsion, the compact and efficient capacitor heats water to steam to produce high thrust & total impulse. The advanced optical system allows for the thermal capacitor to charge through solar power alone with no protruding concentrators or power draw from the main bus. Additional solar panels, body mounted to the ThermaSat, provide auxiliary heating of the thermal capacitor when not directly incident to sunlight to promote non-sun pointing operations.

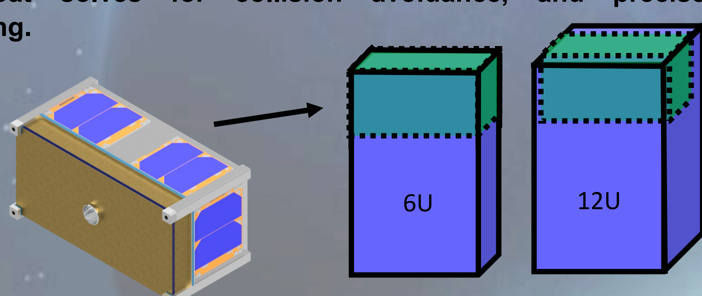




Plug-n-play system with customizable total impulse to match specific mission requirements. Up to 60s of continuous thrust for maneuvers and debris avoidance.



ThermaSat can be sized from a 1U to 4U form factor. The compact 2U version supports a wide range of payloads and missions. The configuration, as shown, is well suited to a 6U, 7kg bus, providing 200 m/s of delta-V. With few moving parts, reliable propulsion can be provided for satellites with payloads exceeding 16U. ThermaSat is a cost effective solution to dramatically increase mission duration at any orbit. But ThermaSat can also sustain operations down into the Ionosphere, with the attendant enhancement of mission objectives including higher resolution images, lower latency, and science data collection. In addition to station keeping, ThermaSat solves for collision avoidance, and precise deorbiting.



www.thermasat.com Dr. Troy Howe, CEO engineering@howeindustries.net

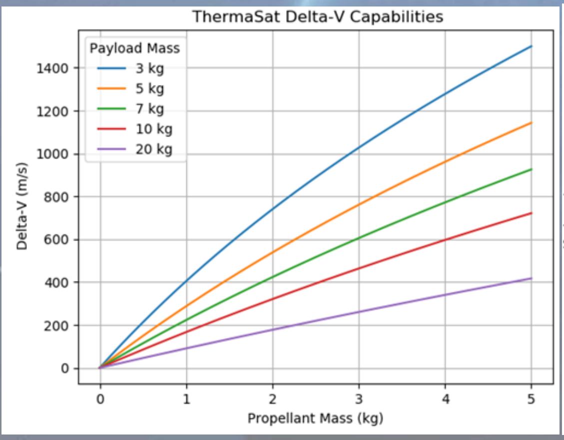
ThermaSat

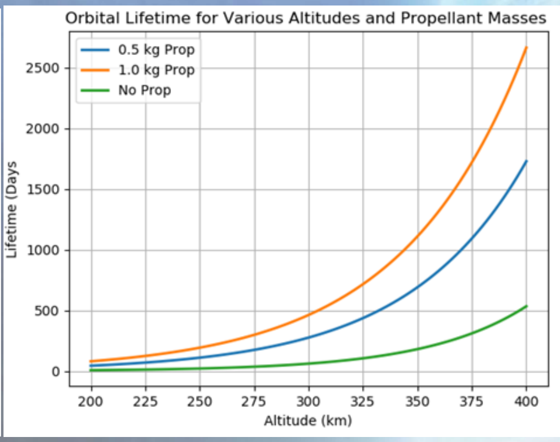
HOWE INDUSTRIES

Attitude control is accomplished through the use of optional ACS cold-gas thrusters. While the high-temperature steam primary thruster is utilized for more demanding maneuvers. without requiring a power draw from the main bus. In the base configuration, room can be reserved for dual use systems including command and data handling, communications & antenna, ACS, an auxiliary battery and other control boards with decrease in delta-v. While the included, body mounted solar panels provide auxiliary heating, charging of the thermal capacitor is most effective when at 0 angle of incidence to sun. And though optimal performance occurs when capacitor is fully charged, the system is designed for excellent heat retention and is still operational even at lower temperatures.

Comparison of CubeSat Propulsion Systems

Propulsion Type	Power from Spacecraft Bus	Typical I_{sp}	Typical Thrust	Propellant	Special Considerations
Hall Effect	75-450W	700-1500s	4-33 mN	I, Xe, Kr, Ar, Ne	High power requirements, may require deployable solar array, low thrust
Electric Plasma	20-60W	700s	0.25-0.65mN	CO_2, Ar, Xe, I	High power requirements, high pressure at launch, low thrust
Electro Thermal	25-55W	175-185s	17 mN	NH_3, H_2O, N_2	High power requirements, may require deployable solar array, green propellant
Monopropellant	4.5-50W	214-230s	100-5000 mN	Hydrazine, AF-M315E	Traditionally uses hazard-ous fuels, recent green propellant
Bi-propellant	25 W	285-310s	500-1500 mN	H_2, C_2H_5OH HTP, O_2	Potentially hazardous fuels & complex mechanisms
Cold Gas	0-1W	40-60s	53 mN	R134a, N_2, CO_2	High pressures at launch, limited I_{sp}
ThermaSat	**0W (solar ther-mal) 2.3-4.6W (auxiliary power from unit)**	**>200s**	**>1000 mN**	**H_2O**	**Safe, green propellant, simple phase-change to steam, low pressure at launch, power neutral**





SYSTEM POWER

Passive solar thermal charging to peak efficiency in just under a day

Advanced optical technology with photonic crystals

Thermal capacitor comprised of phase changing materials with exceptional heat retention

Power neutral, 0W power draw from main bus

2.3-4.6W electrical from included solar panels (for electromechanics, standby heating and satellite power reserve)

PROPULSION PERFORMANCE

>1040 K Peak operating temperature

>200 m/s for 7kg payload primary thruster

>200s I_{sp}

>1N nominal thrust

>1800N-s total impulse with 1kg H_2O propellant

130-60,000 mNs impulse bit

H_2O propellant, no explosive risk or high pressure containers, minimal RF interference

Thermally isolated from spacecraft bus

BASE SYSTEM

Compact, few moving parts

No protruding concentrators

2U configuration

2445 g wet mass (~1kg of H_2O propellant)

4U of payload+bus volume

Applicable to 6U+ CubeSats

Available in 1U to 4U configurations

OPTIONAL

Scalable ΔV with increased propellant

Configurable for larger bus platforms

All-in-on option to co-locate non mission payload components including: command and data handling, communications & antenna, ACS, auxiliary battery, and other control boards.

www.thermasat.com Dr. Troy Howe, CEO engineering@howeindustries.net