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Single-stage-to-orbit Reusable Launch Vehicle

2001: NASA Stenis Space Center Aerospike Engine Burn Test

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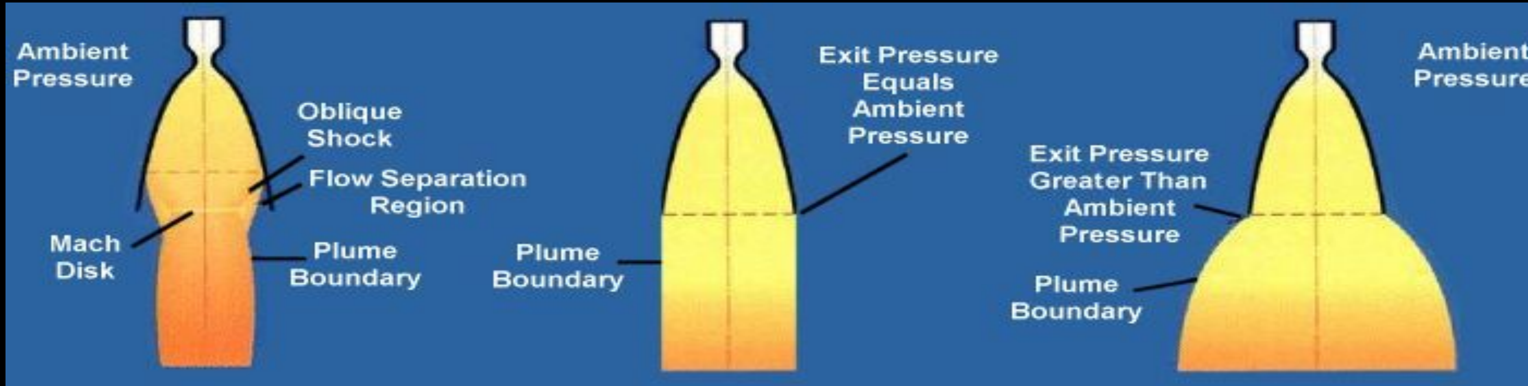
Bell Nozzle vs. **Aerospike** at various altitudes

Bell Nozzle

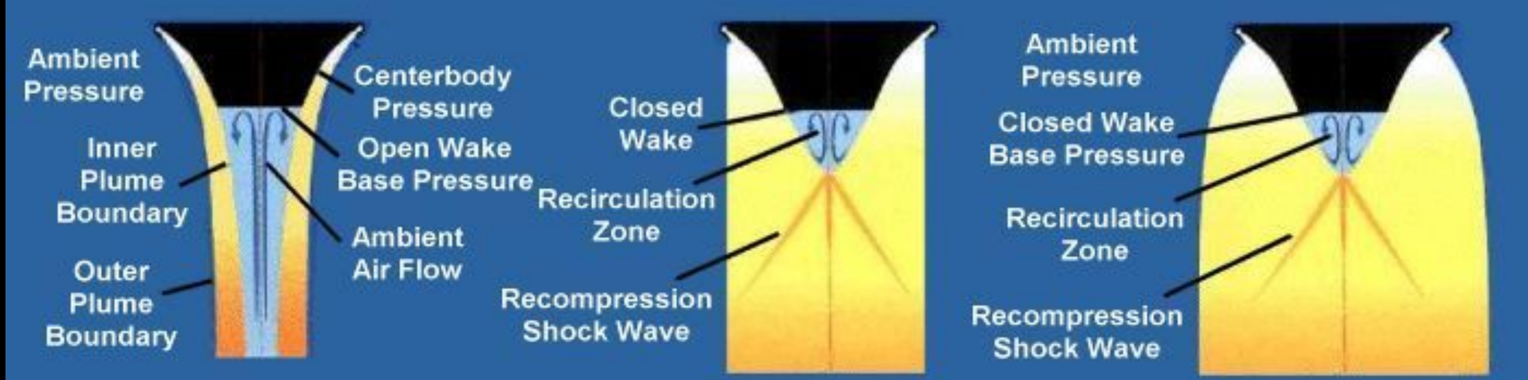


(a) Bell Nozzle at Sea Level: the exhaust plume is "pinched" by high ambient air pressure, reducing its efficiency.

(b) Bell Nozzle at Optimum Altitude: the exhaust plume is column-shaped producing maximum efficiency.

(c) Bell Nozzle at High Altitude: the exhaust plume continues to expand past the nozzle exit reducing efficiency.

Aerospike



(a) Aerospike at Sea Level: high ambient pressure forces the exhaust to remain close to the centerbody maintaining high efficiency.

(b) Aerospike at Optimum Altitude: the exhaust plume is column-shaped producing maximum efficiency.

(c) Aerospike at High Altitude: the exhaust plume is bound by shock waves that force it to remain column-shaped for high efficiency.

Star-Lord 1

Payload: 100-200 kg

Range: LEO → ~185 km

Propellant: LOX/Methane

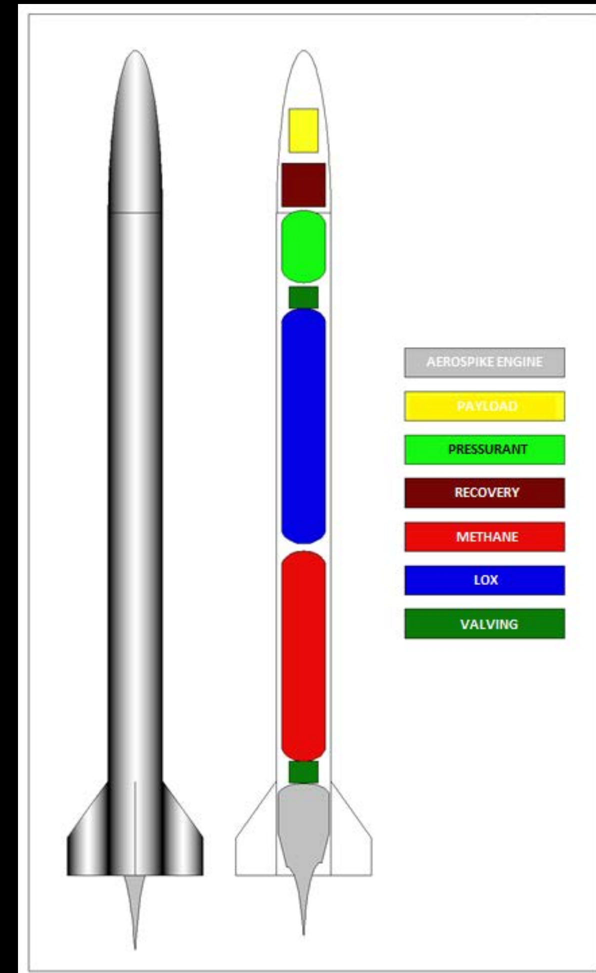
Cycle: Pressure-fed

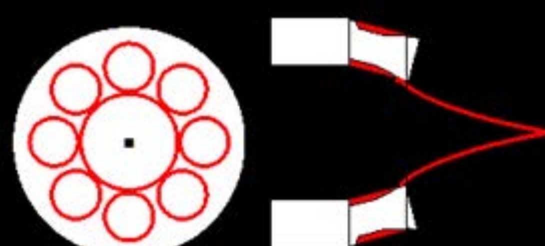
Thrust: ~20,000-50,000 lbf

or up to 220,000 lbf for a linear spike

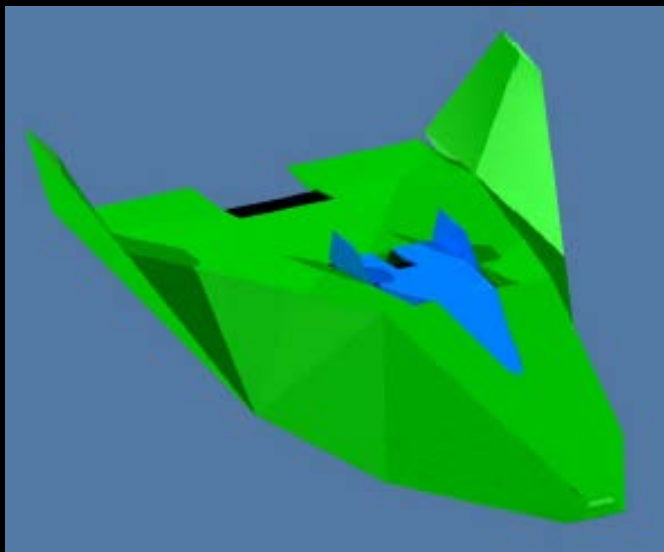
Isp: ~339-438 sec (sea level / vac)

Width x Height: 6 ft x 90 ft





Spaceplane Concept



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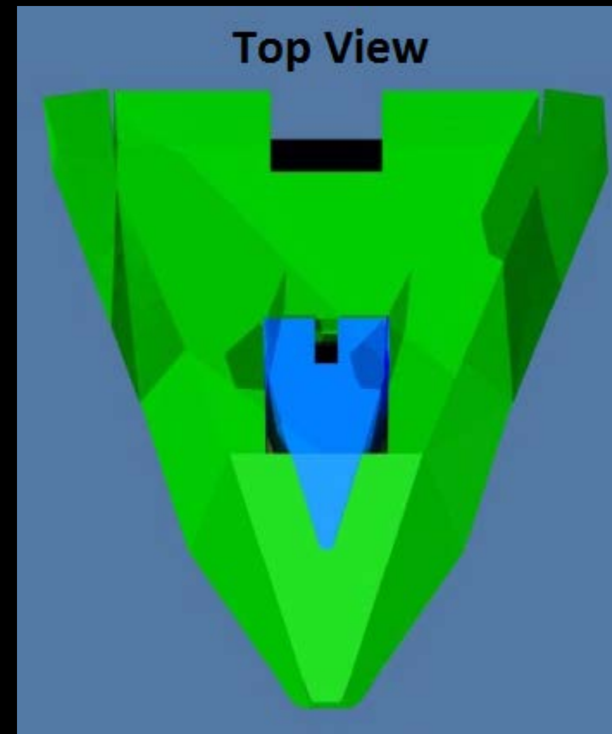
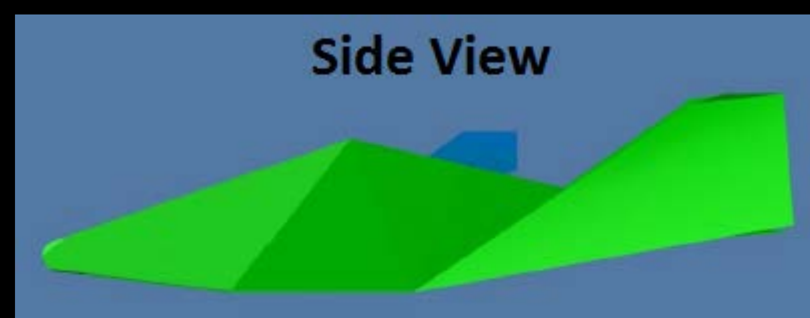




AgileAero

ConstantQ™ Plasma Thruster

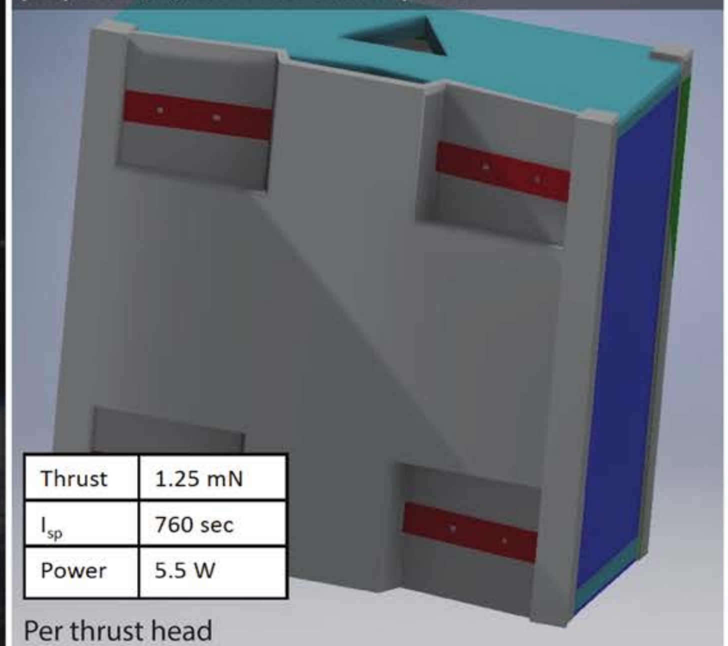
Fluid & Reason, LLC 734-476-1437
Contact: Wesley Faler, wes@fluidandreason.com

The ConstantQ™ is a hybrid electrostatic thruster, featuring an exceptionally compact and power-efficient design with a self-neutralizing plasma flow.

The Model H features 4 thrust heads giving 5mN at 22W in only 0.5U and 1.5kg total mass. Its thrusters are canted for attitude control, unloading reaction wheels, and main propulsion. See the reverse side for full specifications.

Propellant options include solid iodine, noble gases, and others (*under NDA). Custom tank structural configurations are available to accommodate your mission's cabling and optical systems.

Model H unit: 4 thruster heads, 5mN, 0.5U, Iodine propellant, 7,456 N sec total impulse.



Thrust	1.25 mN
I_{sp}	760 sec
Power	5.5 W

Per thrust head

Prototype firing with Xenon

Plasma plume with Xenon

Fluid & Reason, LLC provides the ConstantQ™ thruster, mission analysis services, flight software, and engineering services for the CubeSat market.

We proudly sponsor Team Miles, a leader in the NASA CubeQuest Challenge, on their mission to the moon and a near earth asteroid using ConstantQ™ thrusters!

Fluid & Reason, LLC
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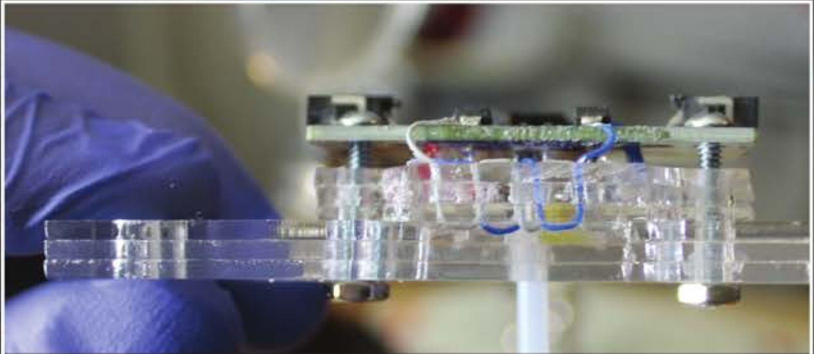
ConstantQ™ Plasma Thruster

What are your mission's design drivers?

Parameter\Model	ConstantQ™ Model H	Other (Compare!)
Thrust	5 mN	
I_{sp}	760 sec (* higher available)	
Impulse	7,456 N sec	
Power	22 W	
Wet mass	1,500 g	
Propellant mass	1,000 g	
Propellant	Iodine (*others available)	
Volume	10x10x5 cm (0.5U)	
Thrust: Mass	3.3 mN/kg	
Impulse: Power	338 N sec/W	
Impulse: Volume	21.3 N sec/cm^3	
Delta-V 4kg craft	2,145 m/s	
Delta-V 8kg craft	996 m/s	
Delta-V 12kg craft	649 m/s	

Theory of Operation

ConstantQ™ thrusters create plasma using a spark and pulsed operation, with pulses at several KHz. Plasma is formed near entrances of two electrostatic channels. The channel fields separate the plasma and accelerate the ions and electrons separately. Accelerated electrons leave first, creating a virtual cathode behind the thruster. The remaining plasma is unstable and positive, with a large voltage between it and the virtual cathode. Space-charge mass flow rate is high because of the voltage boost using the virtual cathode. The field geometry naturally neutralizes the plasma without a neutralizer, enhancing lifespan and reducing total power requirements.



Prototype thruster body, showing patent-pending acceleration geometry.

Fusion Thruster Accelerator

Figure 1 ConstantQ™ geometry and operation

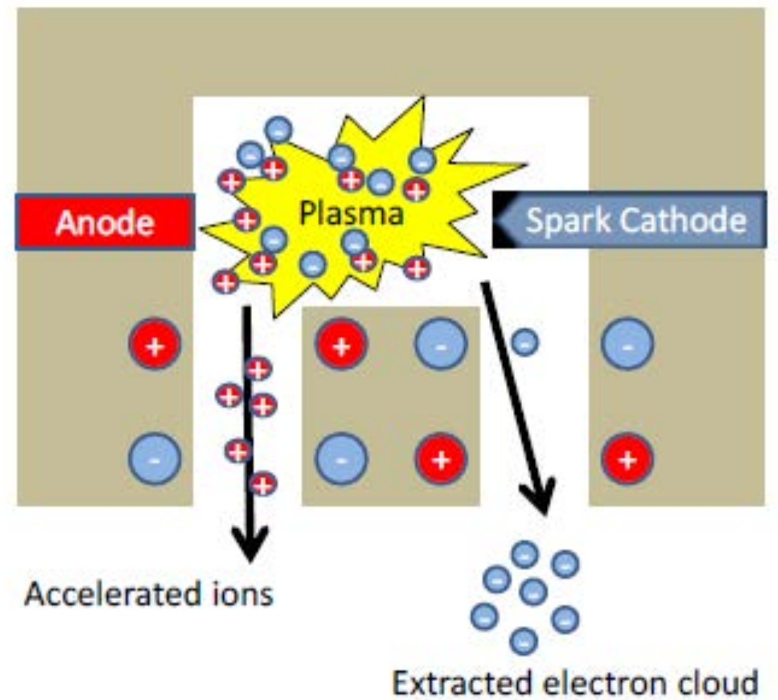
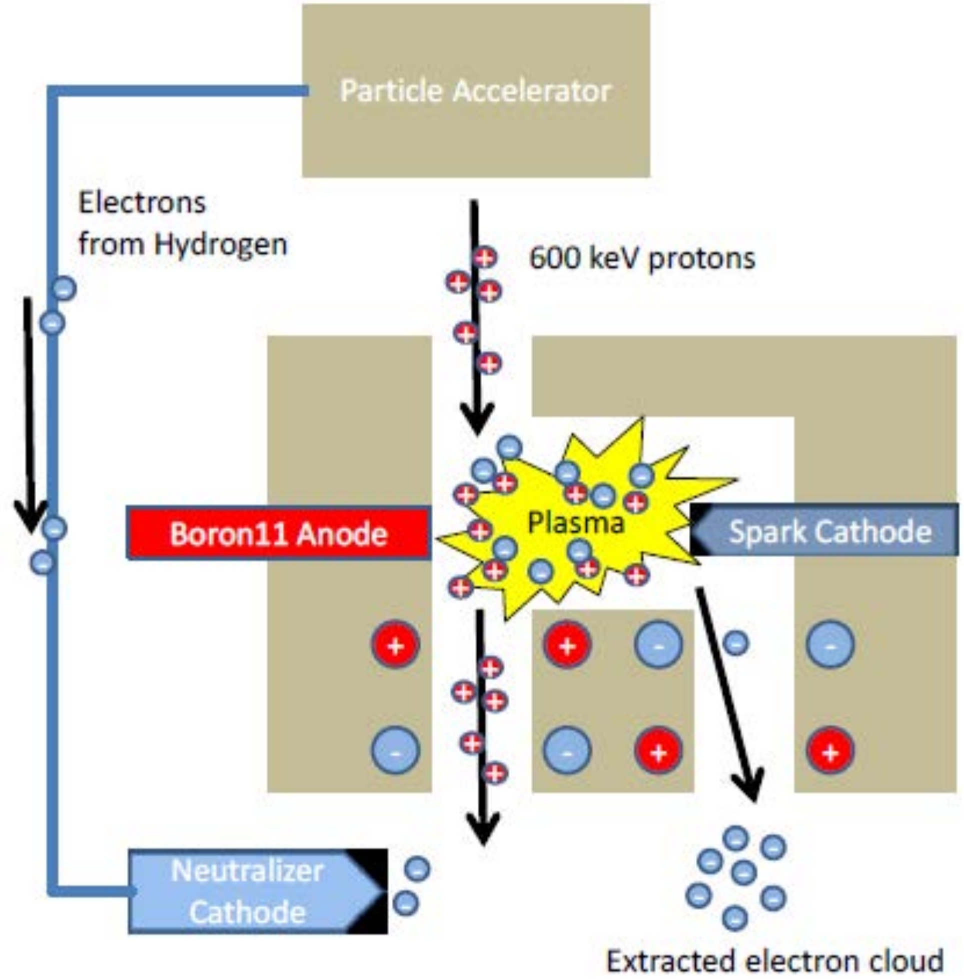


Figure 2 Experiment schematic



Fluid & Reason, LLC

Fusion Thruster Accelerator

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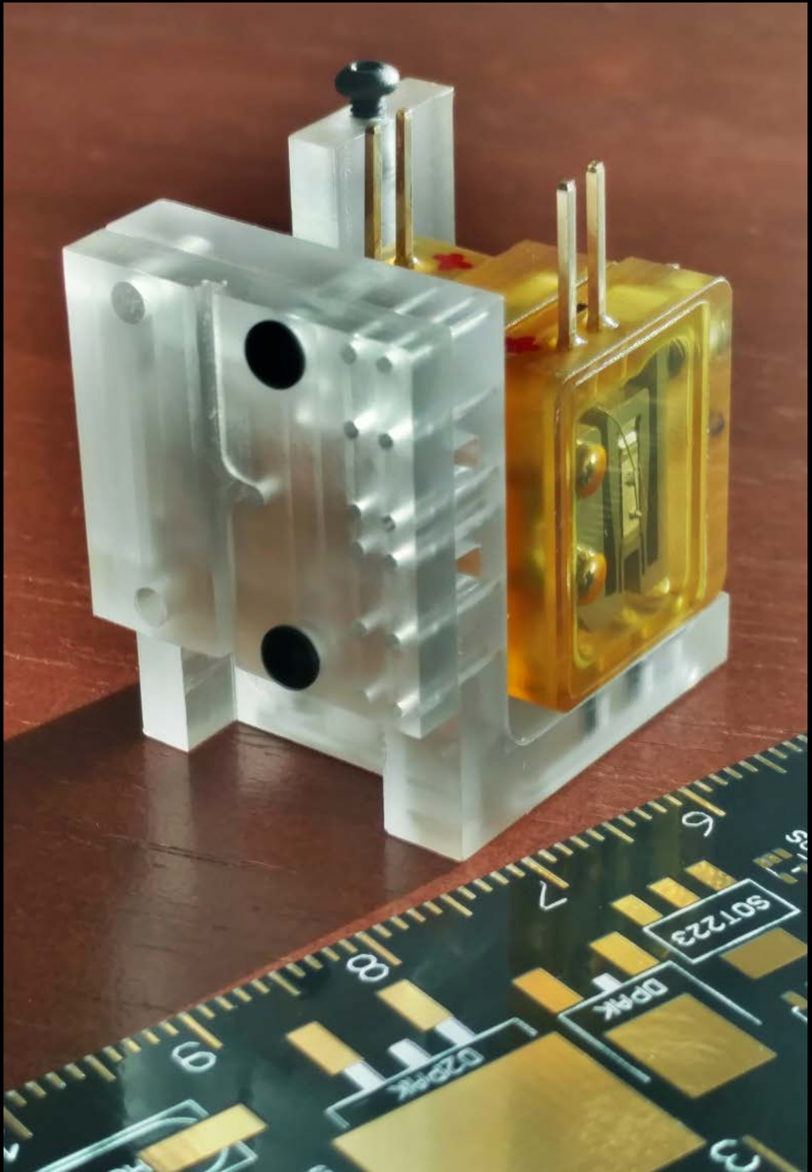

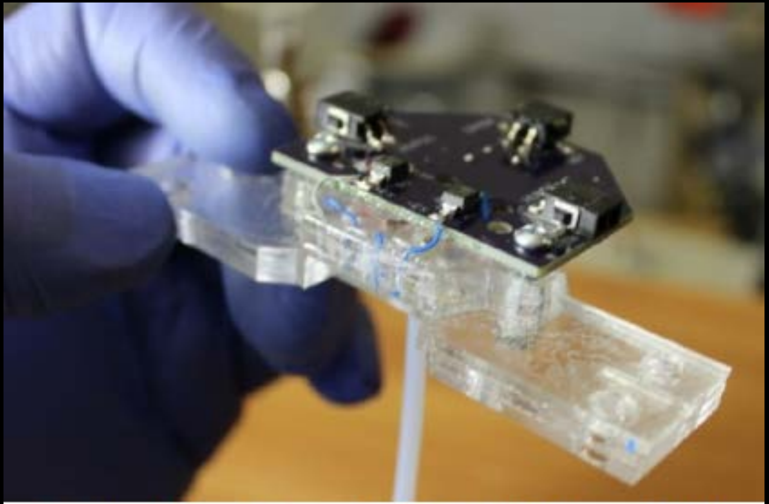

ConstantQ™ prototype (Image: Fluid & Reason, LLC)

6U CubeSat with plasma thrusters

Thank you