A TunaCan Water-Based Thruster for CubeSats: System Development and Qualification

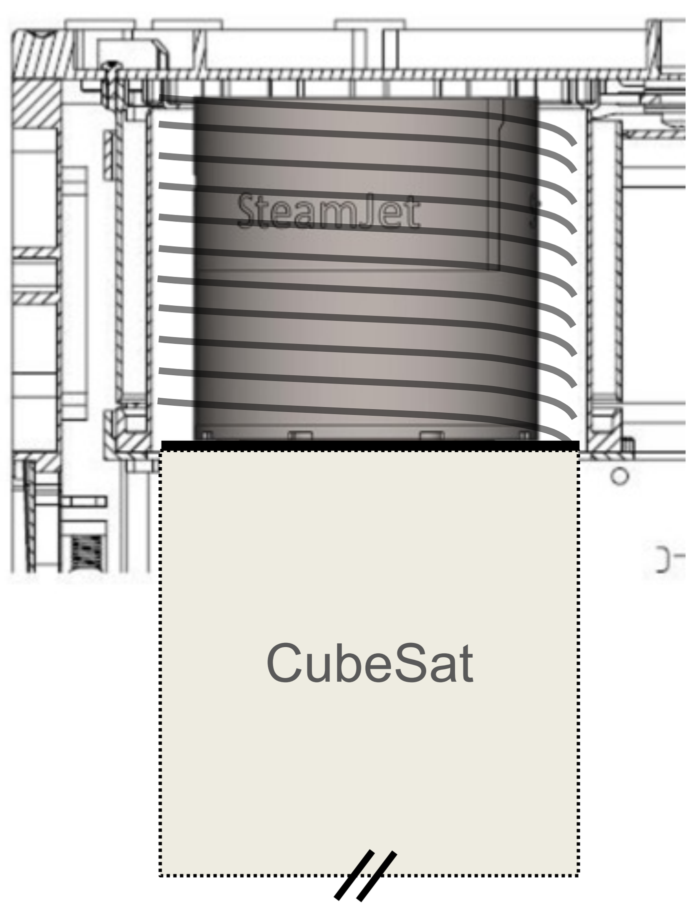
Marco Pavan[1], Roman Zakharov[1], Ivan Timofeev[1], Gleb Philin[1], Pavel Savin[1], Vladimir Fedorov[1]
[1]*17 Moorfield, Canterbury, CT2 7AN, United Kingdom*
marco.pavan@steamjet.space

ABSTRACT

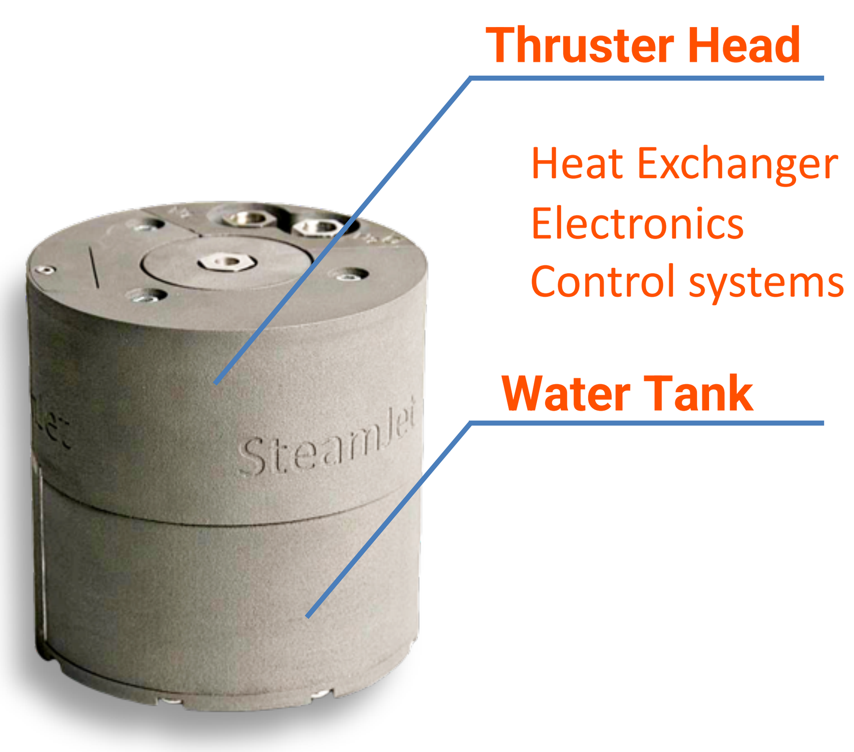
Governments and industries developed an increasing interest towards CubeSats and Small Satellites for commercial and scientific missions, however the general absence of propulsion capabilities is limiting the market potential. Electric propulsion systems are generally associated with low thrust and high power requirements, while cold gas thrusters are inefficient because of the low Specific Impulse (Isp). SteamJet Space Systems has developed a very compact, low pressure, water powered electrothermal thruster able to provide a high level of thrust, using less than 20W of power and with a specific impulse in excess of 170 s.

THE STEAM TUNACAN THRUSTER

CubeSat deployer



The Steam TunaCan Thruster is a water powered propulsion system designed specifically for CubeSats. The system owns a beneficial cylindrical shape factor, which allows its installation within the large tunacan volume (Ø 80mm x 80mm) available in CubeSats deployers. Using just low pressure water as the main propellant, the propulsion system is risk-free and easy to integrate into any platform. The Thruster performance are specified in the table below.



Specifications	Value
Nominal Thrust [mN]	6
Specific Impulse [s]	172
Total Impulse [Ns]	219
Power consumption Thrusting / Idle [W]	19.9 / 0.12
Wet Mass [g]	540
Propellant Mass [g]	130
Propellant	Water
Dimensions [mm]	Ø 80 x 80

TEST METHODS

The TunaCan Thruster was subject to the following tests during its qualification campaign:

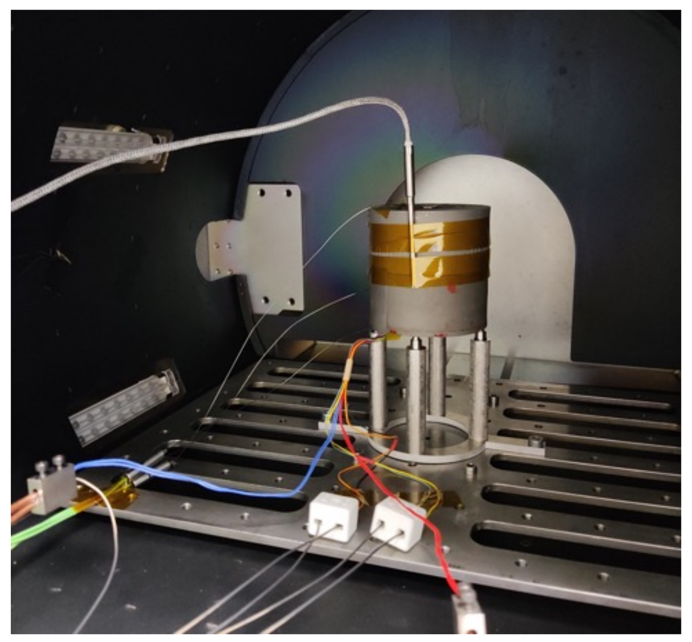
- Thermal Vacuum Test
- Random Vibrations Test

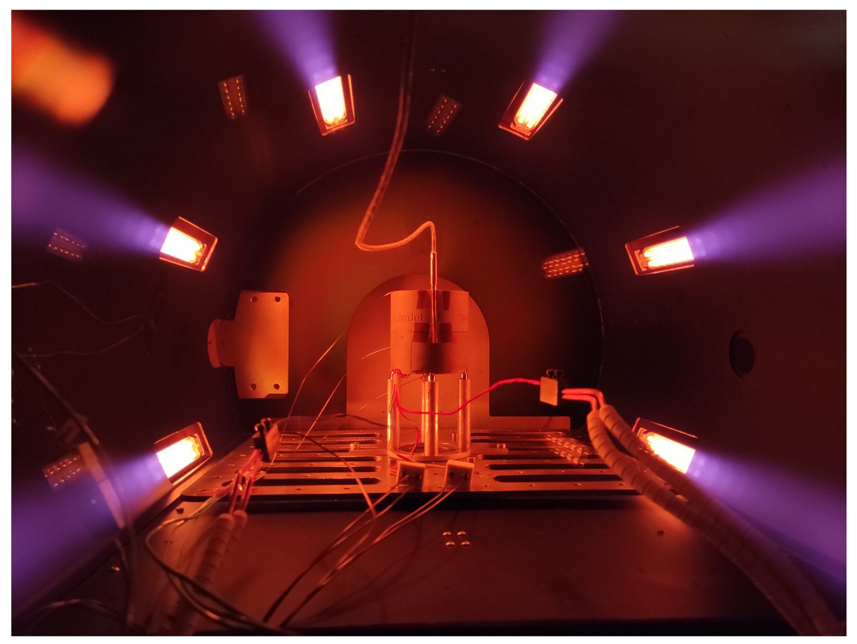
The test levels and durations were selected according to the international ESA and NASA standards ECSS-E-ST-10-03C , GSFC-STD-7000A , NASA-STD-7001 and NASA-STD-7002B.

THERMAL VACUUM

Thermal vacuum qualification is intended to demonstrate performance and survival in vacuum, under temperature conditions representative of a real orbit environment. An operational and a non-operational cycling temperature range was defined, as presented in the table below.

To guarantee a representative temperature measurement of the propulsion system, multiple temperature sensors were mounted on different areas.





Range	Max temperature (°C)	Min temperature (°C)	Hold duration (hours)	Heating/cooling rate (°C)/minute)	N. of cycles
Operational	+60 (±5)	+5 (±5)	6 (or equilibrium)	10(±2)	4
Non-Operational	+80 (±5)	-40 (±5)	6 (or equilibrium)	10(±2)	4

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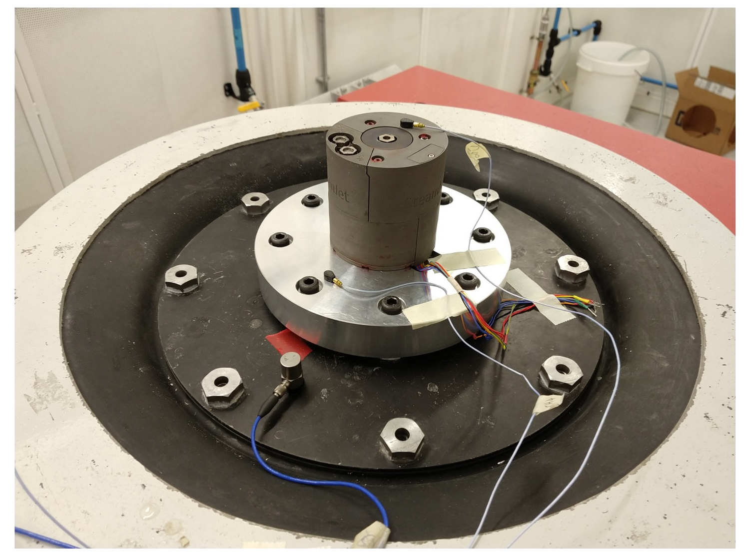
RANDOM VIBRATIONS



Random vibration is performed to qualify the hardware for the expected mission environment and to provide workmanship screening for all electrical, electronic, and electromechanical components.

The test environments selected for the qualification campaign consisted of two levels of random vibration as reported in the tables below. The test item was subjected to each of these random vibration environments in each orthogonal axes amounting to six individual random vibration tests. A modal survey was performed before and after each test run to verify possible structural changes.

Frequency (Hz)	ASD (g^2/Hz)	G_{RMS}
20	0.057	9.47
153	0.057	
190	0.099	
250	0.099	
750	0.055	
2000	0.018	

Frequency (Hz)	ASD (g^2/Hz)	G_{RMS}
20	0.026	14.1
20-50	+6 dB/Oct	
50-800	0.16	
800-2000	-6 dB/Oct	
2000	0.026	

TEST RESULTS

A functional test was performed before and after each test, to verify that the system was working nominally. During the Thermal Vacuum test at its operational temperature range, from +5 °C to +60 °C, the system was also tested at each Max and Min temperature. Results confirmed that the Steam TunaCan Thruster successfully survived the qualification campaign and was able to perform nominally throughout the whole test duration.

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