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Development of a Miniaturised GIE Propulsion System for Cubesats

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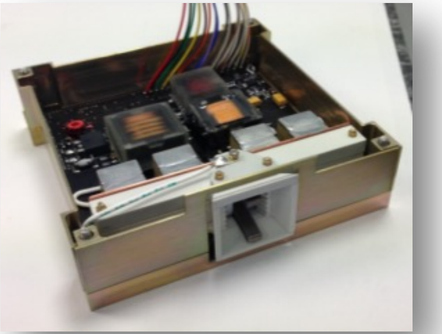
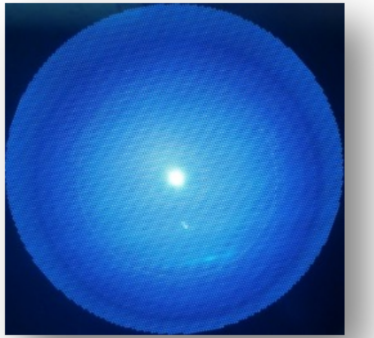
EPIC Workshop 9-12 May, 2023, Naples





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Outline

- Company Background Information
- Applications
- Thruster
- Harness
- Pipework
- TPM interface
- Neutraliser
- FCU
- Tanks

Company Structure and Facilities

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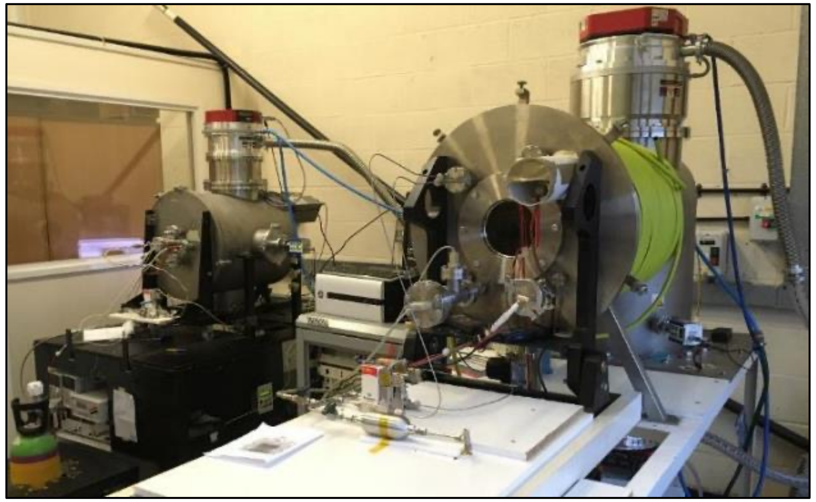
Relocation to a Larger Facility

- MSL is investing substantially in large test facilities
- New premises, ADANAC, Southampton > 14,478 sq ft
- Large vacuum chambers and equipment recently purchased from QinetiQ
- Vacuum chambers: 2 large, 1 medium, 6 small

Current Company's Size

Mars Space presently employs 15 engineers with extensive expertise in EP technology, diagnostics and testing with projections to 20 persons by the end of the year



Potential mission applications

Propulsion requirements of M-argo:

High Delta-V Propulsion unit required

Power to EP @ 1 AU	93 W (6 panels)	120 W (8 panels)
Thrust @ 1 AU	1.7 mN	2.4 mN
Isp @ 1 AU	3050 s	3180 s

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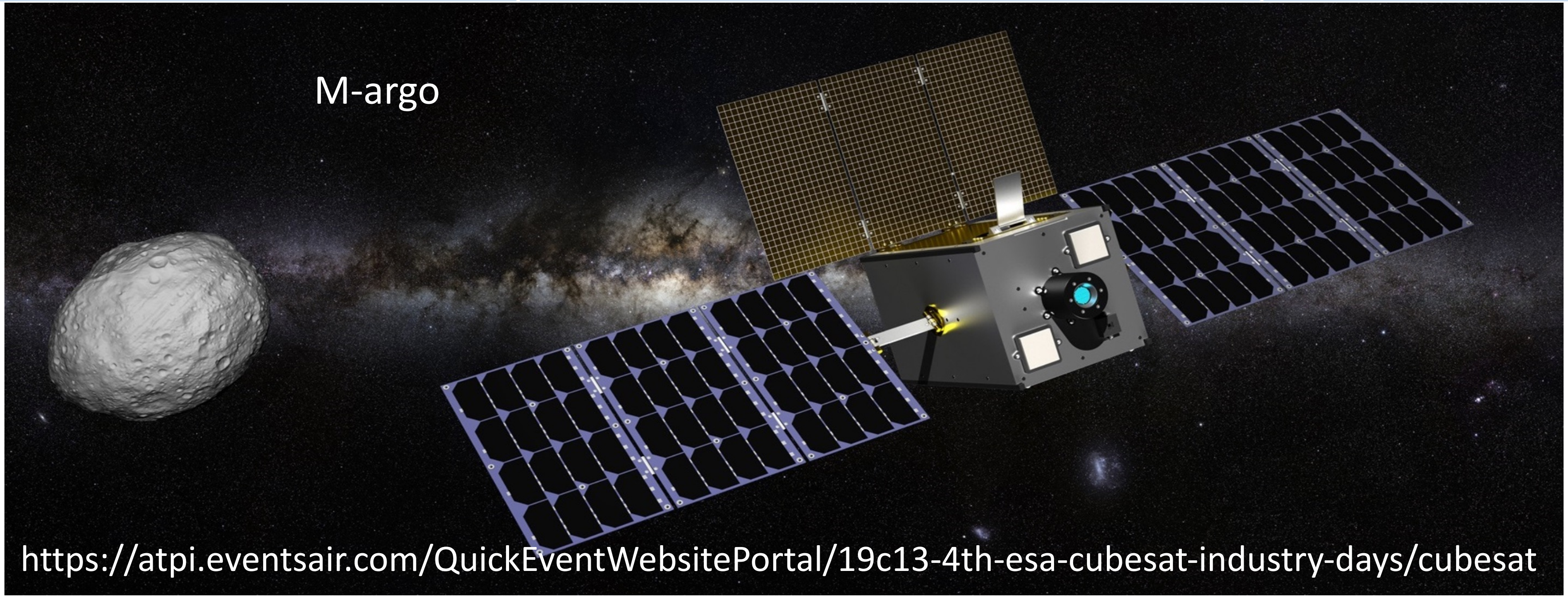

Other Applications

- Low Earth Orbit (LEO) mega constellations;
- The study of space weather (HENON)
- Ultra-low Earth orbit observation (relying on the EP for drag compensation)
- GPS and communication constellations around the Moon and Mars
- Deep-space exploration

EP technology transfer from fundamental Earth Observation missions that open the gate to New Era of low-cost Space Exploration

Example of a possible GIE subsystem architecture

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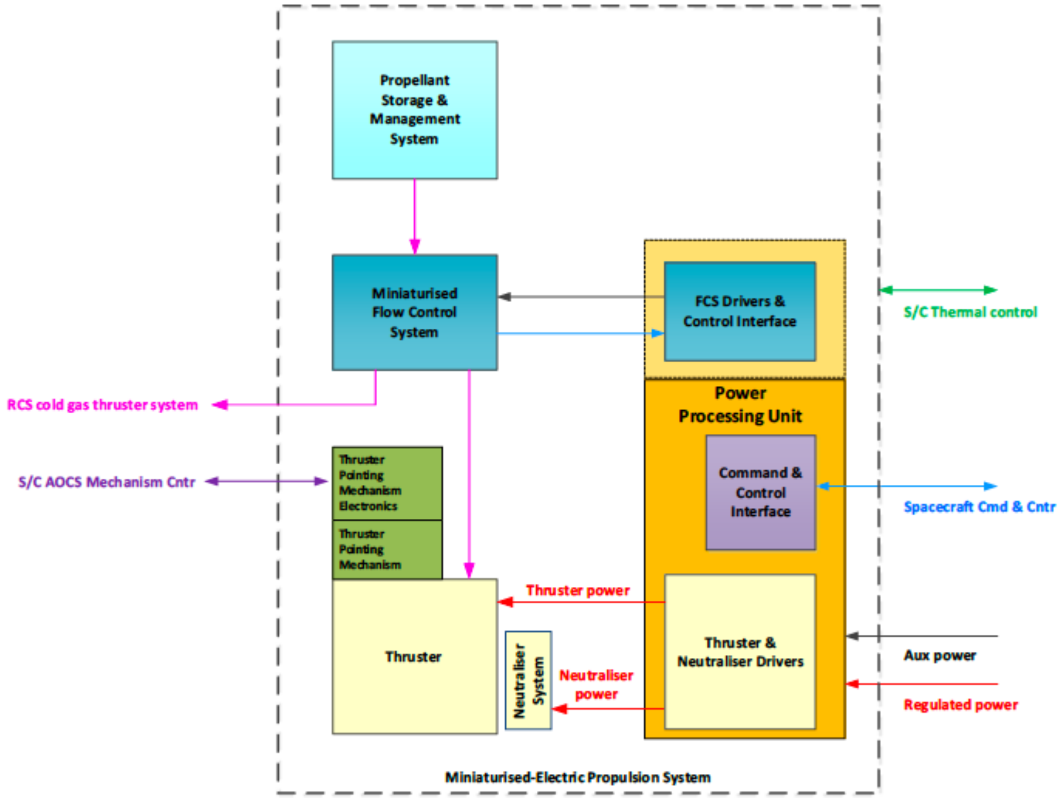

Figure 1: potential EP system architecture (example)

PPU to be specified, including

1) RFG and RFG PSU
2) grid power supplies;
3) neutraliser power supplies;
4) MFCS drivers and control;
5) Physical (size, mass, accommodation);
6) Electrical interfaces (power, cmd/cntrl)

RIT3.5 RF Thruster Development

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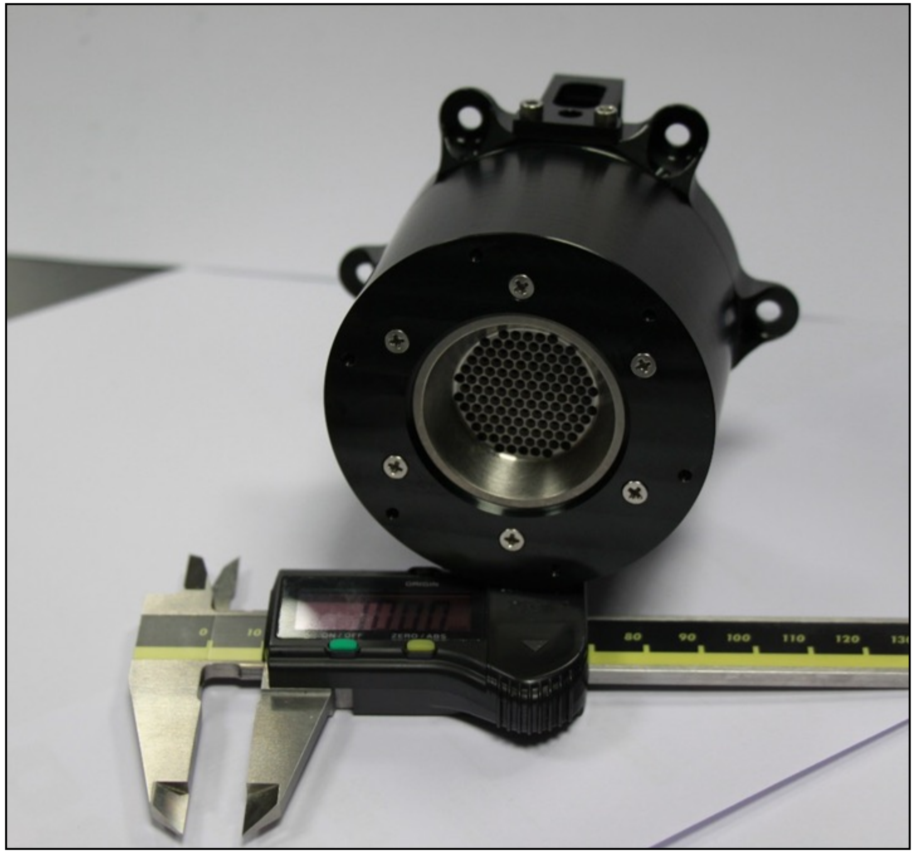
Miniature Ion Thruster, Neutralizer and Harness Development / Qualification and Pointing Mechanism Integration

- Engineering model of Radio Frequency Mini Ion Engine RIT3.5 was originally designed by Transmit (D) in the frame of ESA TRP programmes to fulfill the propulsion requirements of ESA Next-Generation Gravity Mission (NGGM)
- MSL has acquired the rights to the thruster design and signed a collaboration agreement with TransMIT.
- The GSTP Qualification Program allowed the technology to be considered for the NGGM Mission – Ongoing Pre-development activities with the Agency



RIT3.5 EM: requirements vs tests

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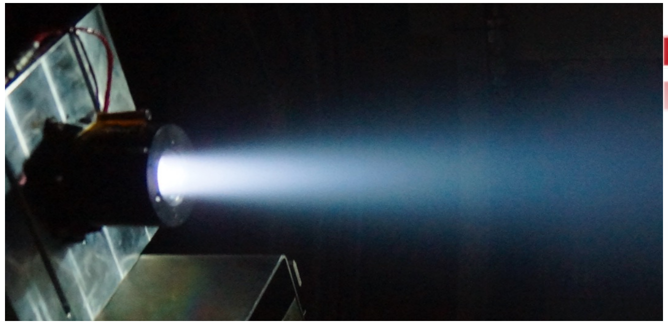

Parameter	Unit	Collinear Lateral Thrusters	
Minimum Thrust	mN	0.05 (0*)	C
Maximum Thrust	mN	>2.5	C
Thrust Resolution	µN	0.5	C
Thrust Noise		<1µN/√Hz above 0.08Hz	C
Rise/Fall Time	ms	< 50	C
Slew Rate	mN/s	> 0.5	C
Update command rate	Hz	10	C
Thrust non linearity		< 2%	C
Lifetime	yr	> 10	
Specific Power	W/mN	< 40	C
*** Thrust has to be turned off completely if thruster is not operating**			

- A detailed characterization test campaign confirmed the compliance of the thruster to the mission profile and together with thermo-mechanical modeling (NASTRAN, ESATAN) exercises performed against NGGM predicted enviroment allowed qualification of the thruster as engineering model at TRL5 with defined delta-qualification for TRL6 (vibration test is to be carried out Q4 2019)
- Lifetime was assessed with the help of Ion Optic System erosion model that has been validated through 1000h Endurance test campaign

High confidence system going through full qualification path instead of CubeSat fast track

RIT3.5 EM: performance

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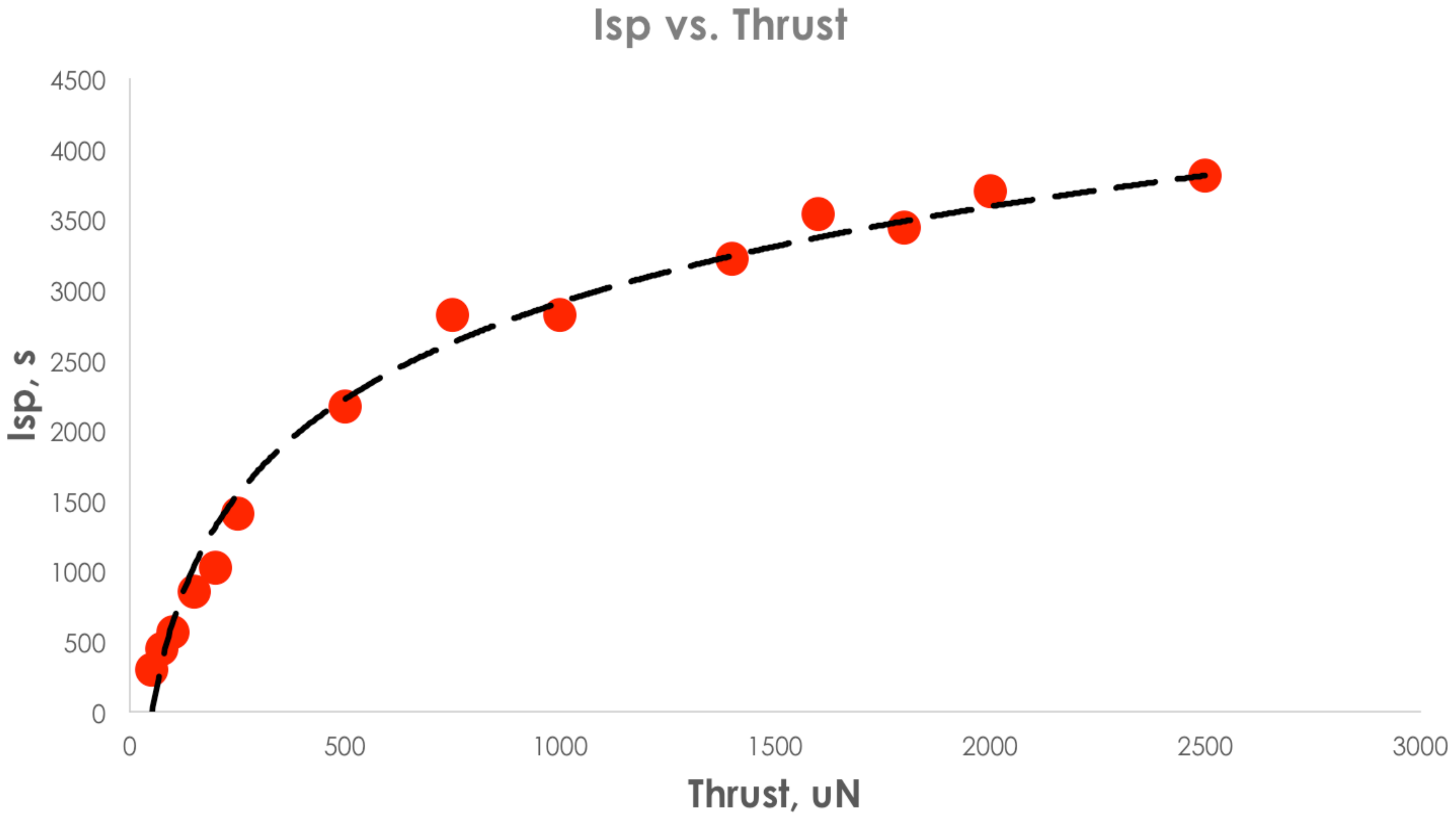

RIT3.5 EM: performance

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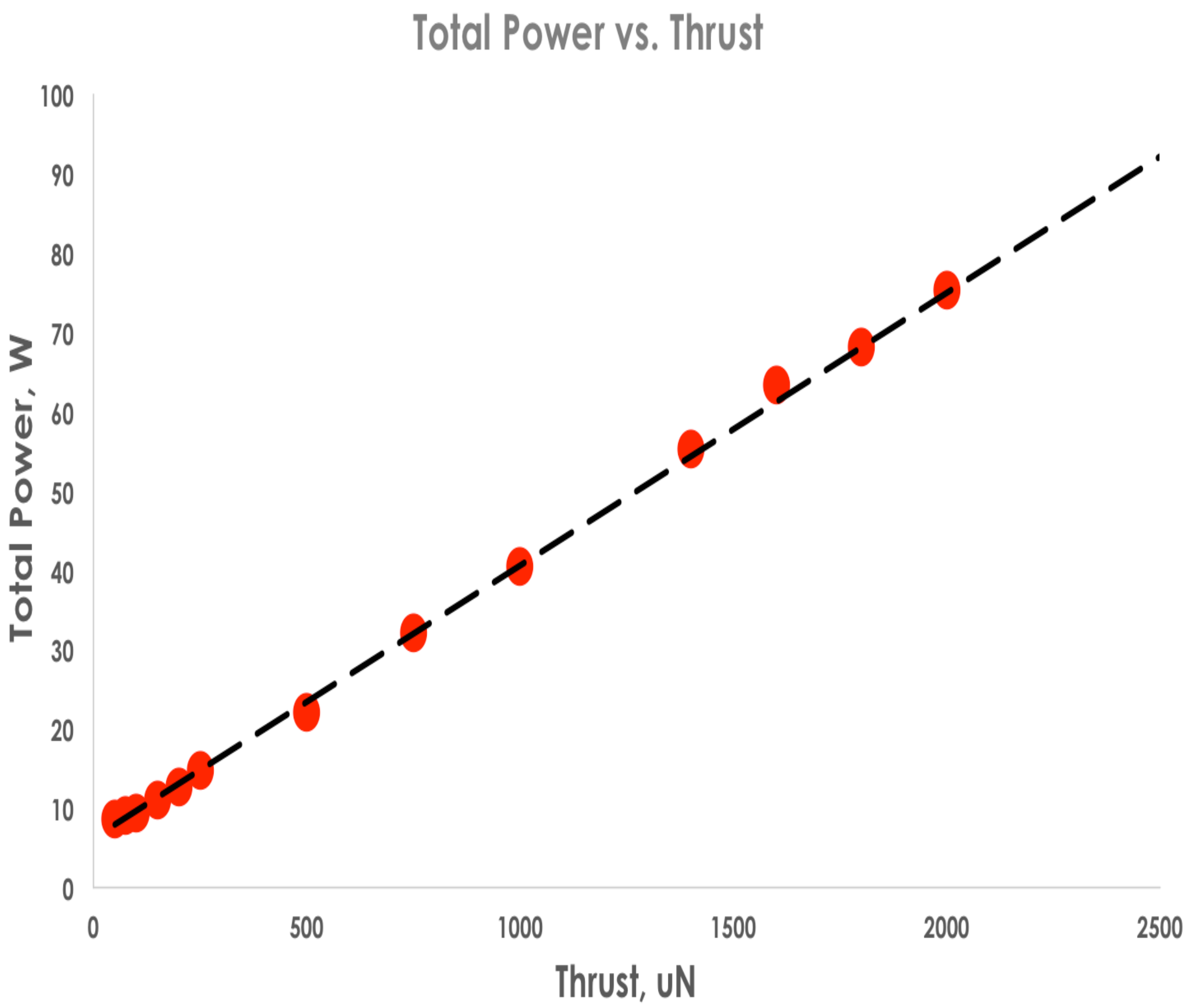

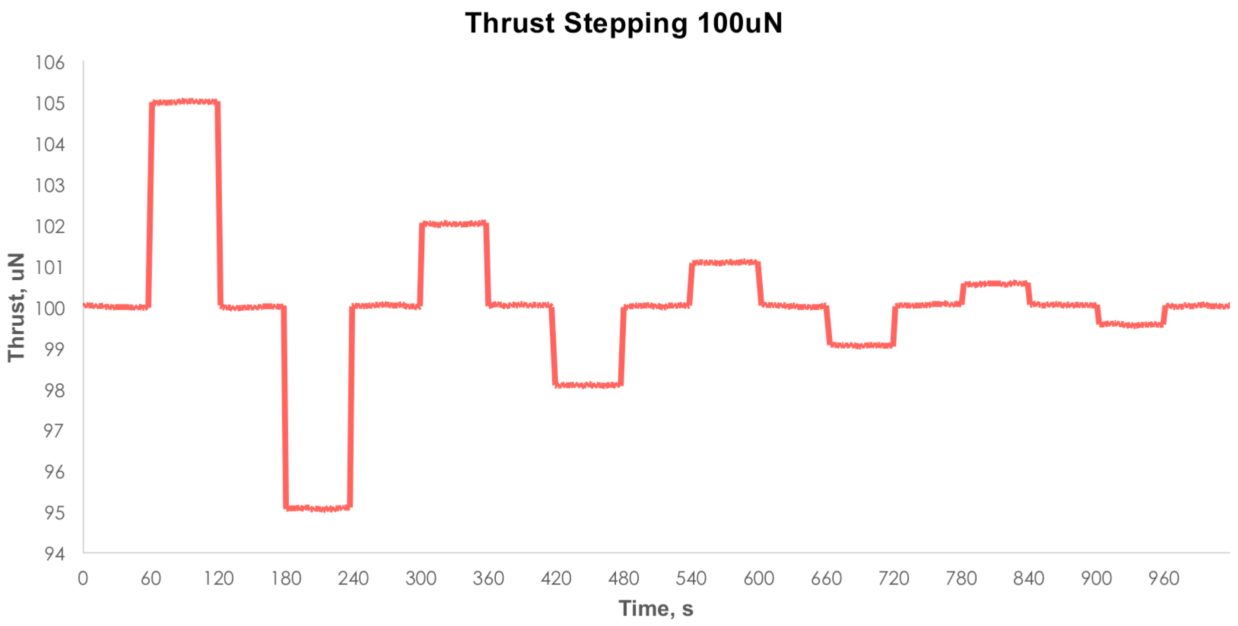

RIT3.5 Cubesat Program

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Miniature Ion Thruster, Neutralizer and Harness Development / Qualification and Pointing Mechanism Integration

- Detailed Requirement Specifications
- Performance Optimisation
- Subsystem Manufacture and Manufacture Process Qualification
  - Establish manufacture supply chain
  - Materials and manufacture process development and qualification
- Neutralisation Concept
  - Identify candidate neutraliser technologies
  - Trade-off (power and Isp) and selection for development qualification
  - Lifetime assessment of the Neutraliser and performance modelling
- Model Development
  - Performance
  - Thermal
  - Mechanical
- Harness Development
- Pipework Development
- Qualification Testing (Target TRL6)
  - Component level tests (neutraliser, EM engine, harness and pipework)
  - Environmental tests (mechanical, thermal)
  - Endurance test (including on/off cycles, minimum 2000 hours)

Thruster Pointing Mechanism(courtesy AVS)

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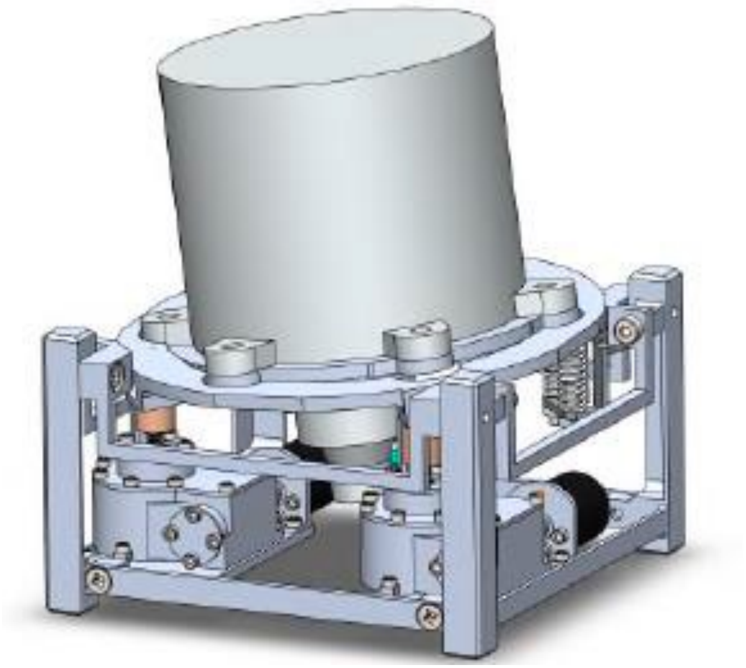
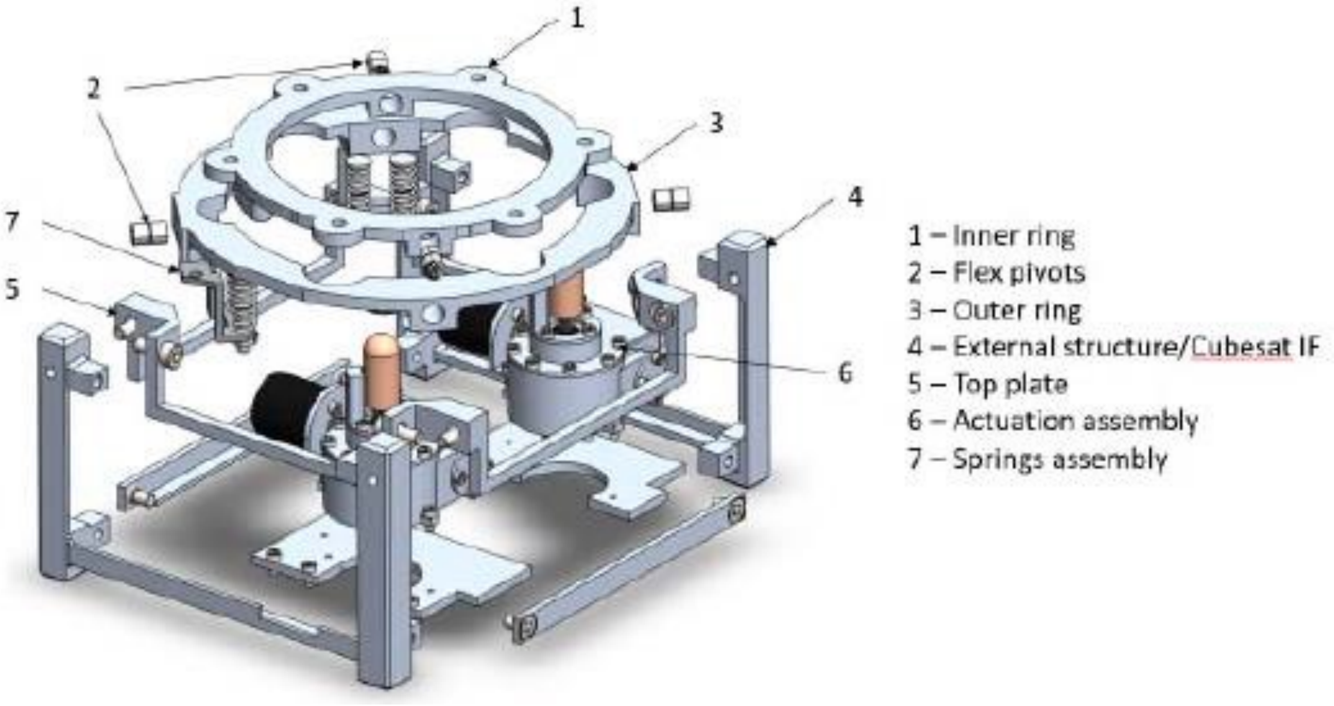
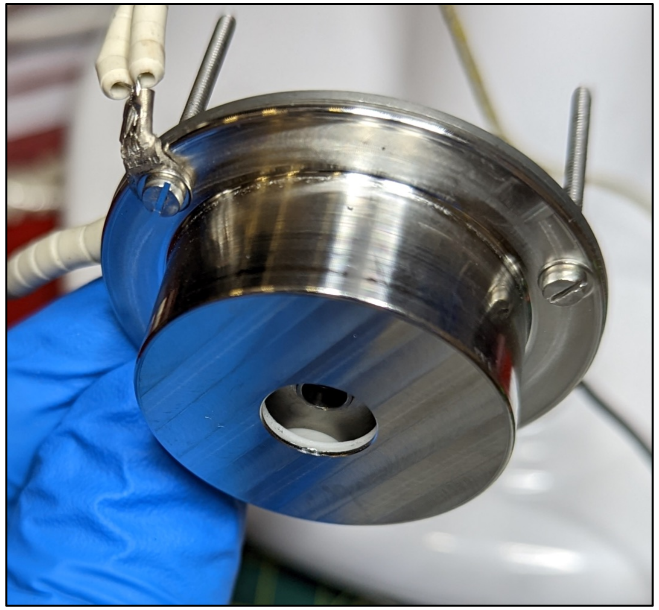


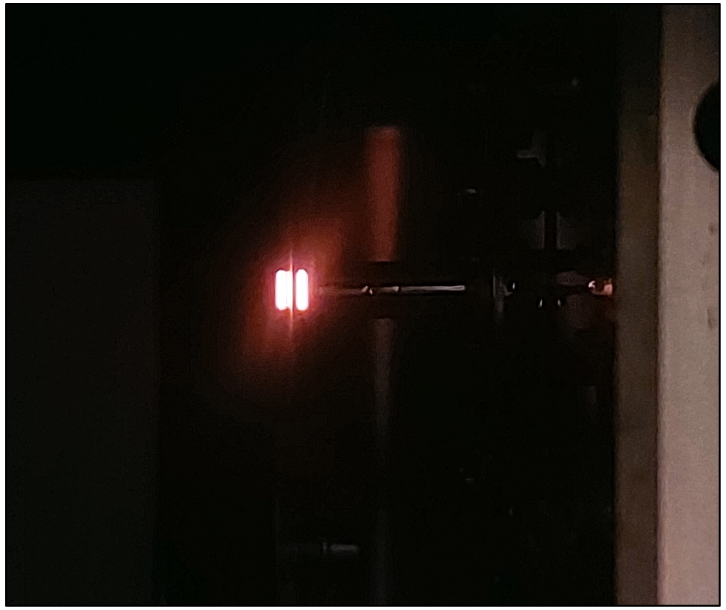


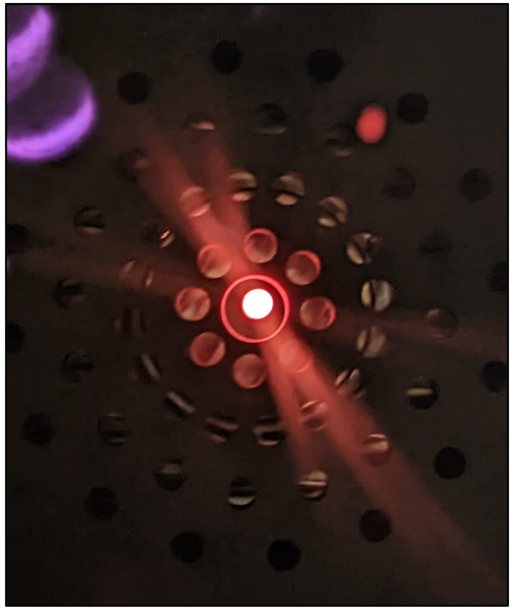
RIT3.5 Program

Miniature Ion Thruster, Neutralizer and Harness Development / Qualification and Pointing Mechanism Integration

- Ongoing Dry Neutraliser Development
  - Model development and Prototype Design
  - Materials and manufacture process development and qualification
  - Performance Characterisation in Diode Mode







Dry neutralizer : (only emitter & anode

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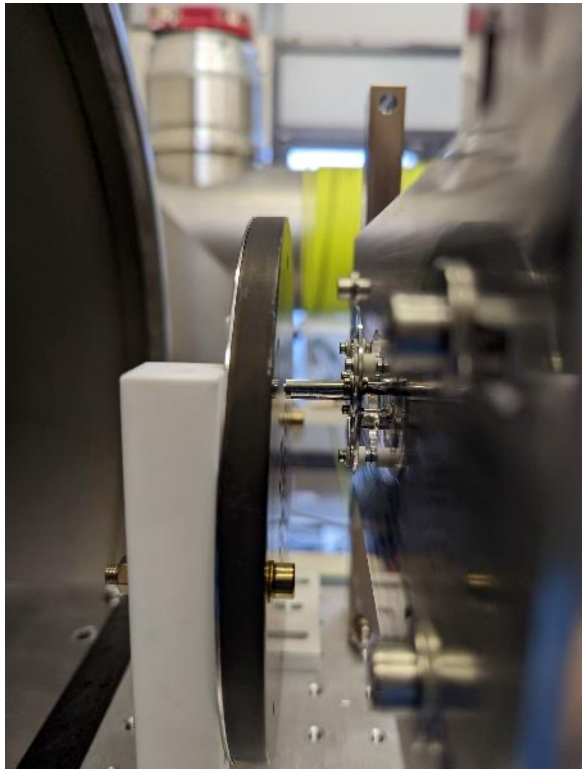

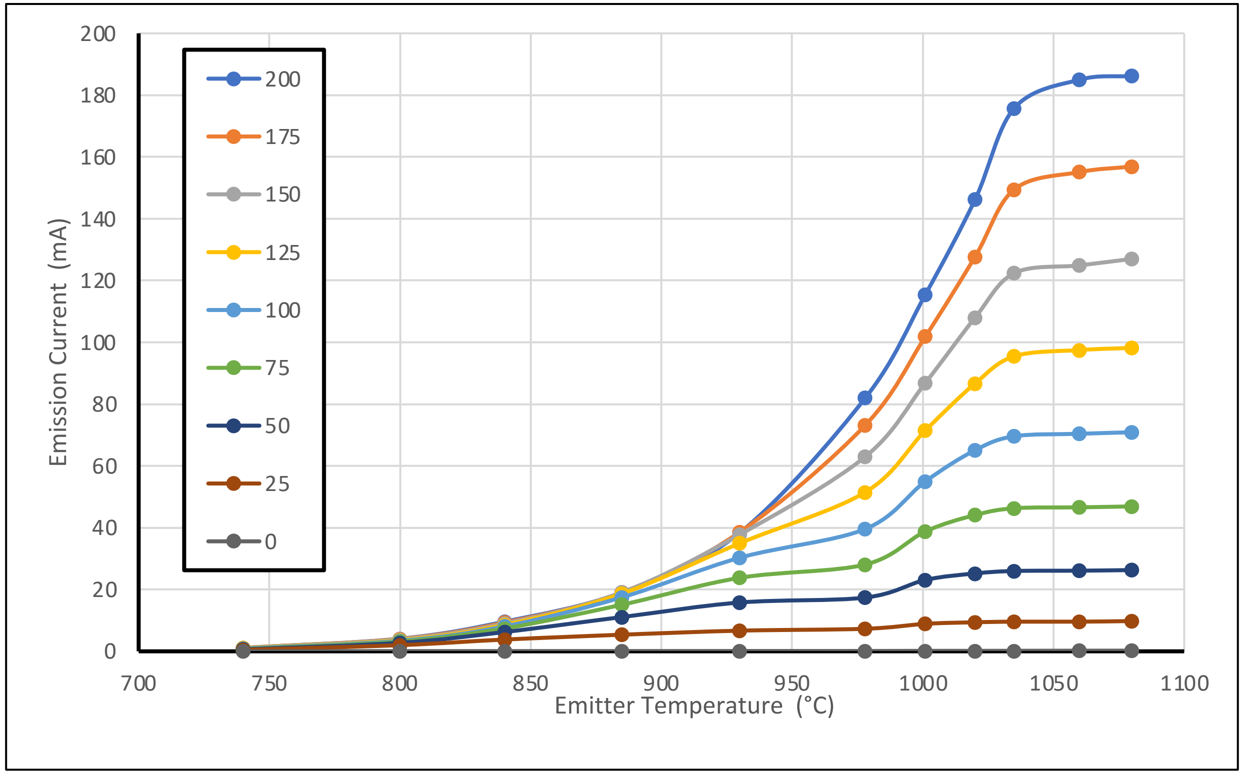

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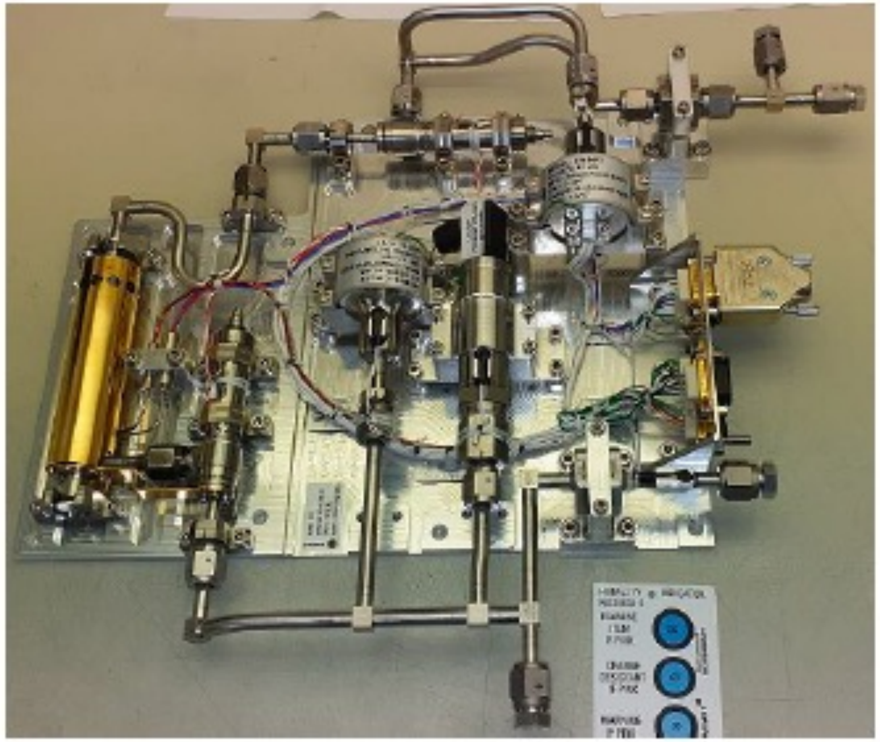
Flow control unit(Nammo)

Figure 2 – EPR Engineering Model developed by Nammo



Development 'goal' is an MFCS architecture in which a single control valve (or at least a single valve technology) provides single stage regulation with a very wide flow range for both EP and RCS operations

Propellant Tank (TWI)

Figure 1 – TWI's Bread-board Propellant Tank

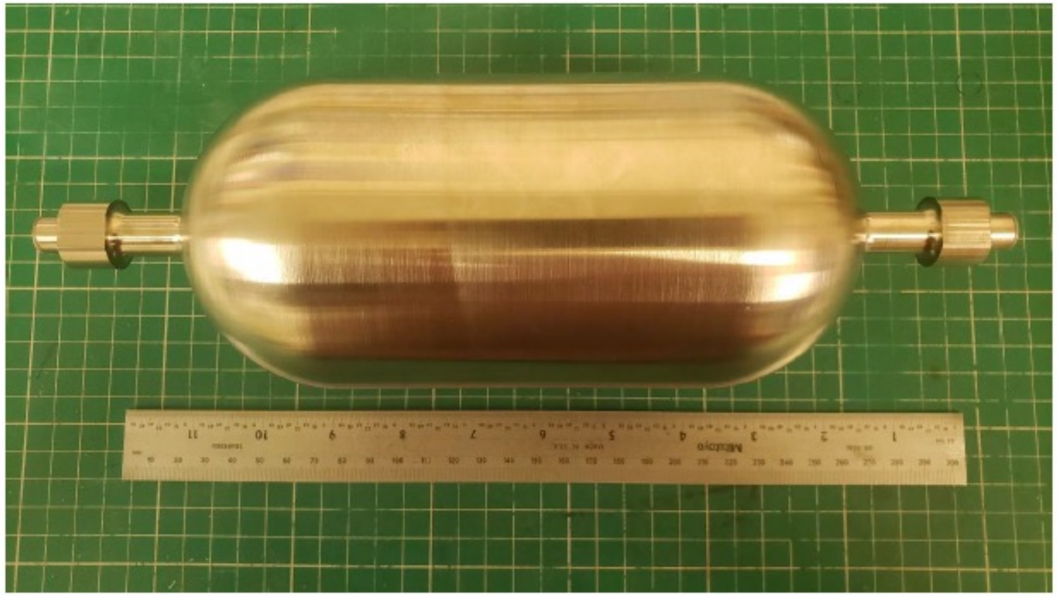


Photo courtesy of TWI

Target specification

- Accommodation of x2 propellant tanks in a 4U volume
- Mass target TBD
- Capacity (volume) target TBD

Potential advantages of cold spray additively manufactured propellant tanks:

- Seamless construction
- Significantly lighter
- Stronger
- Cost and time savings


Thank you for your attention