

Testing and Qualification of EP Thrusters at the FOTEC Propulsion Laboratories

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Company Overview



University of Applied Sciences Wiener Neustadt

- Founded in 1994
- 34 bachelor / master programs
- 3500 students



Subsidiary



FOTEC Forschungs- und Technologietransfer GmbH

- Research subsidiary, carrying out R&D Projects with industry. Owned by University.
- 30+ years of experience manufacturing flight hardware for scientific missions (ESA, NASA, ...)



R&D Projects



Product Spin-Off



ENPULSION

Exclusive License to
Commercialize FOTEC
Propulsion technologies

The IFM Nano Thruster Module

Key Characteristics

- Dynamic Thrust Range: 1 to 350 μN , nominal: 300 μN
- Specific Impulse: 2,000 to 7,000 s
- Propellant mass: up to 250 g Indium
- Total Impulse: more than 5,000 Ns
- Outer dimensions: 94 x 90 x 78 mm
- System mass: 620 g (dry), 870 g (wet)

PPU Features

- Emitter: up to 10 kV, up to 4 mA
- Extractor: down to -10 kV, down to -500 μA
- Heater: up to 8 V, up to 3 A
- Neutralizer filament heater: up to 5 W, two selectable filaments
- Neutralizer bias: -200 V
- Contactless temperature measurement

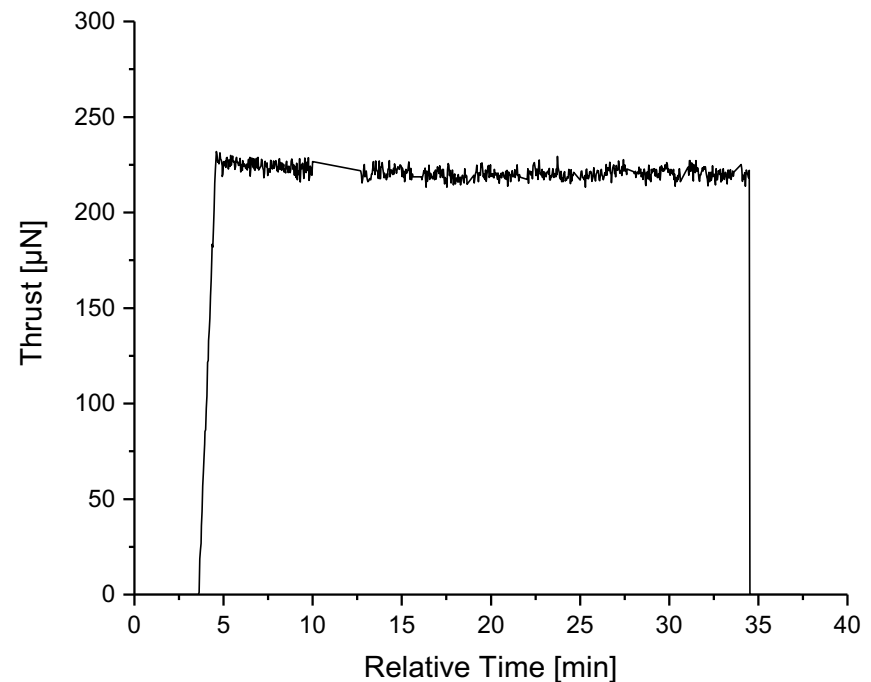
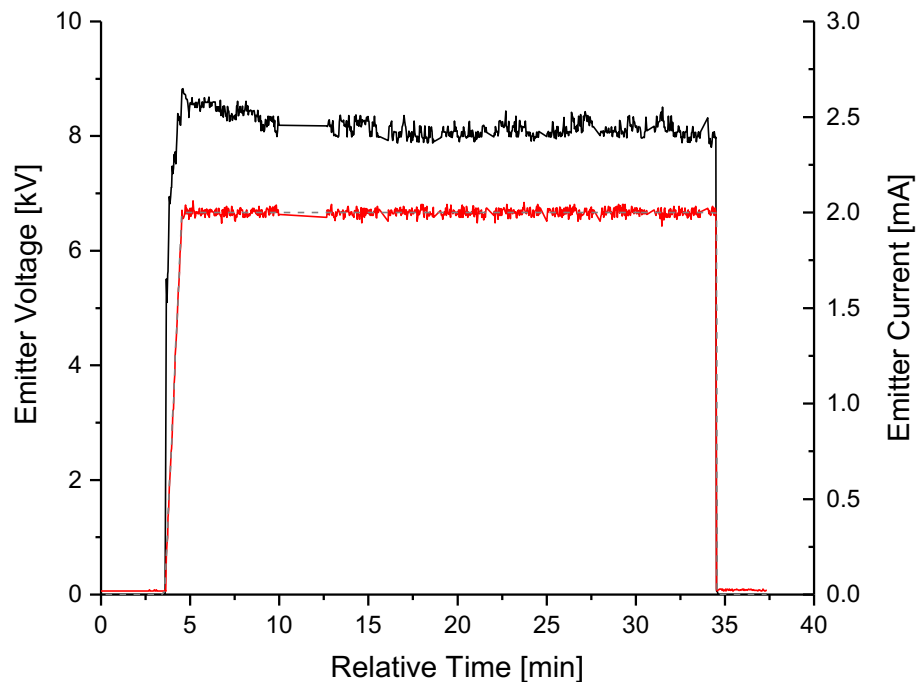


In-Orbit Demonstration



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- Continuous operation for 30 minutes at 2 mA emitter current
- Good accordance between reference and measured current



Emitter voltage (black), emitter current (red) and
commanded emitter current (dashed).

In-Orbit Demonstration (cont'd)

Test Summary

- Internal thrust computation: 226 μN (begin) to 220 μN (end)
- Very stable operation
- Spacecraft attitude could not be maintained for the whole period (wheels saturation)

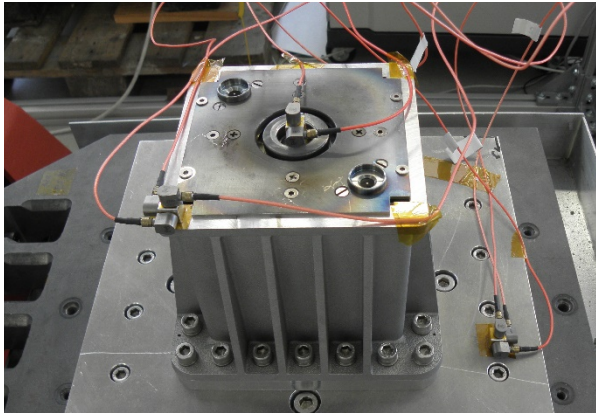
Orbital Change

- Expected Δv : 6.68 cm/s (considering cosine losses)
- Expected orbit raise: 115 m
- Verified orbit raise (GPS data with 50x50 Earth gravity field model): 116 ± 5 m/s
- **Excellent accordance between predicted and confirmed orbit raise**

In-house Electric Propulsion Testing Facilities

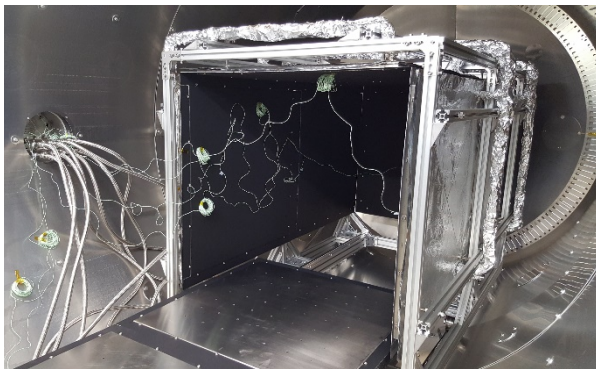
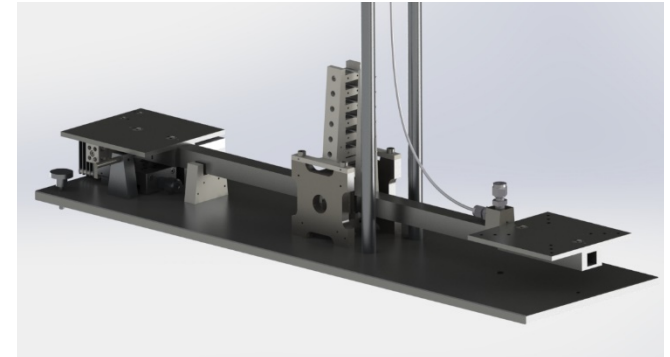


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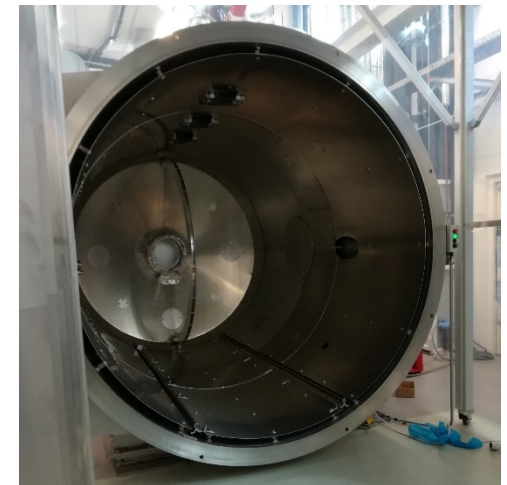
Thrust balance development
0.1 μN to 100 mN
Verified at EPL/ESTEC

Vibration Testing
Shock Testing



Plume characterization
23 Faraday cups
QCM and RPA measurements
Large chamber: 2.5m \varnothing , 4m length

Thermal Shroud -60 to + 90°C
2x1x1m usable volume
Vacuum pressure < 10^{-6} mbar

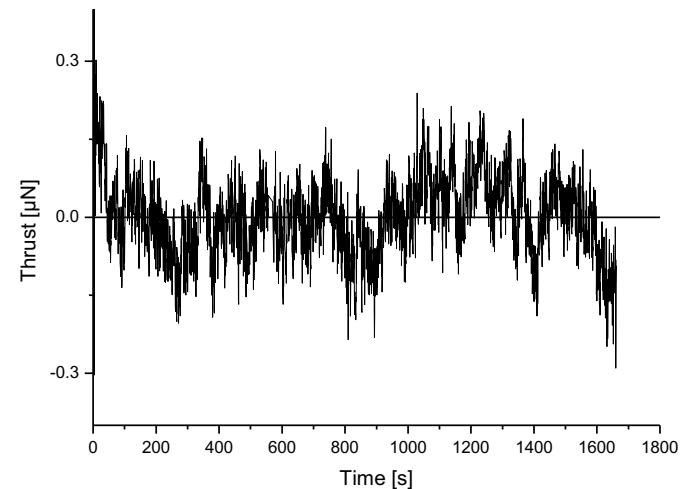
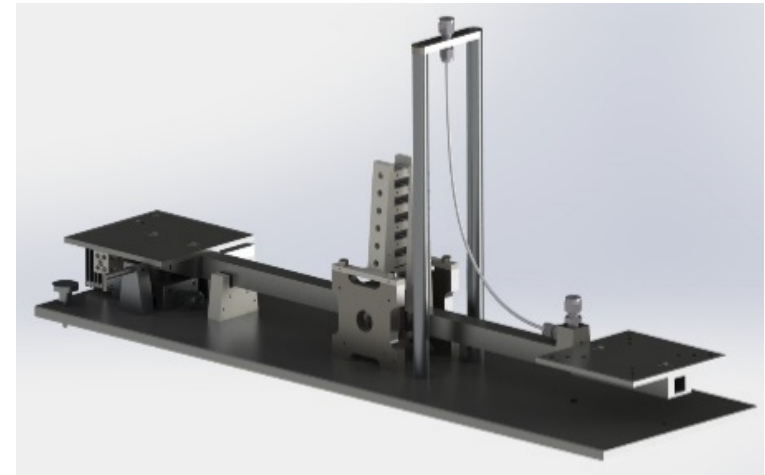


μN to mN Thrust Balance



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- Horizontal deflection balance suspended by spring bearings
- Developed for electric propulsion and cold gas thrusters
- Gas and friction-less electric feed-throughs
- Thrust range: $0.1 \mu\text{N}$ to 100 mN
- Force-feedback control with electrostatic and electromagnetic force actuators
- Low thrust noise: $< 0.15 \mu\text{N}_{\text{RMS}}$ (range: $500 \mu\text{N}$)
- Low drift rate: $< 2 \mu\text{N/h}$ (range: $500 \mu\text{N}$)
- Verified at ESTEC/EPL with MOOG cold gas thruster



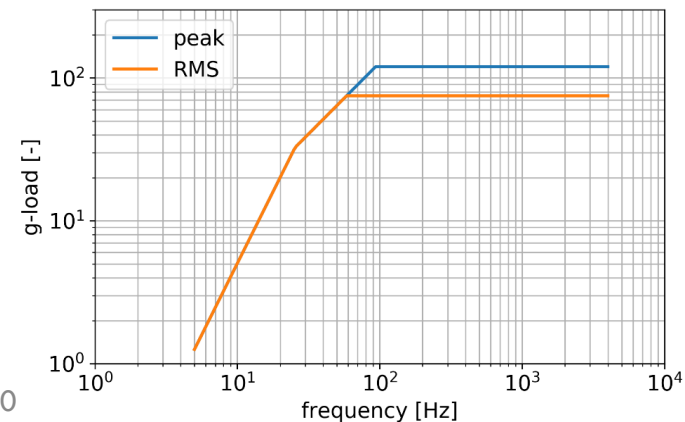
Shaker

- Rated sinusoidal force: 8896 N
- Rated random force: 5782 N
- Usable frequency range: 5 – 4000 Hz
- Maximum displacement amplitude: 25.4 mm
- Rated peak velocity: 2.0 m/s
- Maximum acceleration:
 - 120 g peak
 - 75 g RMS
- Maximum payload mass (vertical operation): 160 kg
- Fundamental armature resonance: 3000 Hz



Shock table

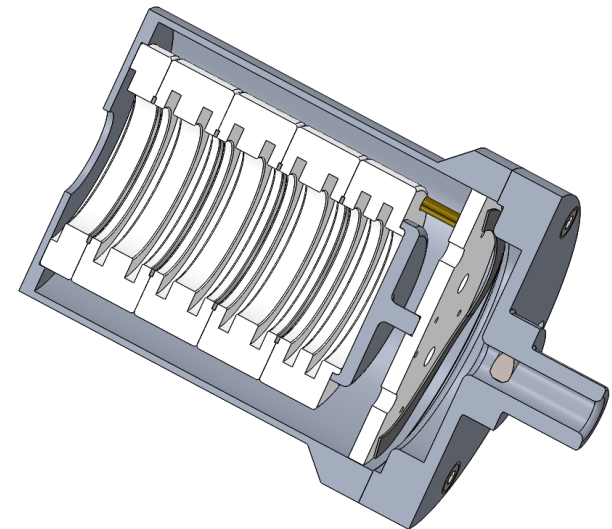
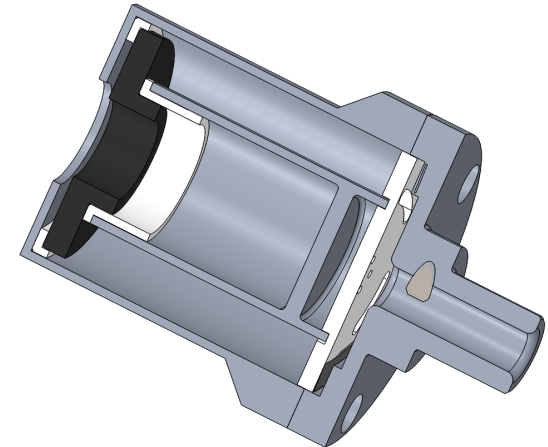
- Shock response up to 1024 g



Plume Characterization

Faraday cups and RPAs

- Plume characterization with:
 - Langmuir probes
 - planar probes
 - Faraday cups
 - Retarding Potential Analyzer (RPA)
- In-house design of Faraday cup and RPA optimized for LMIS
- Design based on numerical simulations and experimental verification
- Specifically designed for low electron density plasma fields
- Probes mounted on a remotely controlled boom allowing scans of a whole hemisphere



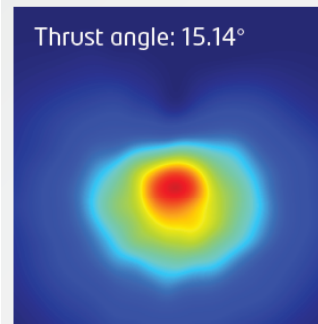
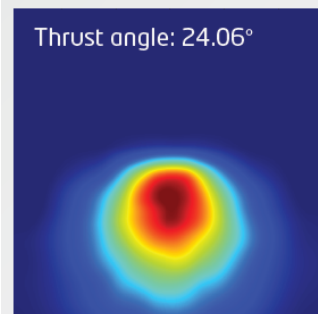
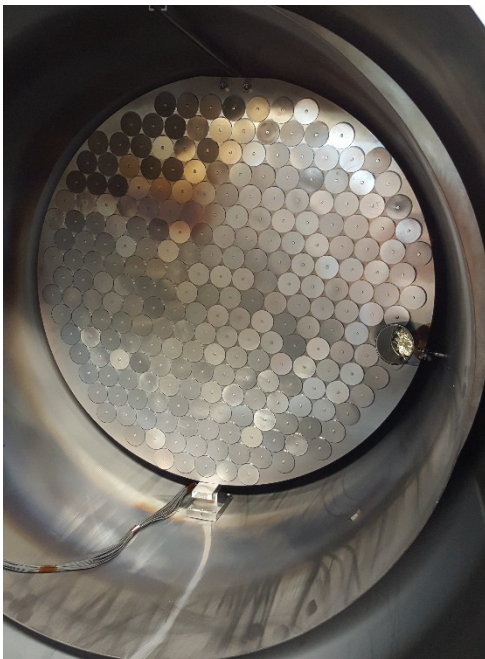
Plume Characterization (cont'd)



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Segmented collector

- 250 planar probes
- Real-time monitoring of beam divergence and deflection
- Update rate up to 7 Hz



SIMULATION

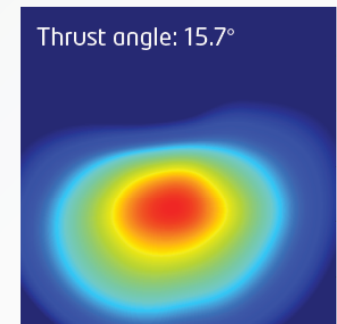
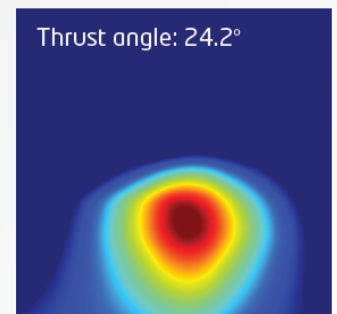
5 needles firing
Emitter: 12 kV / 1 mA
Extractor: -5 kV



14 needles firing
Emitter: 18 kV / 6 mA
Extractor: -5 kV



OPERATING CONDITIONS



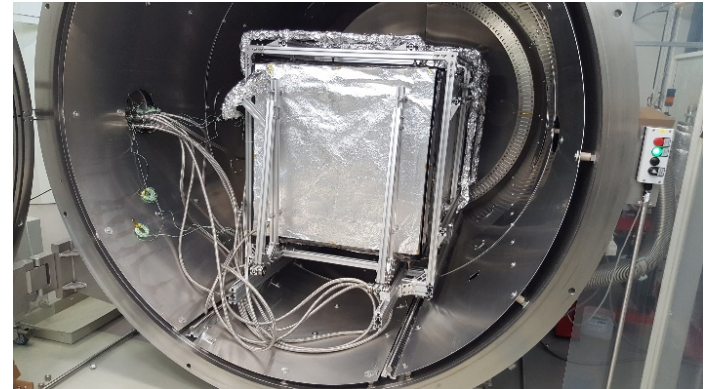
MEASUREMENT

Thermal Vacuum Tests



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- Volume: 2x1x1m
- Vacuum pressure: $< 10^{-6}$ mbar
- Removable process plate for DUT mounting
- Individually controllable process and shroud
- Process plate: -40 to +90 °C
- Shroud: -60 to +90 °C
- Temperature ramp: up to 15 °C/h
- Interior covered with vacuum-compatible high-emissivity coating
- Scripted temperature ramps and DAQ



Thank You for your Attention!
