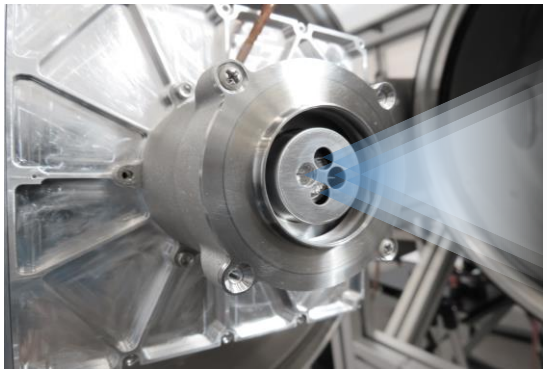
Electric Propulsion Technology for Active Spacecraft Potential Control

EPIC Workshop
9-12 May, 2023
Naples, Italy



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Agenda

- Motivation
- EP Technology for ASPOC
  - Technology Details
  - Emitter Module
  - Electronics Control Unit
  - Results Summary
- Key Features
- Follow-up Development
- Roadmap
- Development Branches

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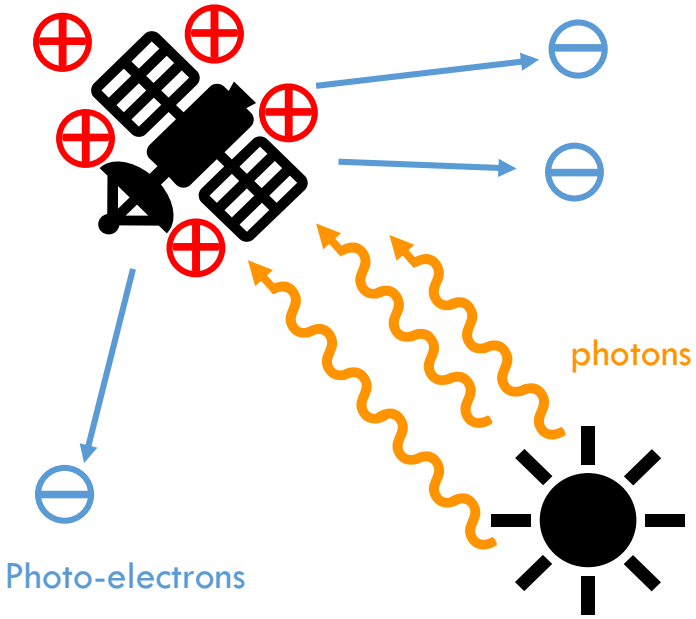
EP Technology for Active Spacecraft Potential Control

Motivation

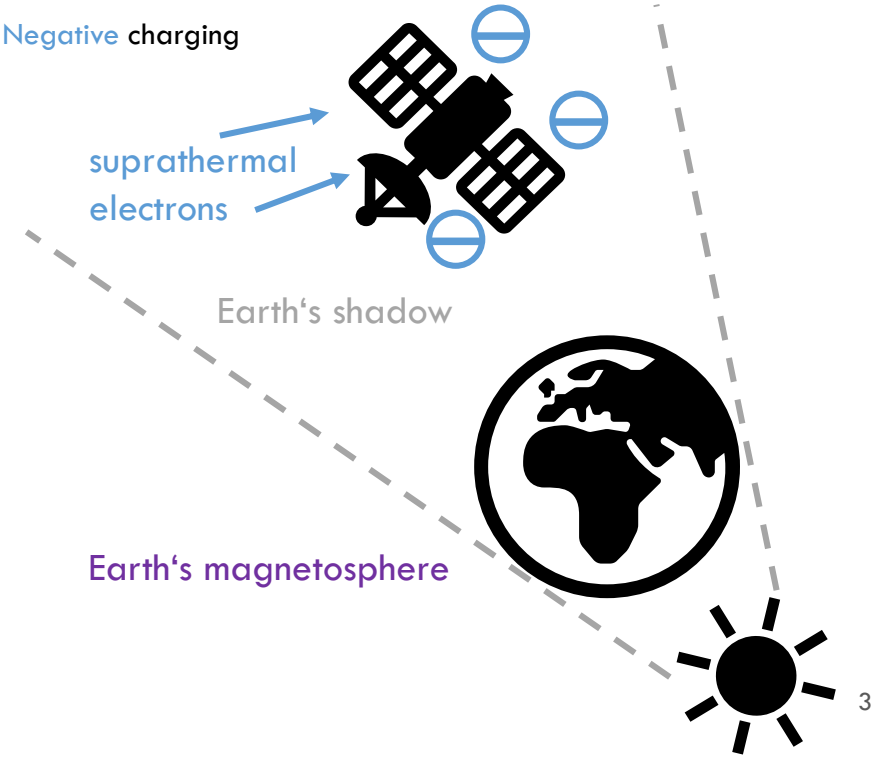
Spacecraft exposed to **sun**

→ Positive charging



Spacecraft in **Earth's shadow**

→ Negative charging



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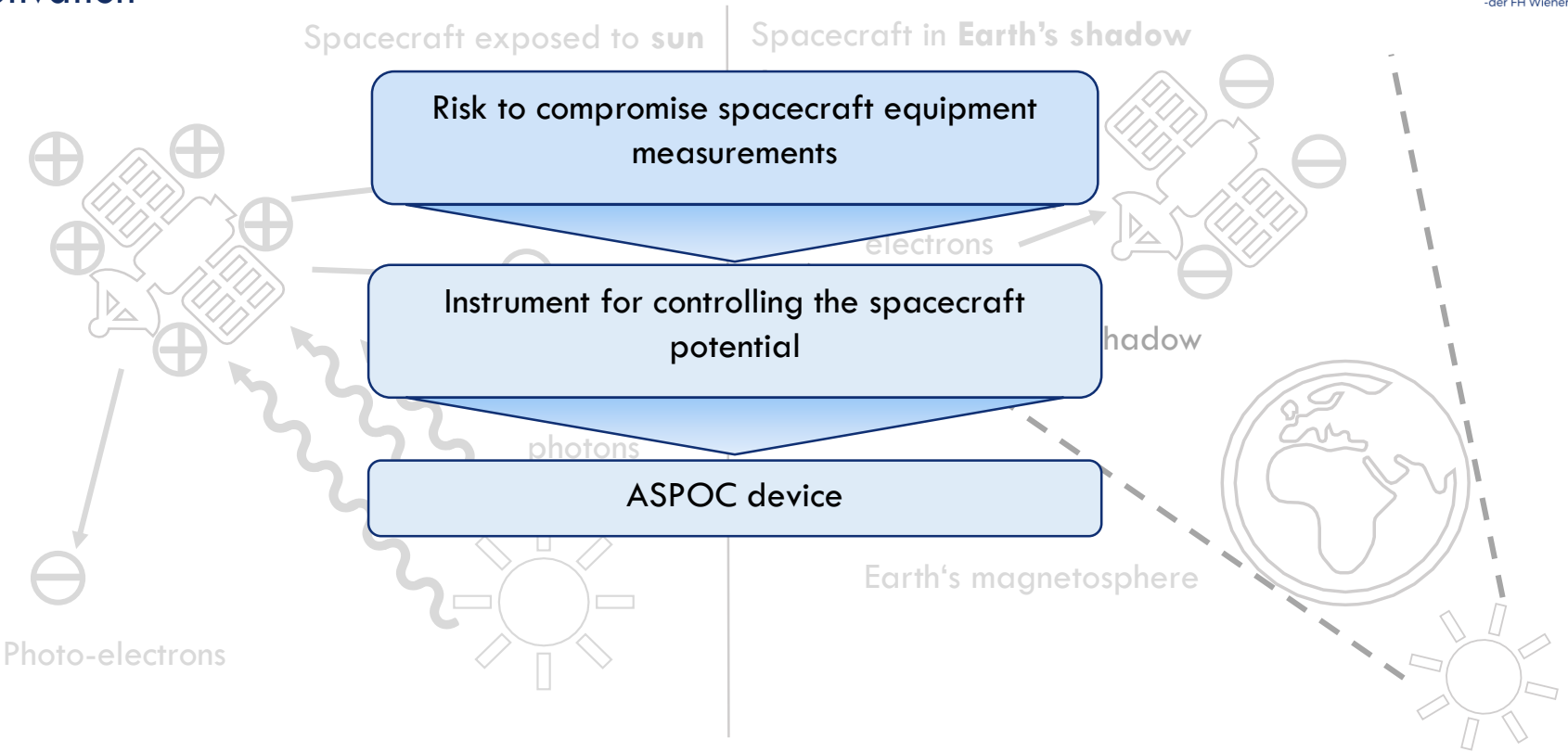
Motivation



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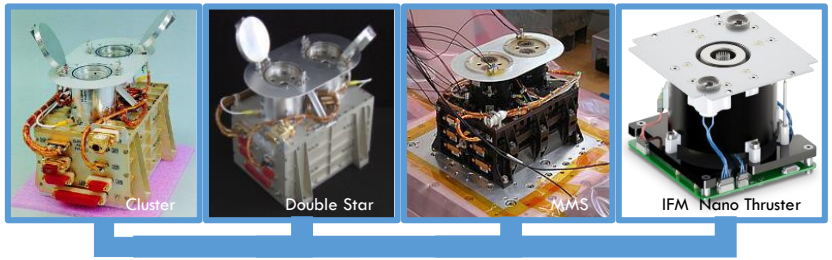
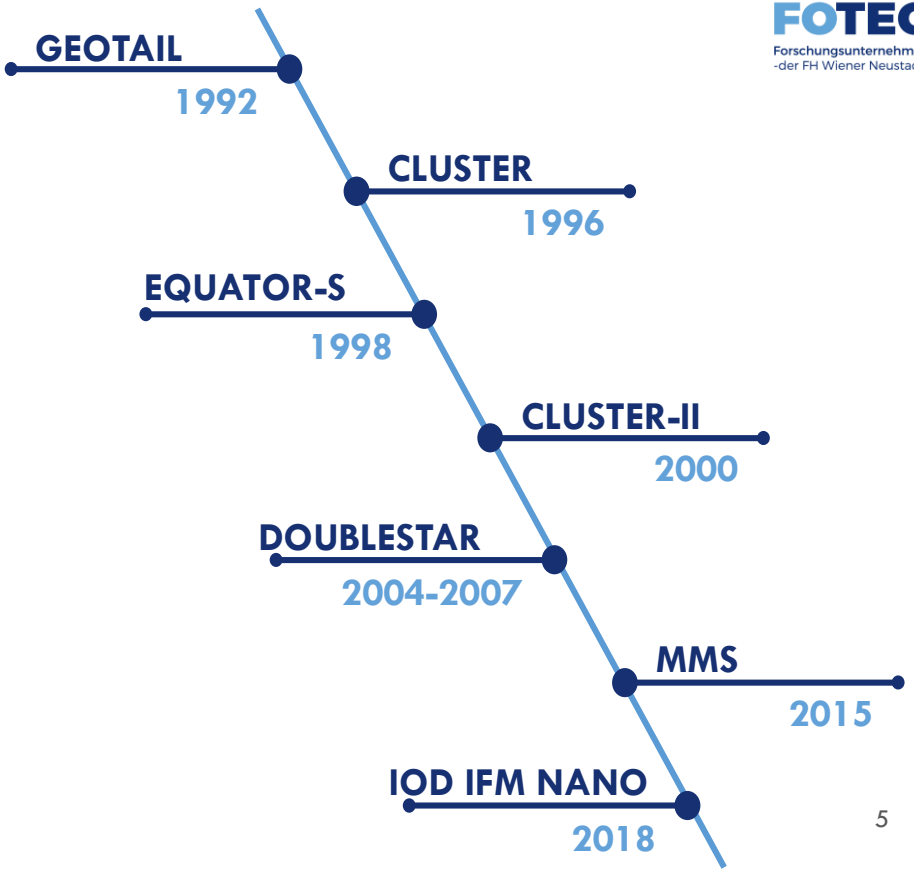
Technology Details



Instrument based on

- Previous mission experience
- FOTEC's proprietary FEEP technology (i.e. IFM NANO Thruster)



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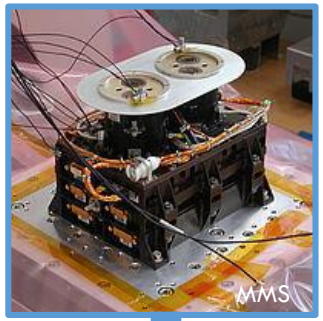
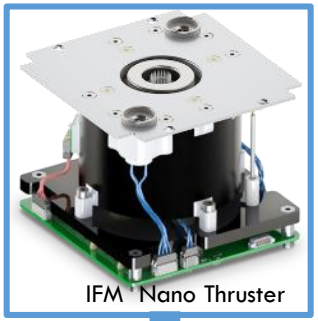
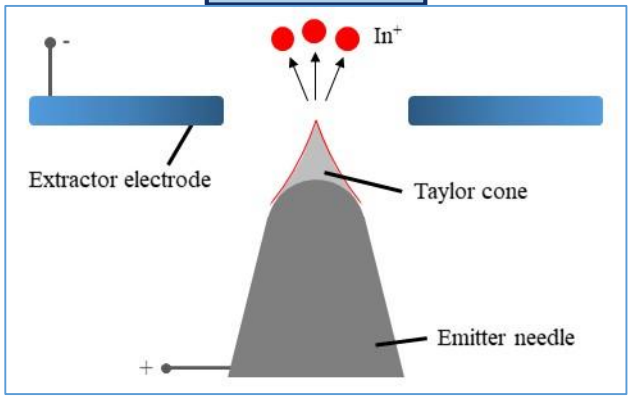
Technology Details





ASPOC + FEEP devices were based on Liquid Metal Ion Source (**LMIS**) technology

LMIS principle



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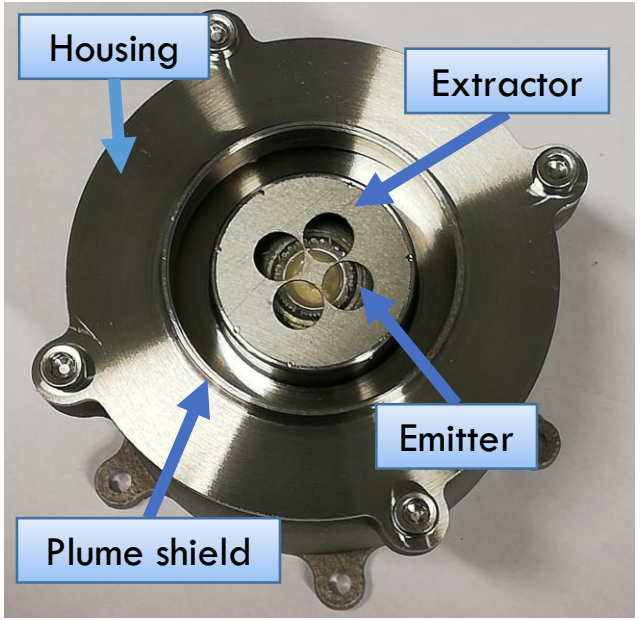
ASPOC Next Generation Emitter Module: Design challenges

- Potential control device with **reduced mass and power consumption**
  Change from pure indium → alternative propellant
- **Increased mass efficiency** and controllability
  Change from capillary → porous needle emitter



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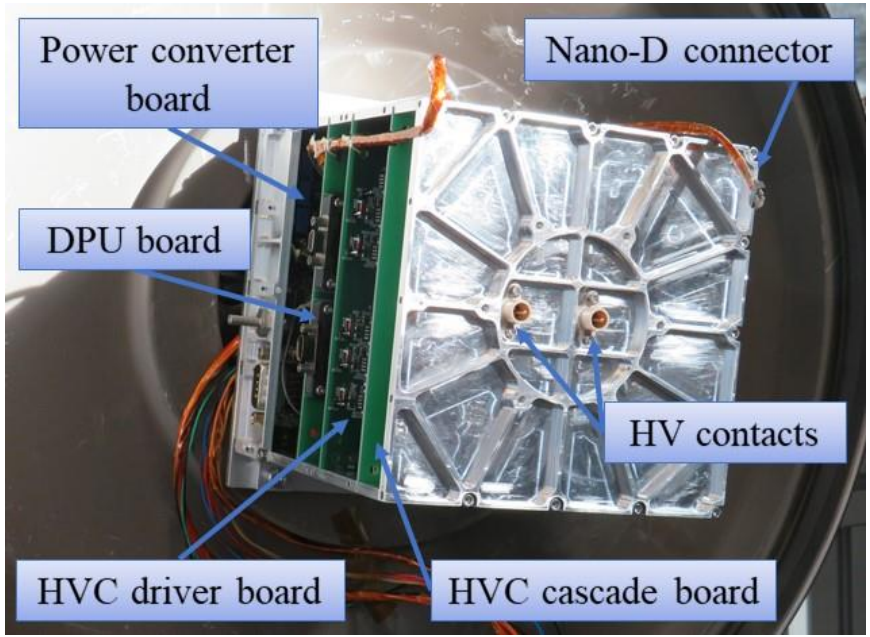
ASPOC Next Generation Electronics Control Unit: Design Challenges

Electronics for **high reliability** (ESA / NASA missions)

- High susceptibility to radiation
- Low failure rates (MTTF and MTBF)
- Miniaturization limited



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Test Results

	Ion emitter	Liquid e^- emitter	Solid e^- emitter
Needles	4	28	28
Propellant	Alternative	Alternative	-
Emission current	≤ 50 µA	≤ 100 µA	≤ 100 µA
Efficiency	≥ 95 %	7 – 96 %	≥ 96 %
Accuracy	± 0.06 µA	± 2.99 µA	± 0.05 µA
Emission	stable	pulsed	stable

Fries *et al.*, IAC-22-C4.6.4 (2022).
Mühlich *et al.*, Advances in Space Research (2022).

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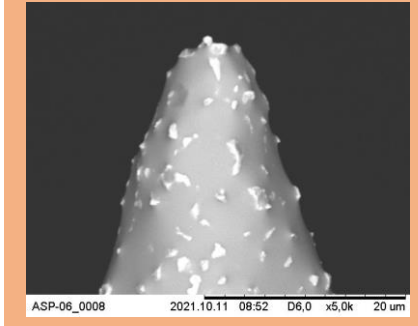
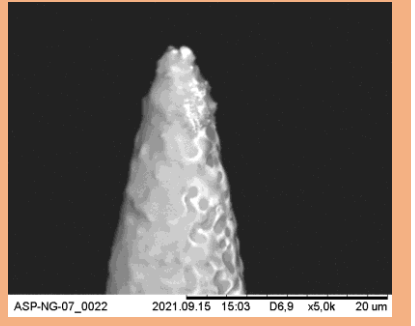
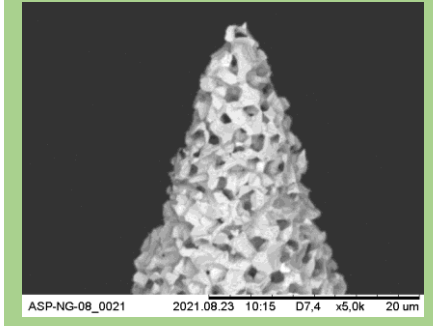
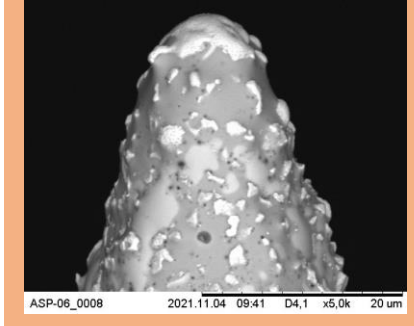
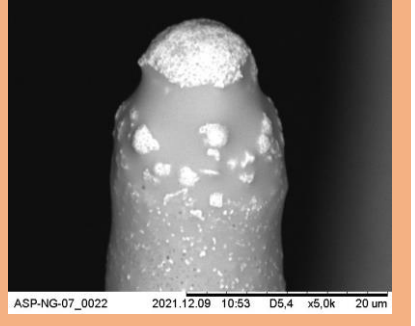
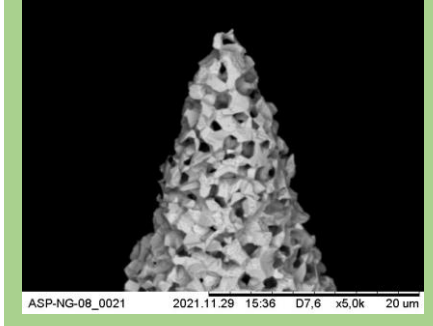
Test Results

Ion emitter | **Liquid e⁻ emitter** | **Solid e⁻ emitter**

	Liquid electron EM6	Liquid electron EM7	Dry electron EM8
Before Test:			
After Test:			

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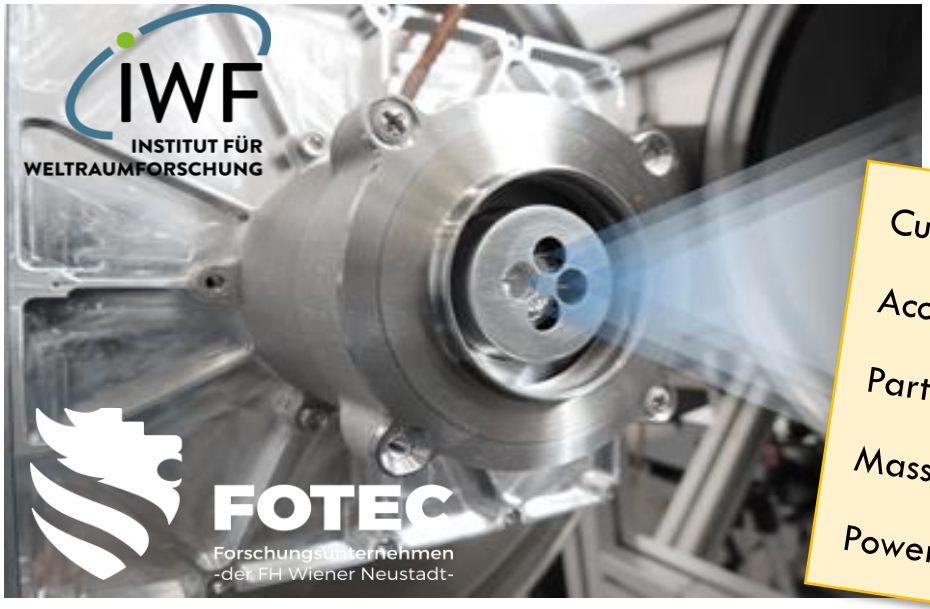
Key Features



Successfully developed and tested ASPOC-NG instrument based on elective propulsion technology

- Ion emission
- Solid electron emission without propellant

Current: ~100 µA

Accuracy: < 0.1 µA

Particle energy: < 6 keV

Mass: ~1.2 kg

Power: ~2.2 W

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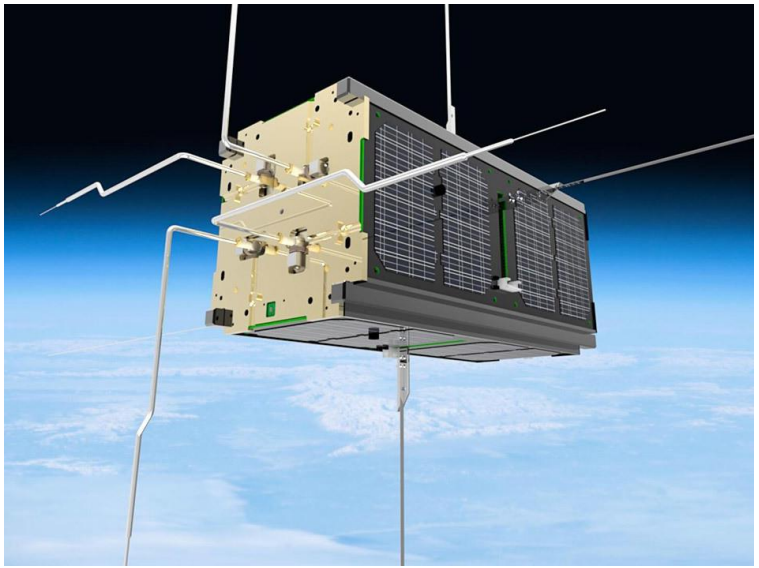
Follow-up Development

- ✓ Vastly growing market of small satellites (1-500 kg)
- ✓ ASPOC necessary for specific missions to ensure proper potential neutralization of spacecraft
- ✓ Ensure precise measurements using plasma diagnostics, magnetometers etc.
- ✓ Reliable and accurate atmospheric measurements

Potential missions

- ✓ Earth observation
- ✓ *Plasma Observatory Mission* (near-earth space)
- ✓ Science missions



Satellite PEGASUS with plasma probes

SpaceWorks Nano/Microsatellite Forecast, 10th edition (2020), accessed on 20.12.2022, https://www.spaceworks.aero/nano-microsatellite-forecast-10th-edition-2020/

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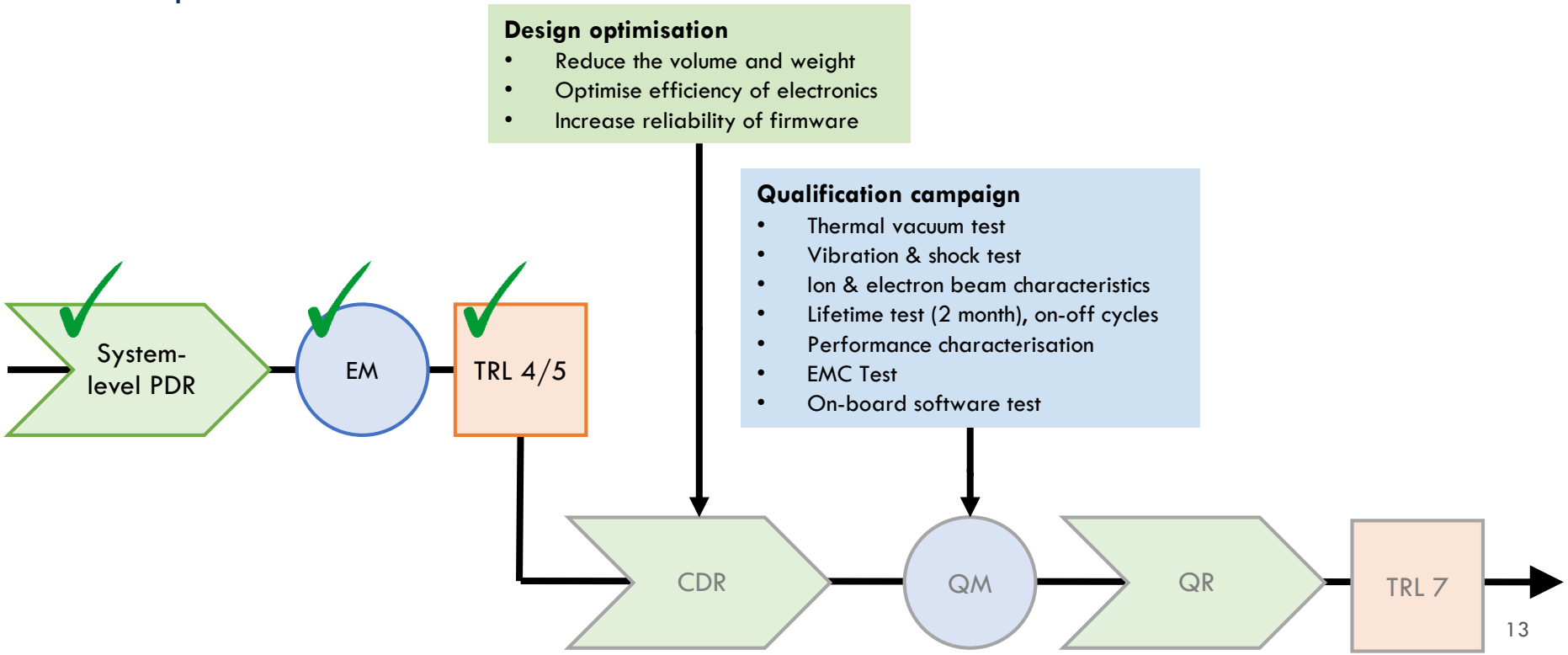
Roadmap



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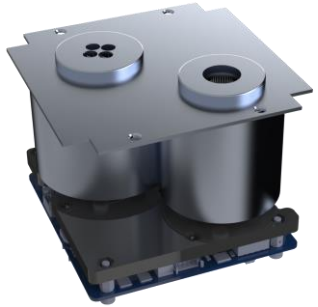
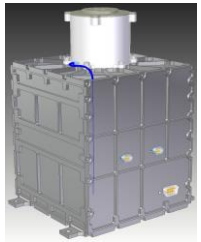
FOTEC
Forschungsunternehmen
-der FH Wiener Neustadt-

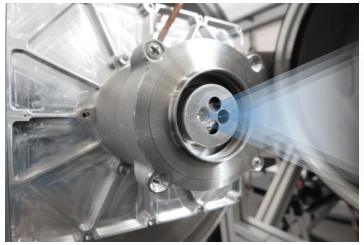
Development branches



ASPOC-NG TRL 4/5

2022

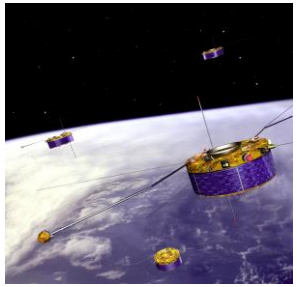




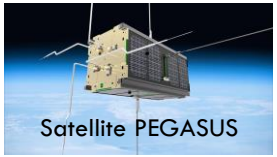
ASPOC-NG TRL 6/7

ASPOCube TRL 4/5

IOD ASPOC-NG



https://www.esa.int/ESA_Multimedia/Images/2015/01/Cluster



Satellite PEGASUS

IOD ASPOCube

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Conclusion and outlook

- ✓ 30 years know-how on FEEP technology
- ✓ Compact design
- ✓ Easy integration because of non-hazardous propellant
- ✓ Combined ion and electron emission
- ✓ Precise controllability of emission current
- ✓ FOTEC is major supplier of ASPOC solutions based on Liquid Metal Ion Sources (LMIS)
- ✓ Successful development of novel optimized ASPOC-NG device

- ❑ Upgrade of ASPOC-NG electronics
- ❑ Environmental test campaigns
- ❑ Development of ASPOCube for small satellites

Thank you for your attention

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Acknowledgments:
Special thanks to **ESA** and **FFG** for supporting the activities.