HEMPT-NG

Stefan Weis, Thales Deutschland GmbH
Julien Degremont, Thales AVS France
Andreas Haschka, Thales Deutschland GmbH

EPIC-Workshop 2018 - London, October 15th 2018

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European Commission | Horizon 2020 European Union funding for Research & Innovation

AGENDA

- Project
  - Overview / status
- Markets
- Technical achievements
- Conclusion / next steps

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Project

HEMPT-NG is developing an **integrated solution EP system** - based on **HEMPT** (Highly Efficient Multistage Plasma Thruster), the fluidic management system and the power processing unit.

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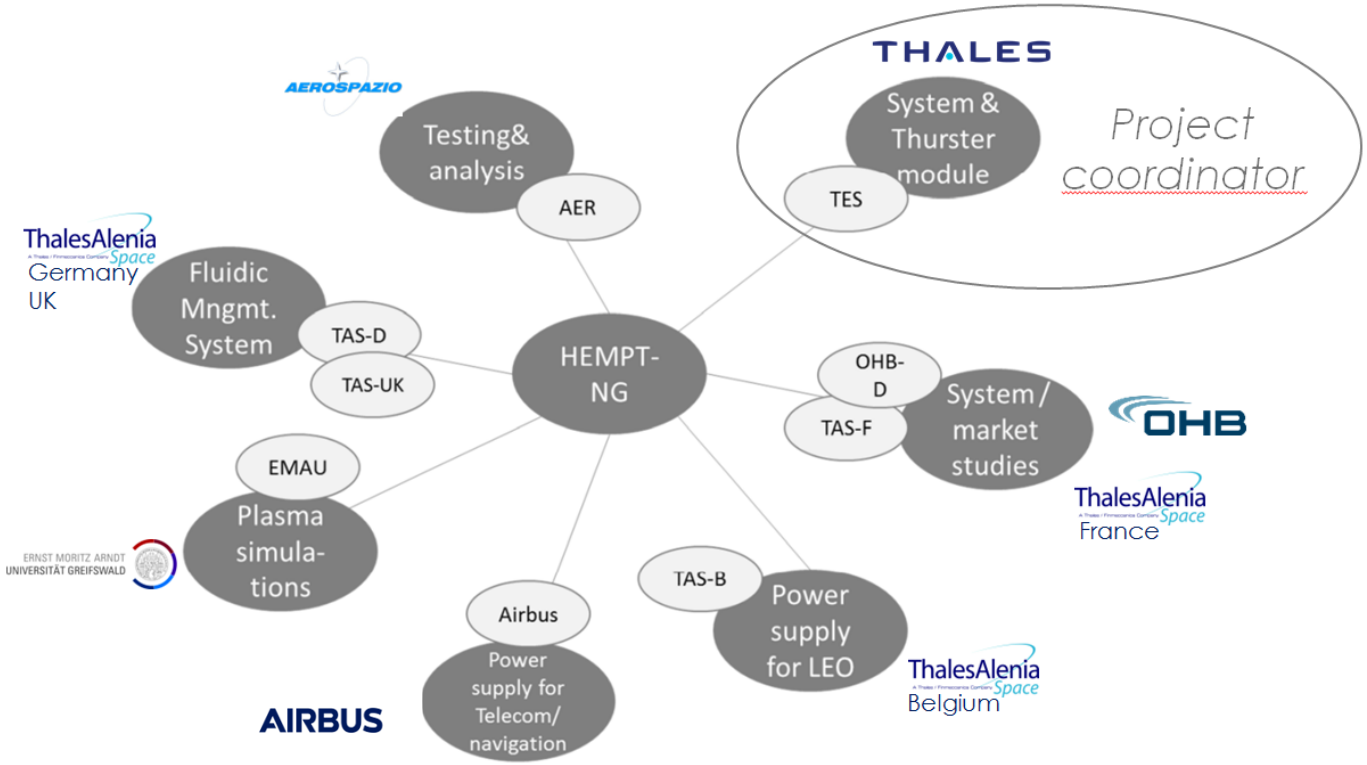
Project

- The team



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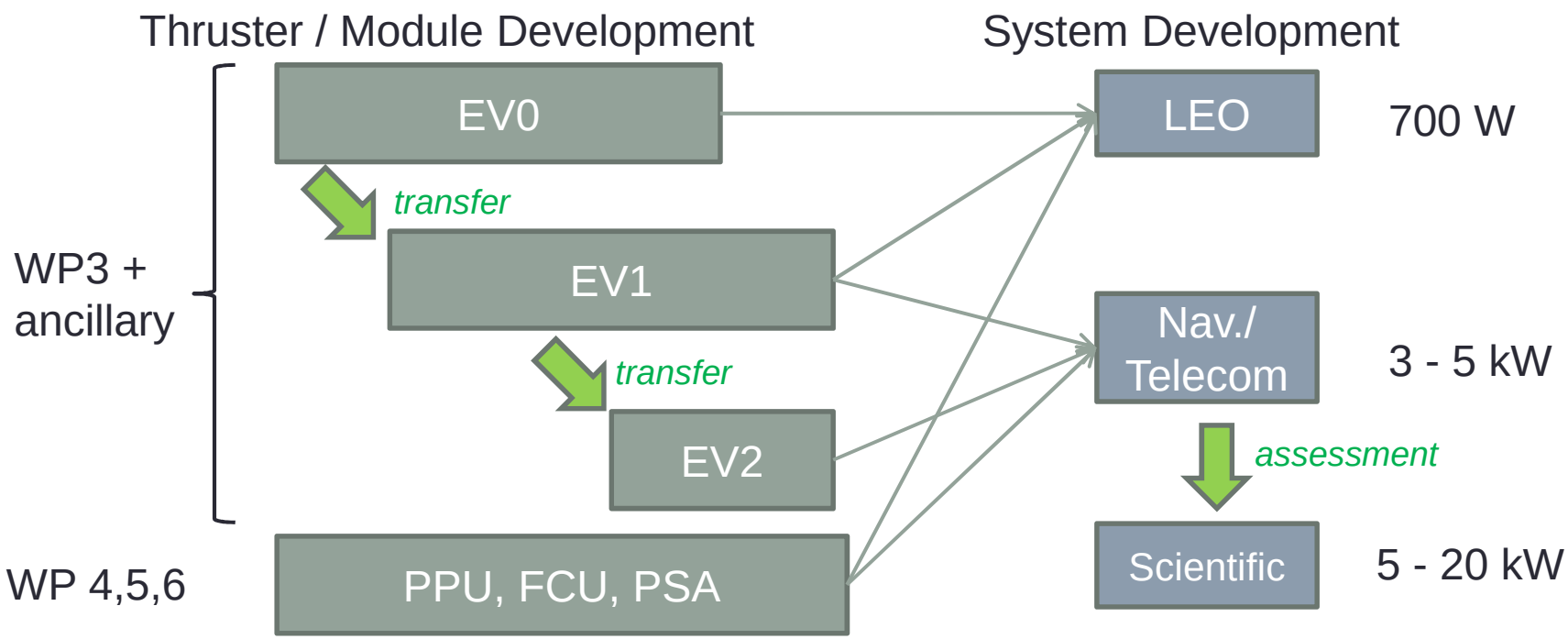
Project – development logic



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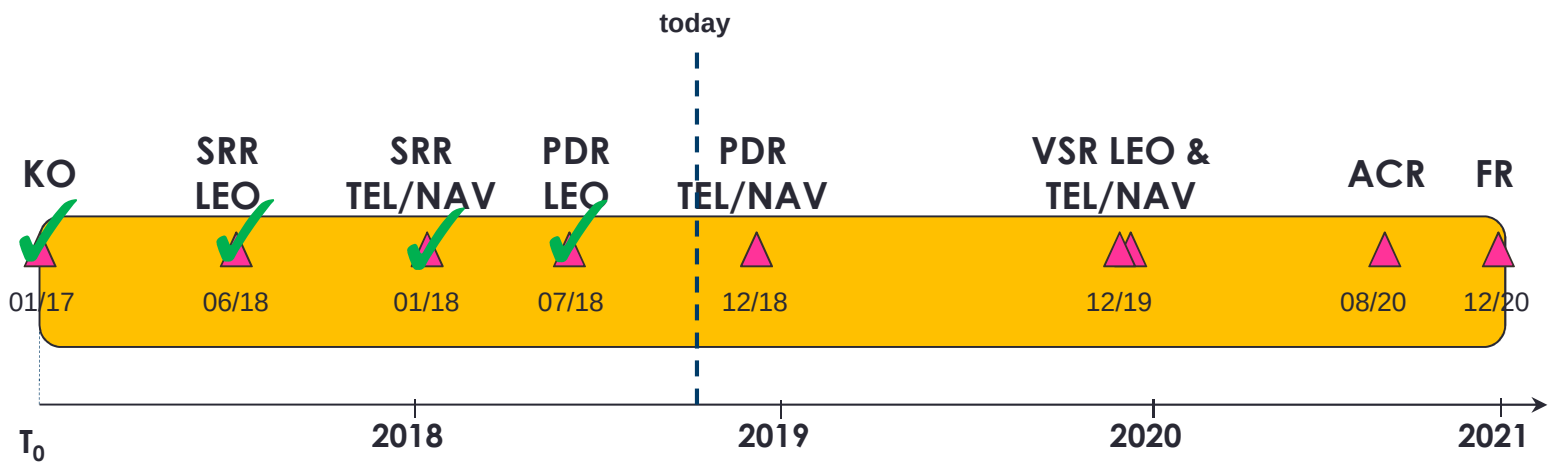
Project



Duration 48 months

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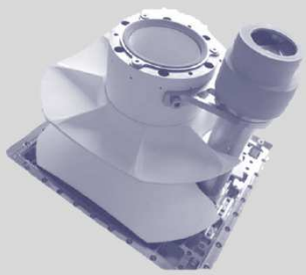
HEMPT Family of products

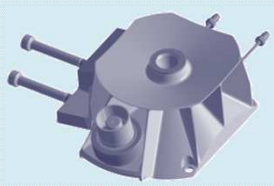
HEMPT 3050

In-Orbit Verification
Small GEO
H2sat in 2021



HEMPT EV0

LEO / MEO
constellations

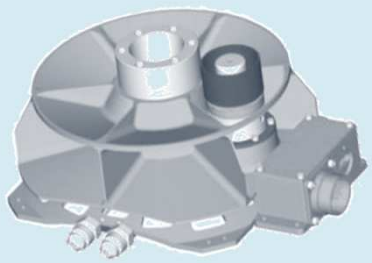


HEMPT EV1

LEO / MEO
constellations,
navigation & telecom

HEMPT EV2

MEO / GEO
cis-lunar,
interplanetary
transportation & more



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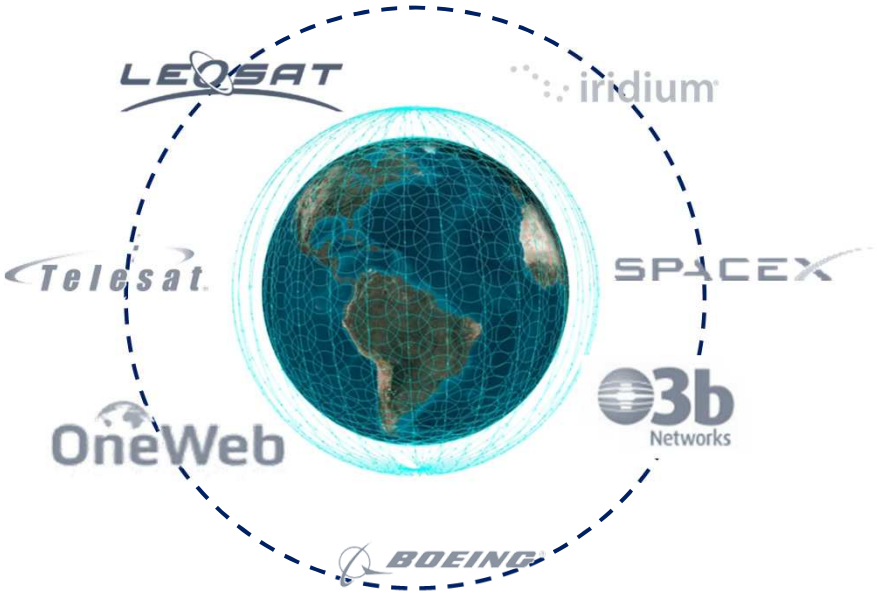
Paradigm of constellations



- > 11 FCC filings
- > 21,000 satellites

- **New business models**
- Broadband and mobility

- Small constellation for EO, IoT, M2M and other applications

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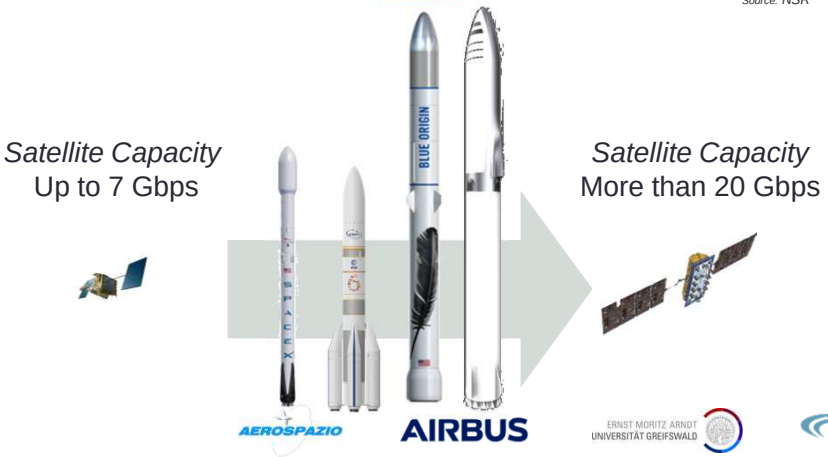
LEO/MEO is the trend



2018-2027

NSR : more than **3,000** satellites over **100kg** to be ordered

Euroconsult : **2,170** satellites between **250kg to 500kg** to be launched

Two waves of procurement with **evolving requirements**

Very competitive launch solutions in LEO

Broadband market to **shift towards bigger satellites** to provide cheaper capacity

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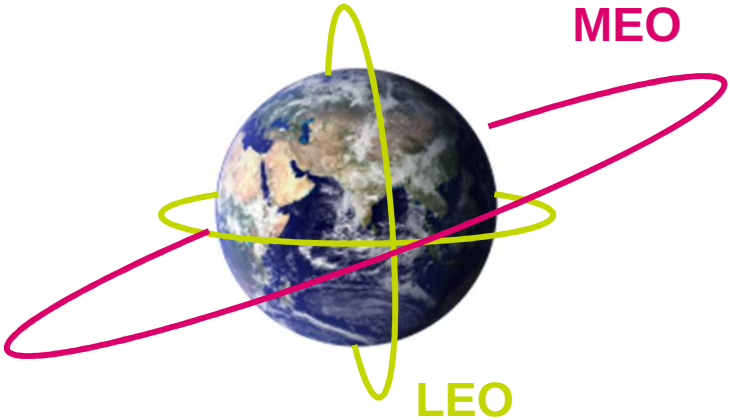
Generic missions by orbits



MEO (2000 – 20000 km)

- ✓ **Market may grow exponentially**
- ✓ MEO constellation in **early stage**
- ✓ **Numerous projects** currently under development

LEO (250 – 2000 km)

- ✓ **Growing market** around **100 to 600 satellites** per year
- ✓ 1st opportunities already **under procurement**
- ✓ **Price** as the main criteria of choice

Launcher to deliver at lower orbit to maximize launch cost and propulsion to :

- ➢ ***Reach*** *operational orbit (Orbit Raising)*
- ➢ *Perform orbit* ***adjustment*** *and altitude* ***maneuver***
- ➢ *Move to* ***disposal*** *orbit at EOL*

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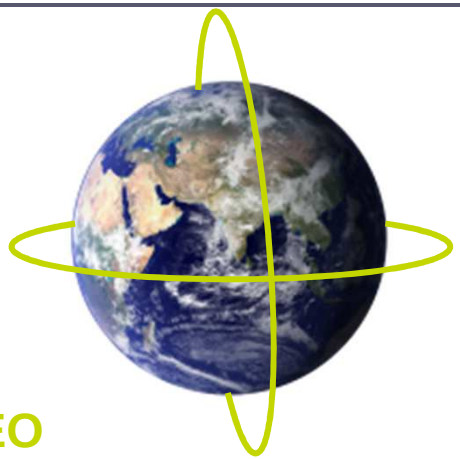
Generic requirements by orbits



LEO

[5-10 year lifetime]

- **One EP system**.
- **Cost of the system** as the main criteria of choice.
- Requirements for **Constellations**: Between **200W to 1,5kW** of available power ; Thrust from **15mN to 60mN**.
- **Minimizing Xenon usage** to be capital (High ISP, Krypton…)

HEMPT EV0

LEO/MEO constellations

Low cost
High volume manufacturing
Good performance with **Krypton**

Thrust: **15 - 32 mN**
ISP: up to **2000s**

Power: **100W - 700W**
Operating Voltage 300V - 800V

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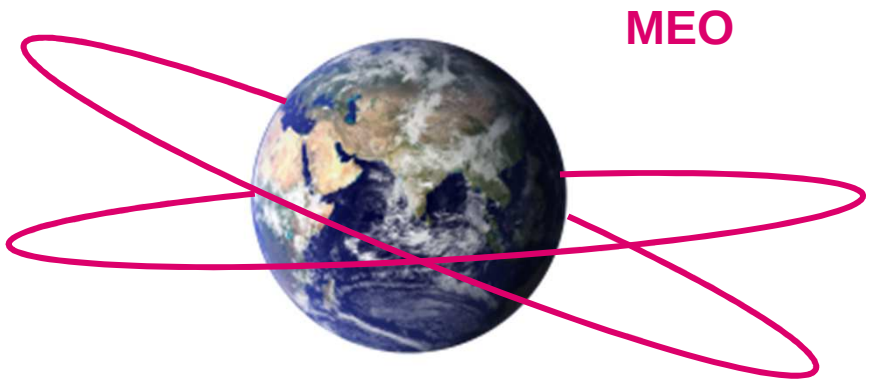
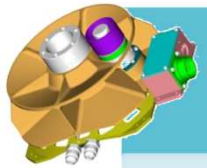
Generic requirements by orbits



MEO

[8-14 year lifetime]

- **One EP system**.
- Constellation MEO market for **EP in early stage**.
- Market to be very **diversified** and **heterogeneous**
- Between 700W to 15kW ; with a thrust between **50mN to 500mN**.
- **Flexibility** to be capital.



HEMPT EV1

LEO/MEO constellations, navigation & telecom

Very **flexible**
Krypton usage targeted

Thrust: up to **175mN**
ISP: **1500s – 3000s**

Power: **1kW - 2,8 kW**
Operating Voltage 300V – 1000 V

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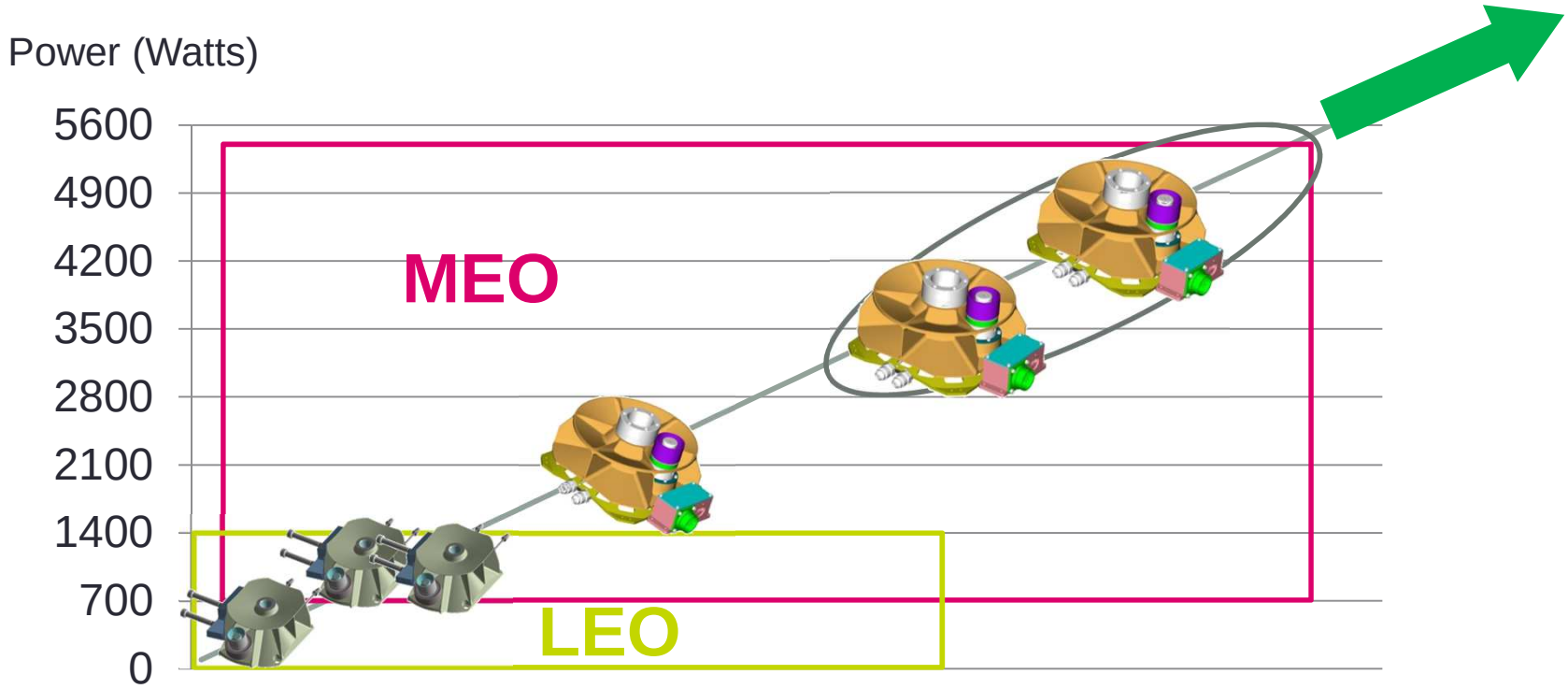
A family covering all needs



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HEMPT differentiators

FLEXIBILITY

- **Multiple working points with the same design** (in-orbit reconfigurability of the working point)
- **Excellent ability for throttling** (wide range of anode voltages and mass flow rates)
- **100% European** (thruster)

RELIABILITY

- Thales **space heritage** and TWT expertise (cathode, thermal management)
- Thales testing facility and **high volume manufacturing capability**
- **Erosion free** discharge channel design over time

COST-EFFECTIVENESS

- Inherent technology **competitiveness** (one cathode, no grid, PPU..)
- **High ISP**
- **Fuel flexible**, with the use of Xenon & **Krypton** (with small decrease)

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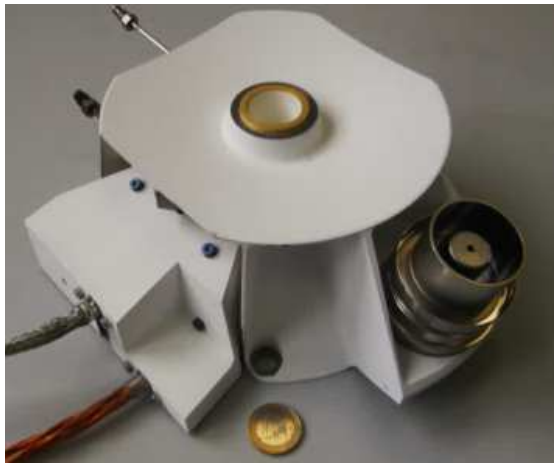
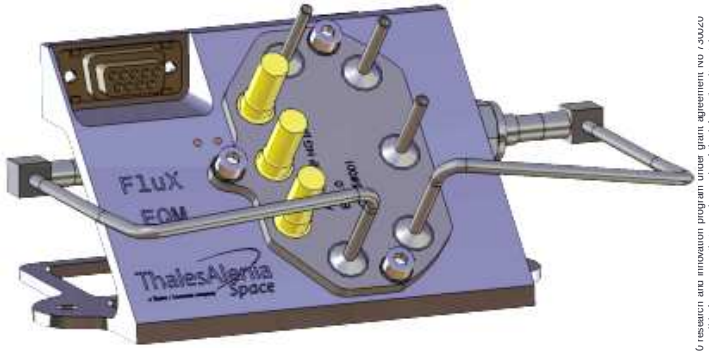
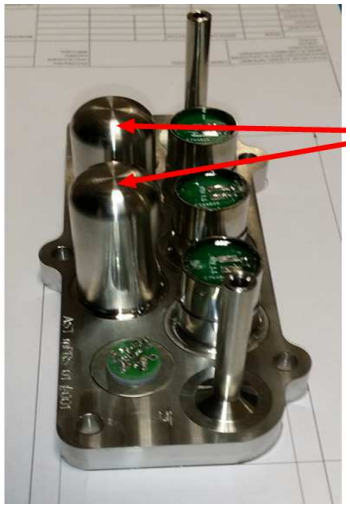
Constituents of a typical system



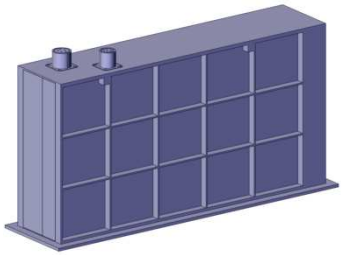
Thruster Module (700W)



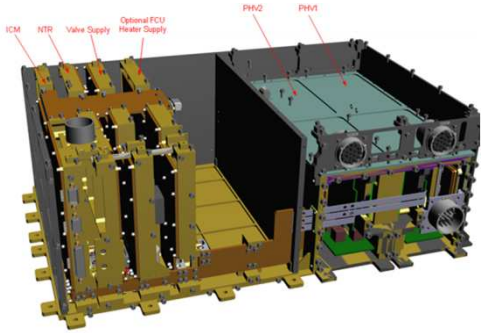
Flow Control Unit (universal)



Pressure Regulator (universal)



Power Supply (LEO)



Power Supply (GEO)

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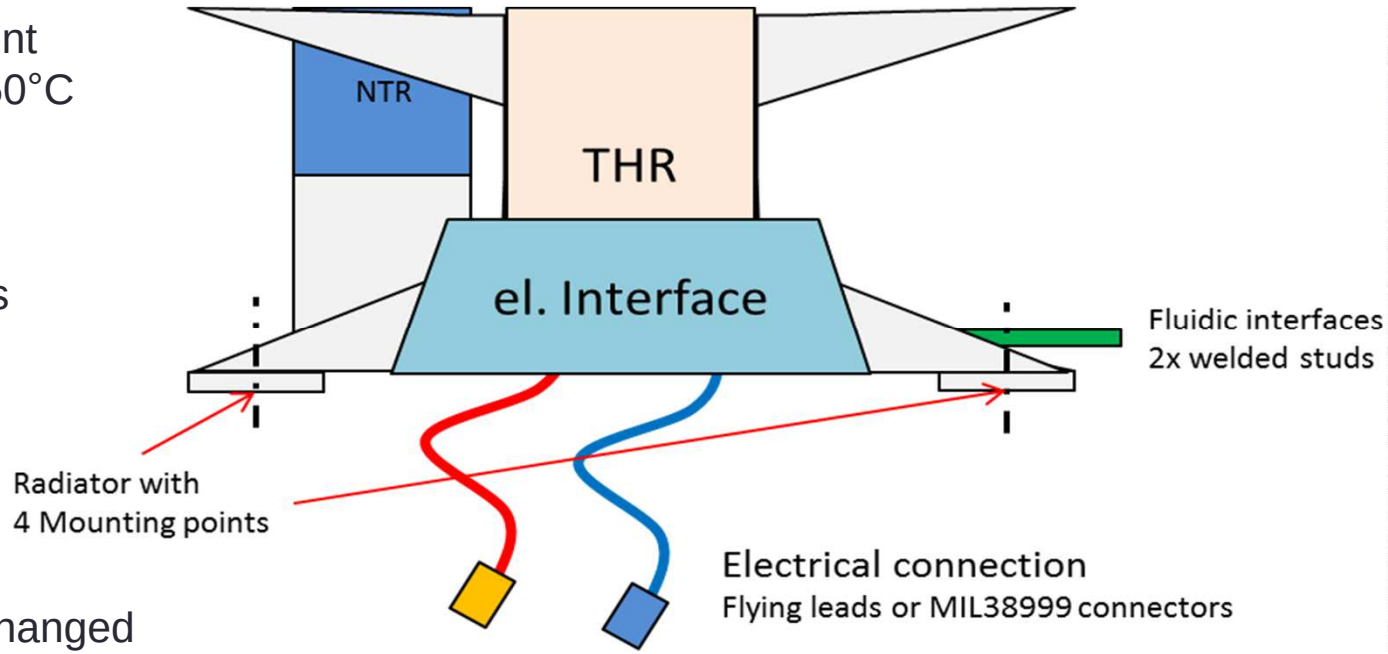
Module Concept - Interfaces

Thermally Independent Interface -45°C … 250°C

Designed for 30grms

Incorporates Harness



Options:
Connectors can be changed without impact to qualification

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HTM – EV0 – Bread Board Model

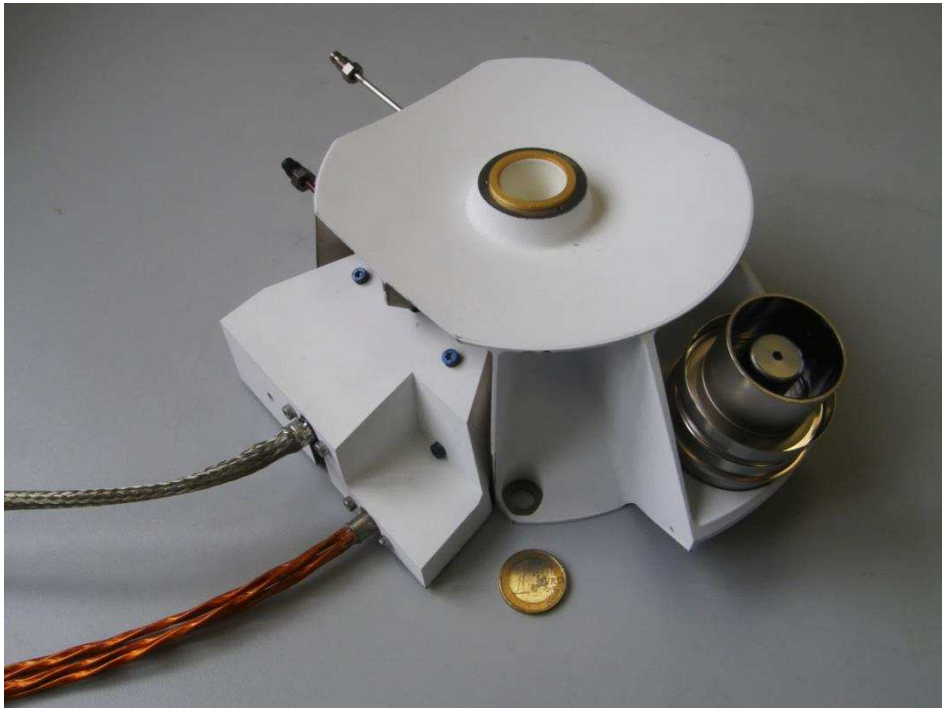

Photo: R. Heidemann 12.7.2018

Key Elements

- Low cost
- 700W power rating (100W - 700W)
- Thrust: up to 32 mN
- Operating Voltage 300V - 800V
- ISP: up to 2000s
- Total Impulse: >1,0MNs…1,5MNs

Achieved Features:

<**1.5kg mass** (depending on harness length)

Envelope: approx. **180x190x90 mm**

Designed for **high radiation tolerance** (option: additional shields for harness for improved radiation tolerance -
Up to 40Grad with add on shields)

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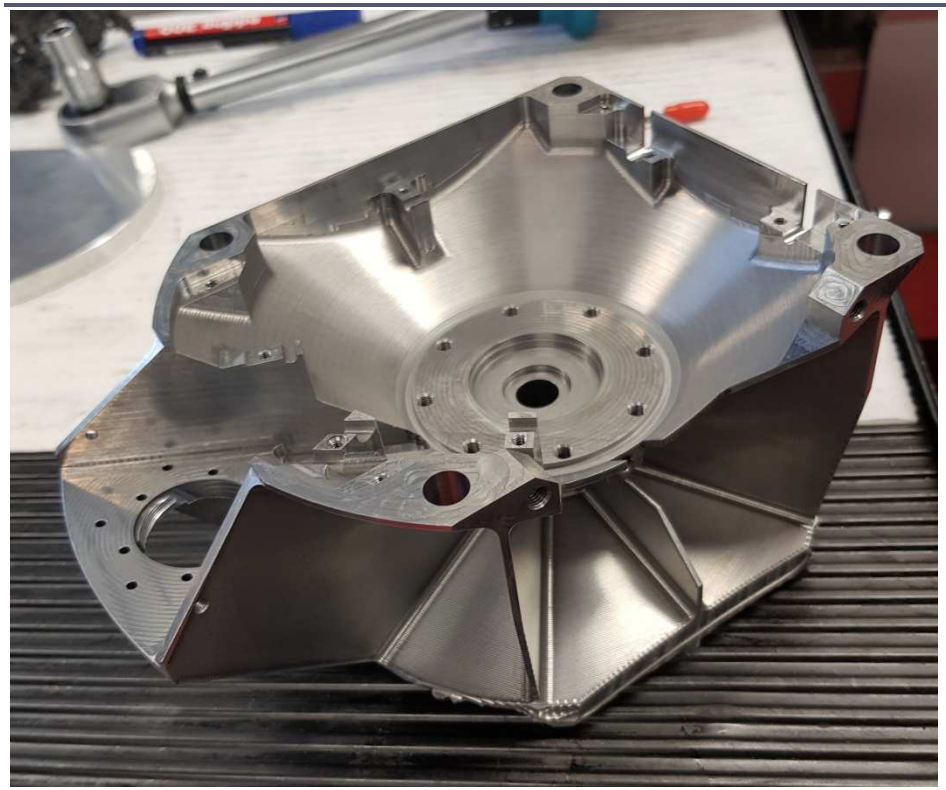
Cost effective Design



Reduction of several mechanical Parts into **one single mechanical structure**

More than **70% reduction of parts**

Only 4 attachment points

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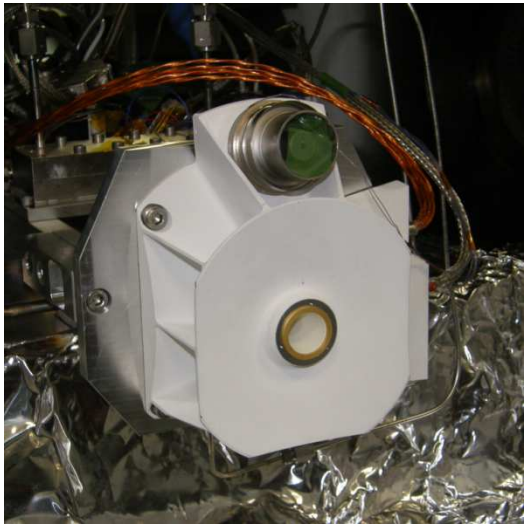
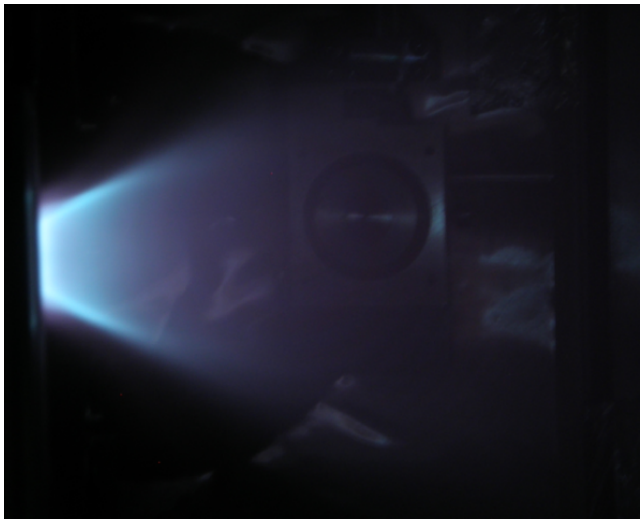
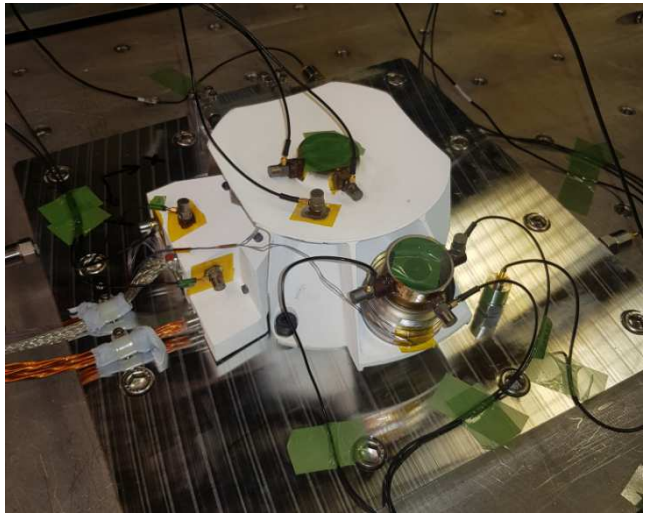
HEMPT EV0 - Test Overview





Vacuum Test Module



Mechanical Test Module

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HEMPT EV0 typical performances

Utilization of Xenon

- Power from **300W to 700W**
- Voltage from **300V to 800V**

- ✓ Thrust from **11mN to 32mN**
- ✓ ISP from **1100s to 2000s**

Utilization of Krypton

- Power from **300W to 700W**
- Voltage from **300V to 800V**

- ✓ Thrust from **9mN to 28mN**
- ✓ ISP from **1125s to 2140s**

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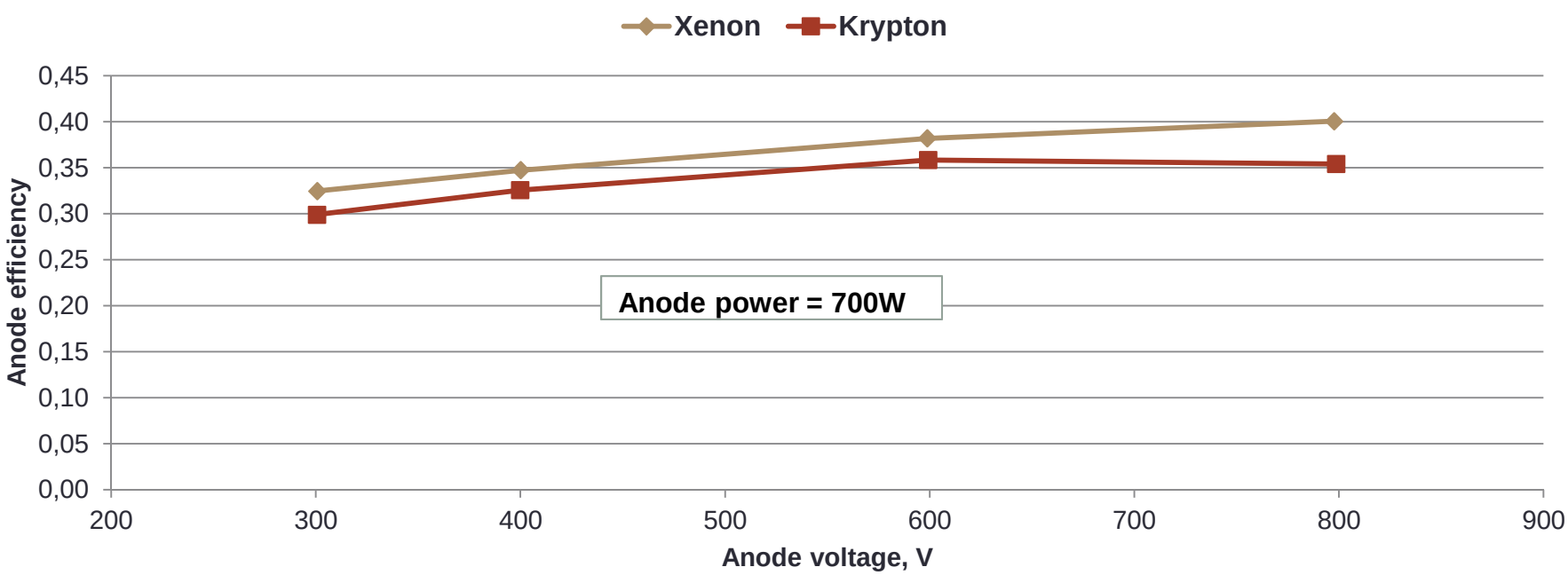
EV0 Module Krypton Efficiency



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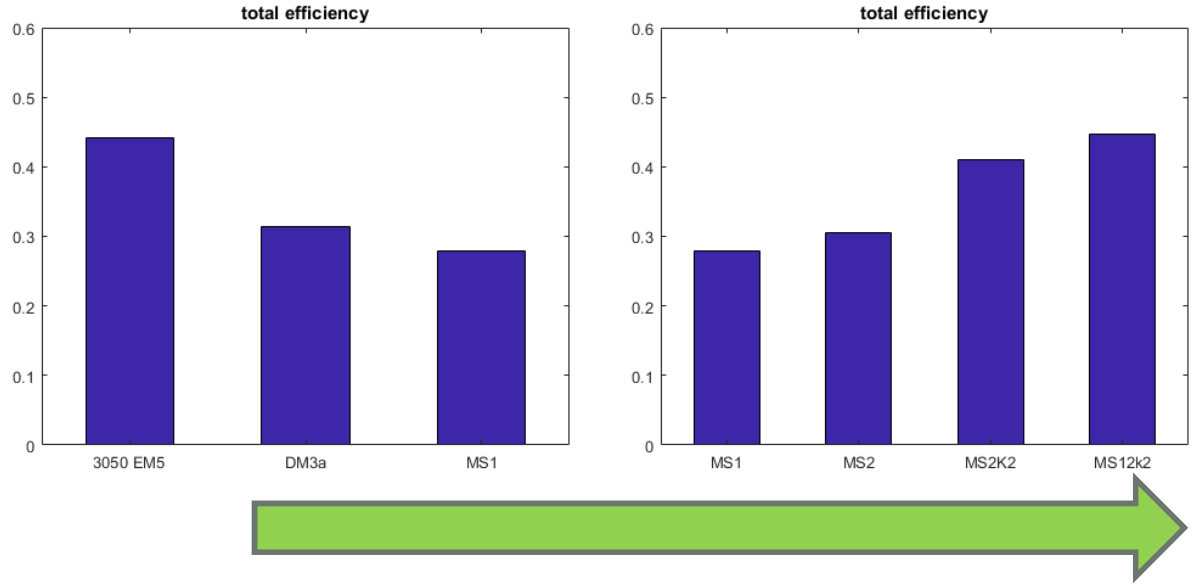
Thruster comparison with Xenon



Development Evolution

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EV0 Development – Achieved Improvements

- **Reduced losses** leads to higher thrust at the same power
- **Stronger confinement** for bulk plasma
- Maximum **efficiency 44.7%**
- Improved beam angle - **Beam efficiency 85%**

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Status EV0 Development - Summary

Target	Result
Performance test on EV0 Bread Board	successful
Performance test Krypton on EV0 BB	successful
Operation of EV0 Module at 700W	OK
Test of EV0 thermal design (radiator <250°C)	OK
Endurance test EV0 – Performance degradation <5%	OK <0.5%
Test of Micro FCU on load dummy	OK

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HEMPT key differentiators - confirmed

HIGH VOLUME MANUFACTURING

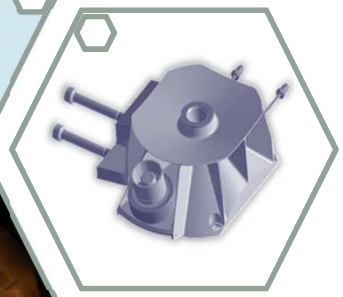
HIGH ISP

RELIABILITY

KRYPTON USAGE

EUROPEAN ORIGIN

FLEXIBILITY



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Next steps

- **PDR Nav. / Telecom**
- **EV1 development**
- **Coupling tests**

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