

## HEMPT – Electric Propulsion Recent results and product strategy L1.3-4 8<sup>th</sup> IVEW 2022

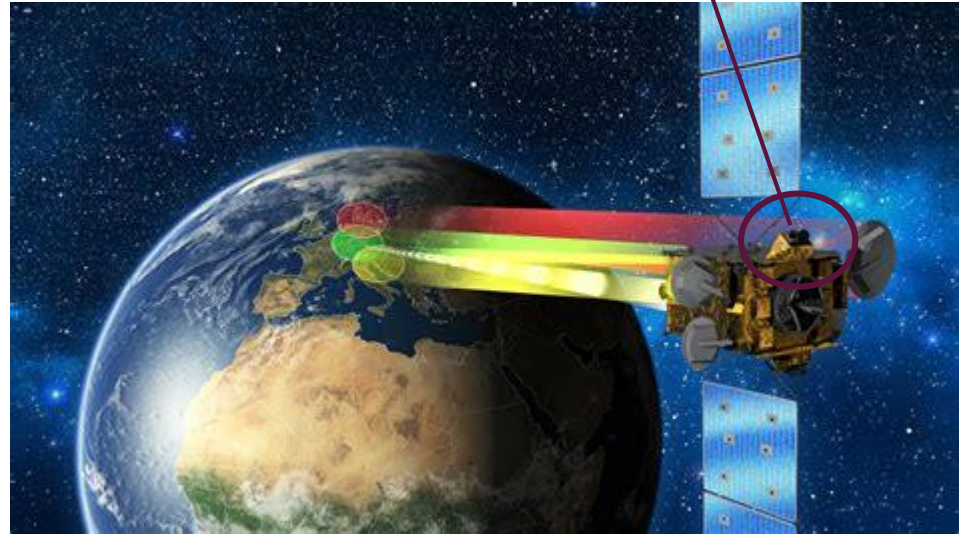
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# Overview

- Heritage HEMPT
- Strategy
- Design
- Results
- Next steps/Conclusion

**H2Sat-**  
first in-orbit Demonstration for HEMPT

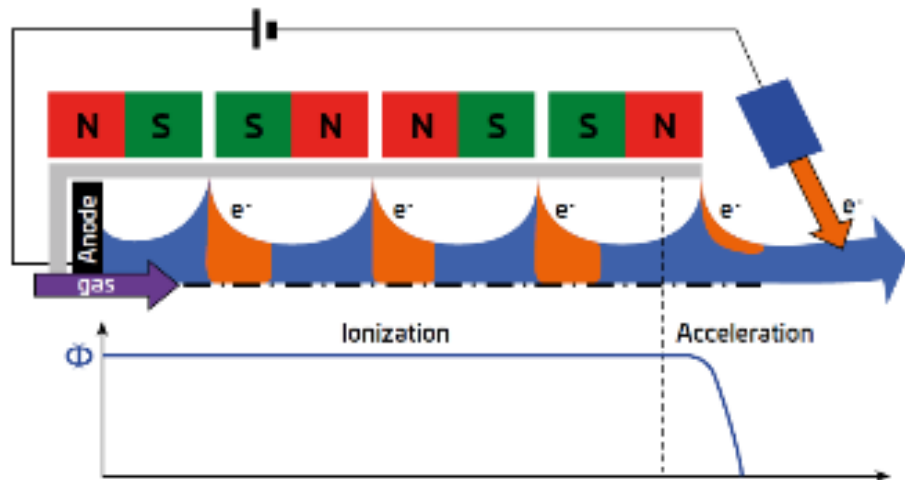


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# What is HEMPT technology ?

- A Thales patented technology
- Electron confinement by fixed magnets
- Ion current  $\approx$  anode current
- Separated ionization and acceleration zones cause most of the ions to be generated at anode potential
- High ion acceleration efficiency



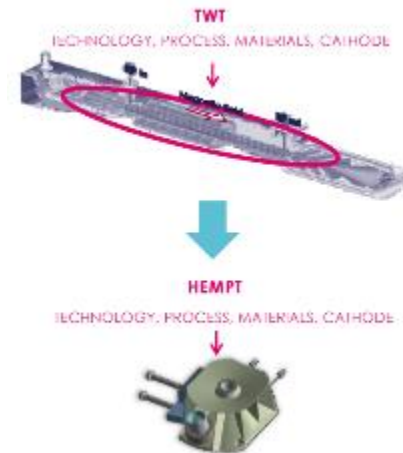
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# Thales MIS heritage with propulsion

## HEMPT & Thales MIS heritage:

- A Thales patented technology
- From Travelling Wave Tubes (TWT) to HEMPT:
  - Expertise in electron magnetic beamforming
  - More than **25,000 space TWTs delivered**
    - Around **1,350,000,000 hours of operations**
  - Reuse of 85% of the technology and 80% of the processes from TWT to HEMPT
  - Industrial excellence and high volume manufacturing capability
    - External MRL assessment successful passed for high volume production



## HEMPT 3050:

- TRL-8: successful qualification demonstrating :
  - **1.47MN total impulse (>9000hrs) & 10200 ON/OFF cycles on 2 units**
  - **No performance degradation or erosion with lifetime**
- All flight hardware integrated on satellite- First flight expected on H2sat in Q1/2023

# HEMPT differentiators

## Motivation for HEMPT:

- Synergy with TWT Technology and process, cathode technology
- Low erosion through Magnet field in the discharge channel
- High ionisation
- High ISP and large flexibility
- Simple assembly

## Actual differentiator for HEMPT for SK and OR:

- Design compatibility for Krypton
- Low erosion in the discharge channel
- High ionization efficiency
- High ISP and large flexibility
- Simple assembly
- Production: integrated in space production and quality system
- Cathode technology

Fully qualified  
thruster



TRL8

First flight :  
Feb/2023

## KEY TECHNICAL ELEMENTS

Mission Station keeping for H2Sator  
others

Thrust: 44 mN

ISP: 2400 s

Power: 1.4kW

Operating Voltage: 1000V

Total Impulse: 1.47MN s

Life time >9000 h operation Qualified  
for space

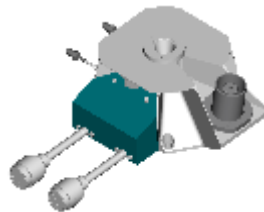
# HEMPT family of satellite thrusters

TRL 8

Final qualification

Delta design

BB tested



## HEMPT 3050

Technology demonstrator

1,400W

Thrust : 44mN  
ISP : 2400s

Fly in 2023

## HEMPT EVO

Low cost small engine for constellations

200 - 700W

10 – 32 mN  
Up to 2200s

Xenon & Krypton

## HEMPT EVO +

Low cost medium engine for any orbits

500 – 1,200W

30 – 45mN  
Up to 2800s

Xenon & Krypton

## HEMPT EV1

Low cost medium engine for any orbits

1,000 – 3,000W

30 – 140 mN  
Up to 3200s

Xenon & Krypton

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# HEMPT family of satellite thrusters

Roadmap



## HEMPT 3050

Technology demonstrator

1,400W

Thrust : 44mN  
ISP : 2400s

Fly in 2023



## HEMPT EV1

**Low cost medium engine for any orbits**

1,000 – 3,000W

30 – 140 mN  
Up to 3200s

**Xenon & Krypton**



## HEMPT EV2

Cost effective engine for any orbits with high stability of performance and lifetime

5,000 – 12,000W  
Dual mode for high thrust and high ISP

Xenon & Krypton

## HEMPT EV3

Very high power engine for cis-lunar and interplanetary transportation & more

>20,000W

Long lifetime & stability of performance

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# HEMPT EVO Development steps

## Design steps from 3050 to EVO:

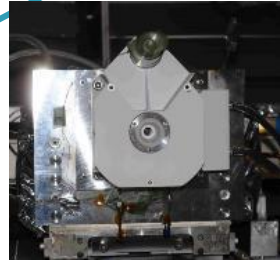
Large knowledge for plasma behaviour,  
qualification manufacturing and test of FMs

Development based on high volume production, less parts  
=> modular design, lower cost, ready for constellations

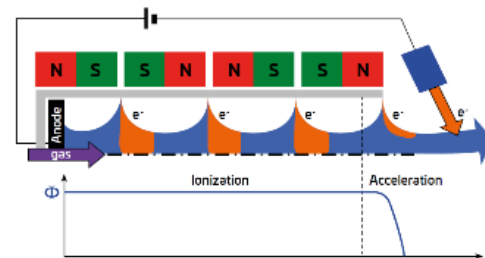
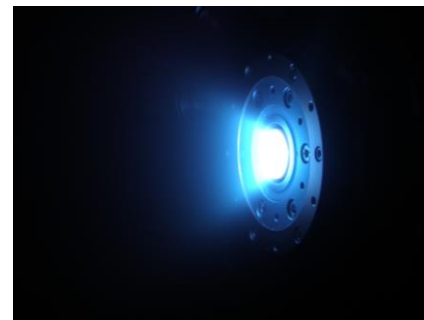
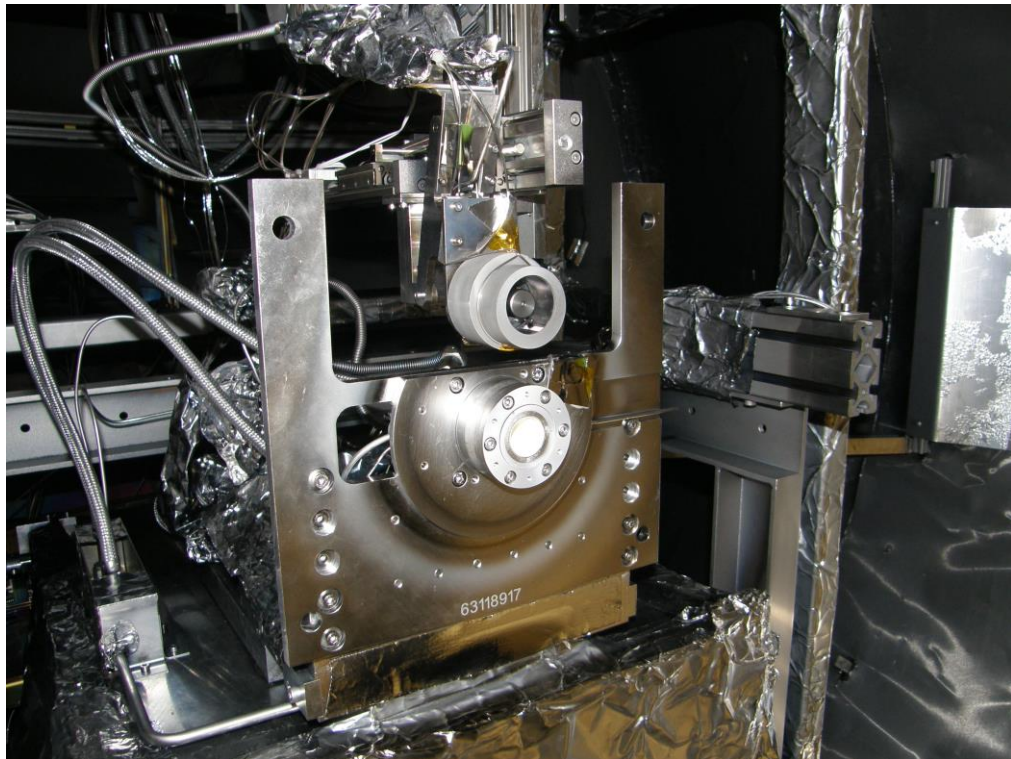
Improved behavior for efficiency,  
design for Krypton & Xenon

No change in basic technology  
Life test data as baseline  
EMC data as baseline  
Same cathode design

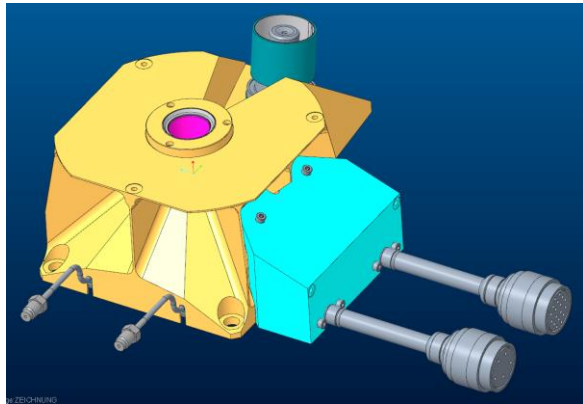
Included in space production, same rules for  
production and quality,



# EV0 Magnetsystem Development on Breadboard

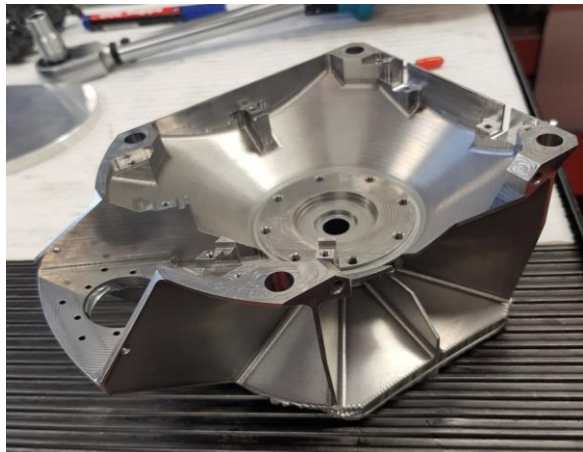


# EVO Module Design



## Main Subassemblies:

- Thruster
- Neutralizer (NTR)
- Electrical Interface thermally decoupled
- Propellant and Electrical connection
- Radiator

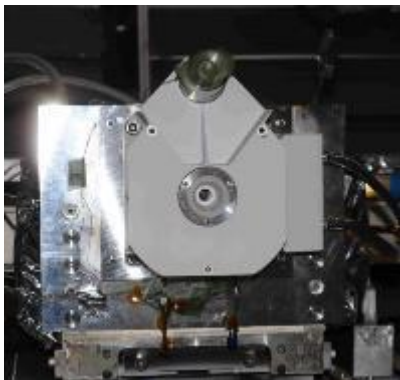
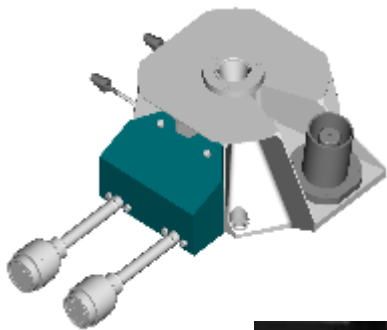


## Assembly Improvement:

- Total amount of parts reduced by more than 70%  
(Mainly Neutralizer)
- 4 attachment points

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# HEMPT EVO –700W



## Key Elements

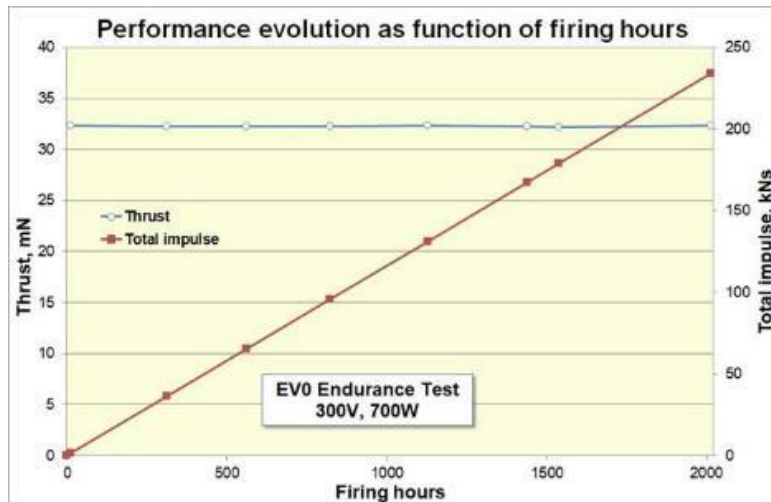
- 700W power rating (200W - 700W)
- Thrust: up to 32 mN
- Operating Voltage 300V - 800V
- ISP: up to 2000s
- Total Impulse target: >1,0MN

## Features:

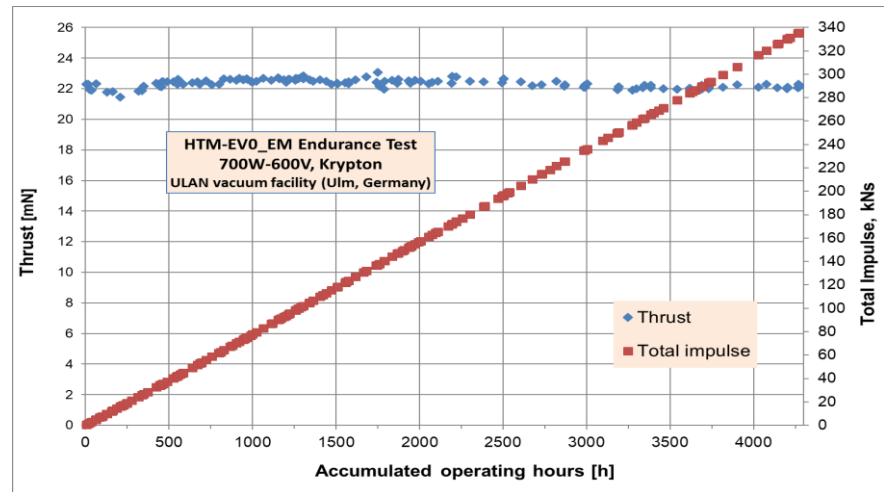
- Low cost
- <1.5kg mass (depending on harness length)
- Envelope: approx. 180x190x90 mm
- Possible to mount with zero heat flux to s/c
- Designed for high radiation tolerance (option: additional shields for harness for improved radiation tolerance -
- Up to 40Grad with add on shields)

# HEMPT EV0 endurance test

- ✓ Xenon 2000h endurance test completed, with no performance degradation



8/2022 4200h performed with Krypton 600V 700W



# HEMPT EVO – Performance

## Xenon

	300W	500W	600W	700W
300V	Thrust 15.3mN ISP 1100s	Thrust 24.1mN ISP 1250s	Thrust 28.2mN ISP 1295s	Thrust 32.0mN ISP 1330s
400V	Thrust 14.5mN ISP 1230s	Thrust 22.8mN ISP 1400s	Thrust 26.3mN ISP 1450s	Thrust 29.9mN ISP 1500s
600V	Thrust 12.8mN ISP 1390s	Thrust 20.1mN ISP 1615s	Thrust 23.6mN ISP 1700s	Thrust 27.0mN ISP 1760s
800V	Thrust 11.3mN ISP 1455s	Thrust 17.9mN ISP 1780s	Thrust 21.2mN ISP 1880s	Thrust 24.7mN ISP 1955s

## Krypton

	300W	500W	600W	700W
300V	Thrust 12.6mN ISP 1125s	Thrust 20.5mN ISP 1305s		Thrust 28.2mN ISP 1425s
400V	Thrust 12.0mN ISP 1305s	Thrust 19.1mN ISP 1495s	Thrust 22.3mN ISP 1585s	Thrust 25.8mN ISP 1660s
600V	Thrust 10.9mN ISP 1445s	Thrust 17.6mN ISP 1755s		Thrust 23.6mN ISP 1940s
800V	Thrust 9.3mN ISP 1585s	Thrust 15.1mN ISP 1910s		Thrust 20.5mN ISP 2140s

*EM Model Measurements as guide line,  
adjustment needed due to individual bus requirements  
Measured data as is, no margins, uncertainties, parts variation, aging considered  
Performance with optimized flow*

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# Next Steps

- Proposal activity for EVO ( Constellations, Small GEO Sats, EO Sats)
- Final Qualification until end 2022
- Life test for EVO
- New Design work on EVO+ based on experience of EVO
- Design Improvement for Krypton ( Plasma Potential )
- Extent diagnostic to improve Plasma and beam behavior
- Demonstrated production and test capability

# Thank you for attention

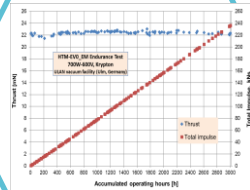
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**HIGH VOLUME  
MANUFACTURING**



**RELIABILITY**



**KRYPTON**

**PERFORMANCE  
STABILITY**



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contribution and support of DLR, ESA, EU and Thales**

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