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Space Debris Mitigation Using Dedicated Solid Rocket Propulsion

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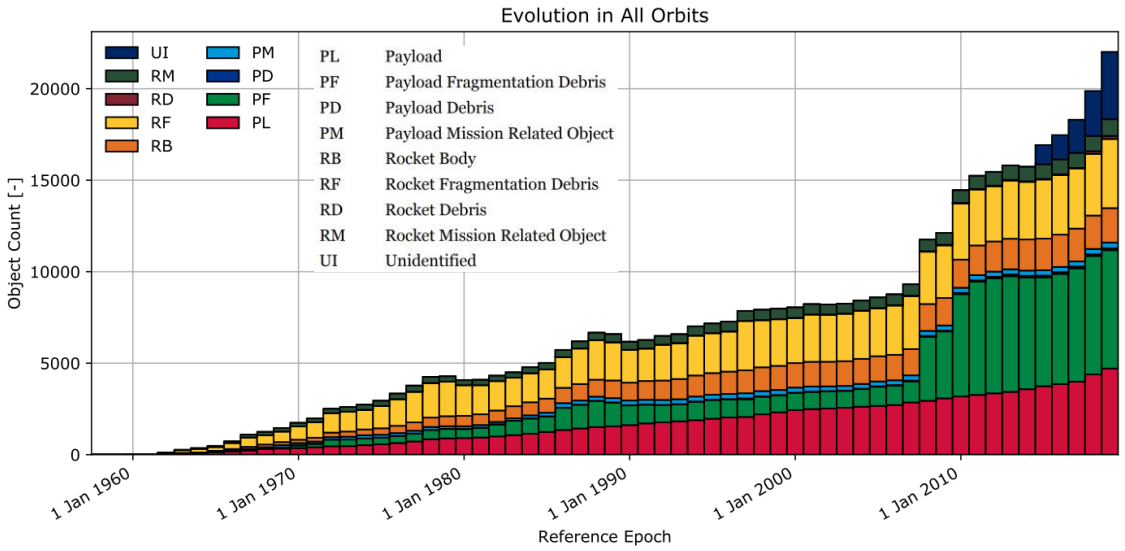
United Nations

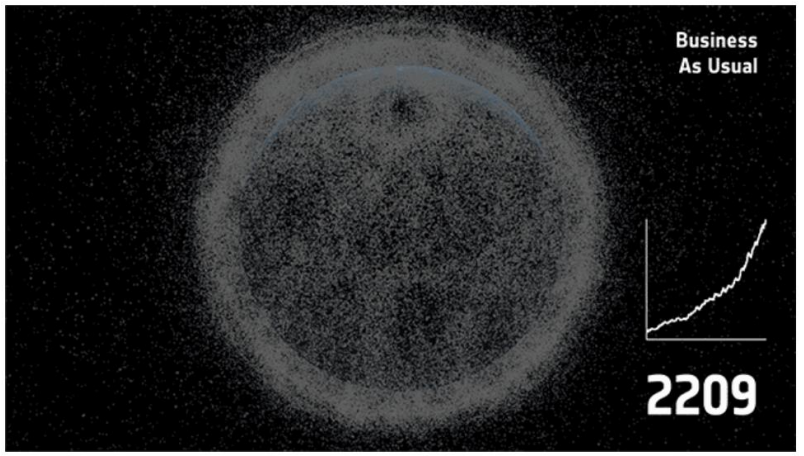
Committee On The Peaceful Uses Of Outer Space

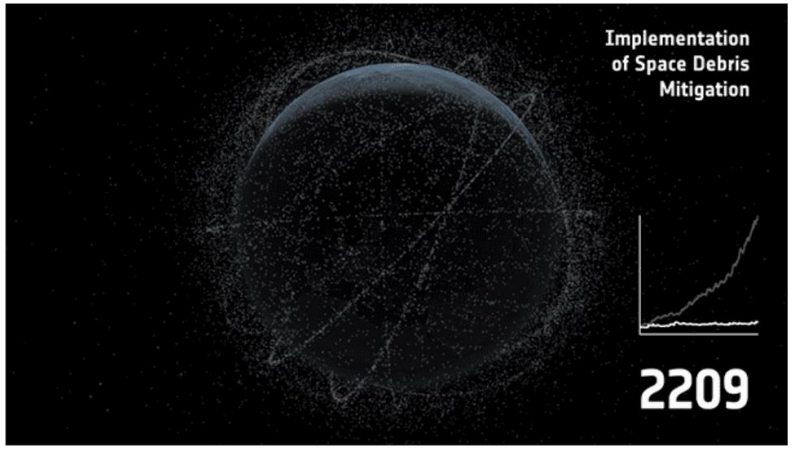
Scientific And Technical Subcommittee

57th Session, Vienna, 3–14 February 2020

Space Debris Mitigation



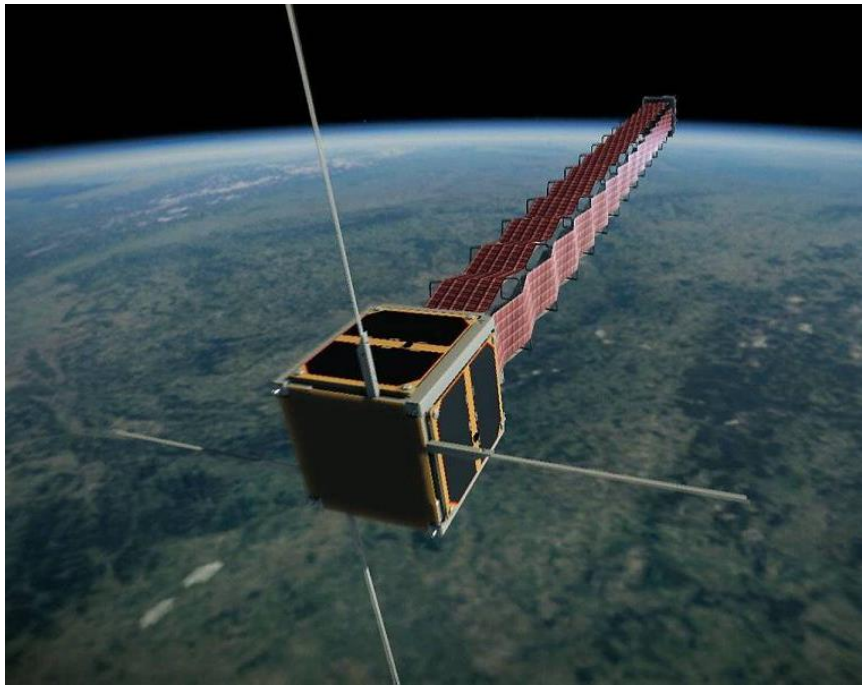




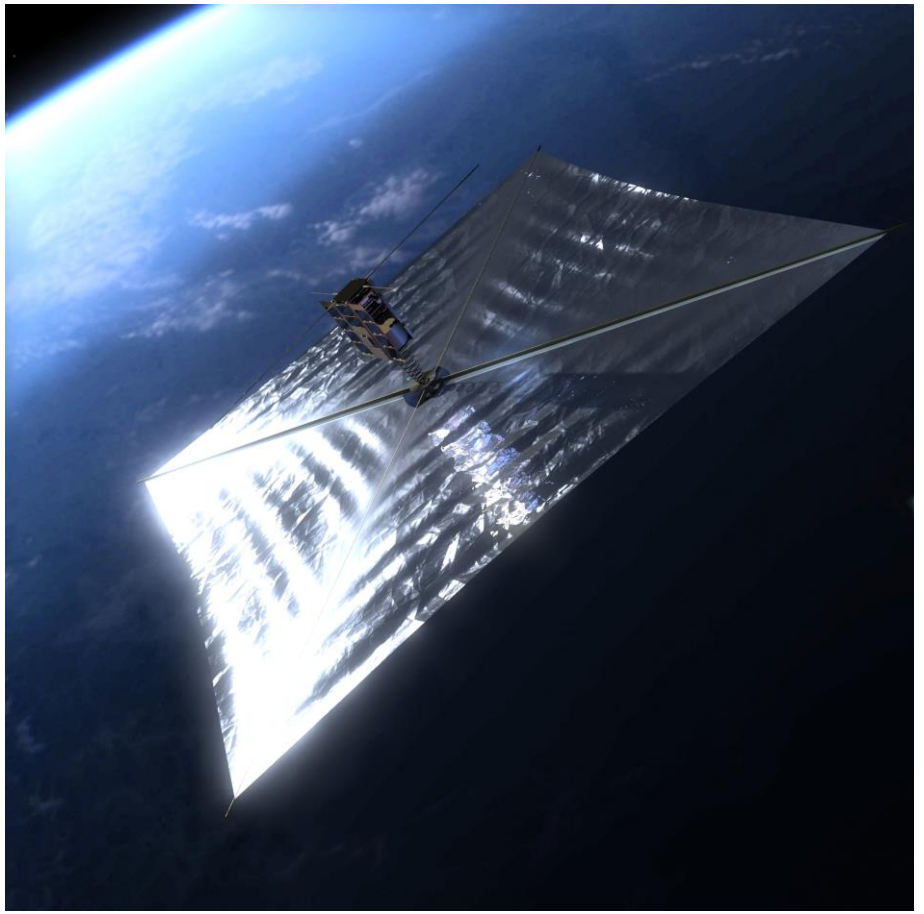
For over 20 000 objects in orbit only around 2 000 is operational

Source: ESA, 2019

Polish deorbitation tests: PW-Sat and PW-Sat2



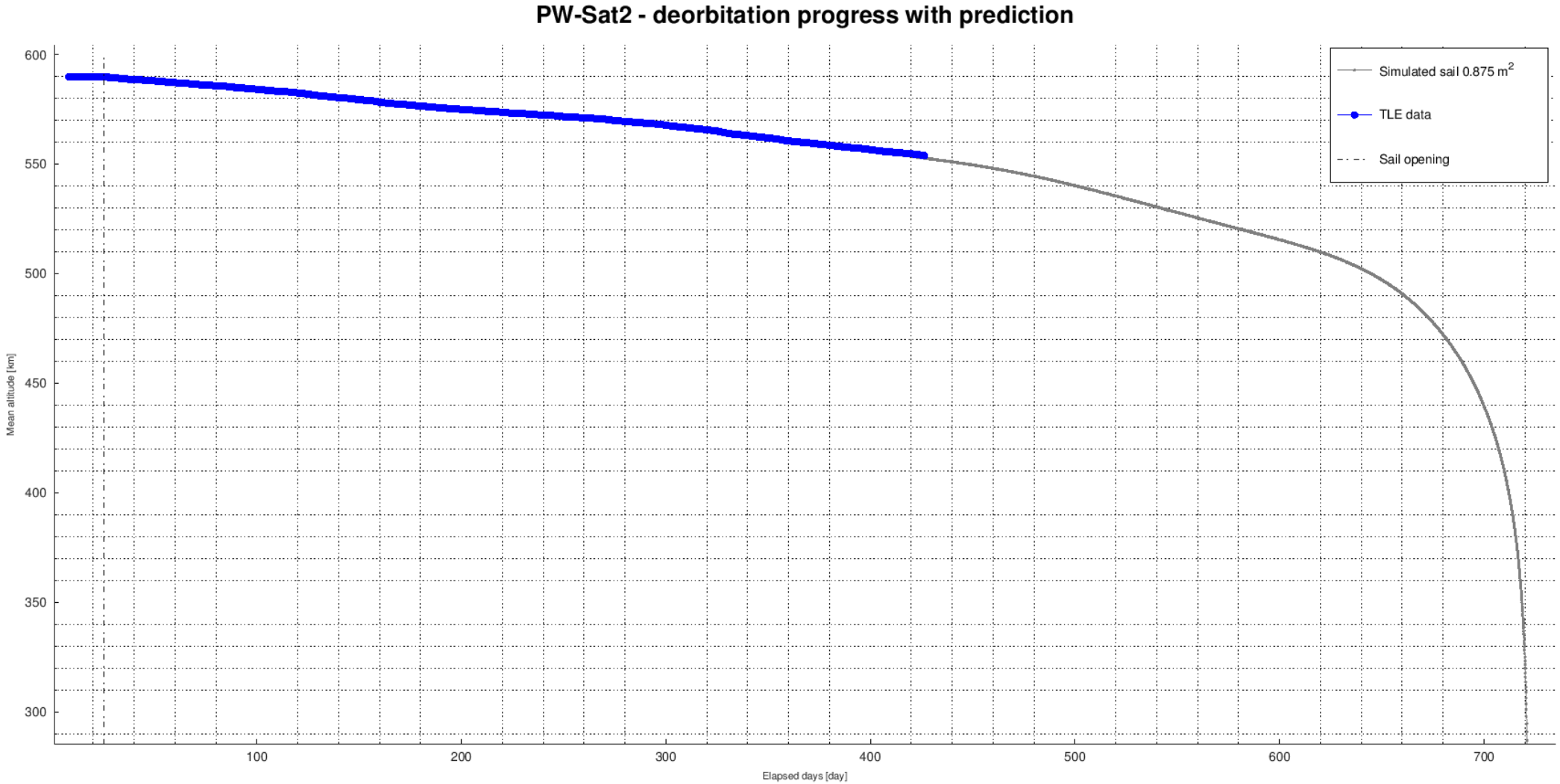
PW-Sat (2012-2014)



PW-Sat2 (2018-?)

Warsaw University of Technology

Polish deorbitation tests: PW-Sat and PW-Sat2



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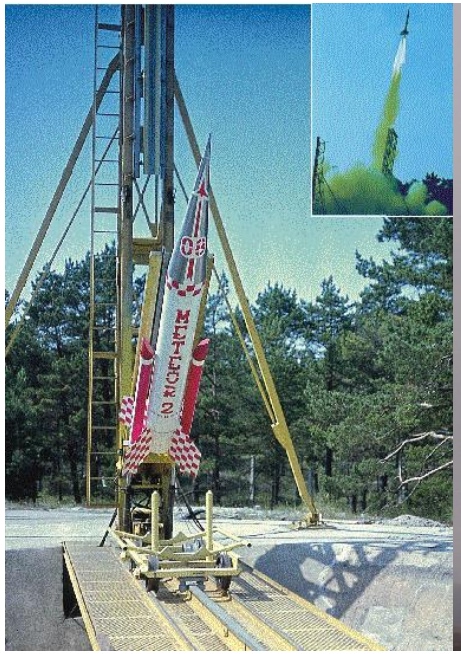
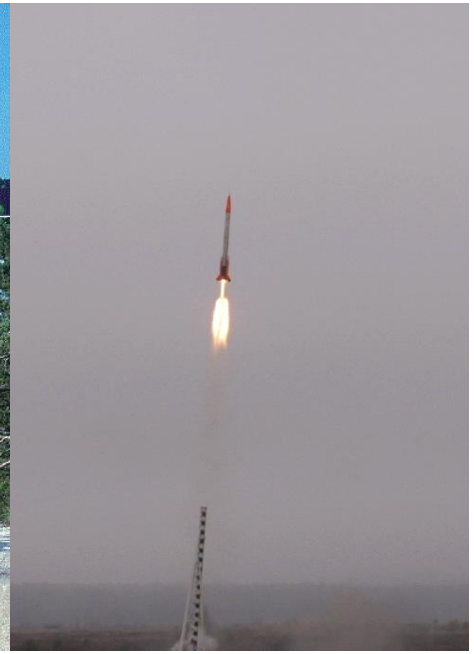


Meteor 2K
(105 km in 1970)



ILR-33 Amber
(2017)

- Over 1300 employees
- 90 years of R&D
- Projects within Aerospace, Energy and Power
- Dedicated Space Technologies Center
- Heritage in satellite flight hardware

Monopropellant Thrusters

Liquid Apogee Engines (bipropellant)

Solid Rocket Motors

Suborbital Rocket

Upper Stage Engine /Lander Engine

SPACECRAFT PROPULSION

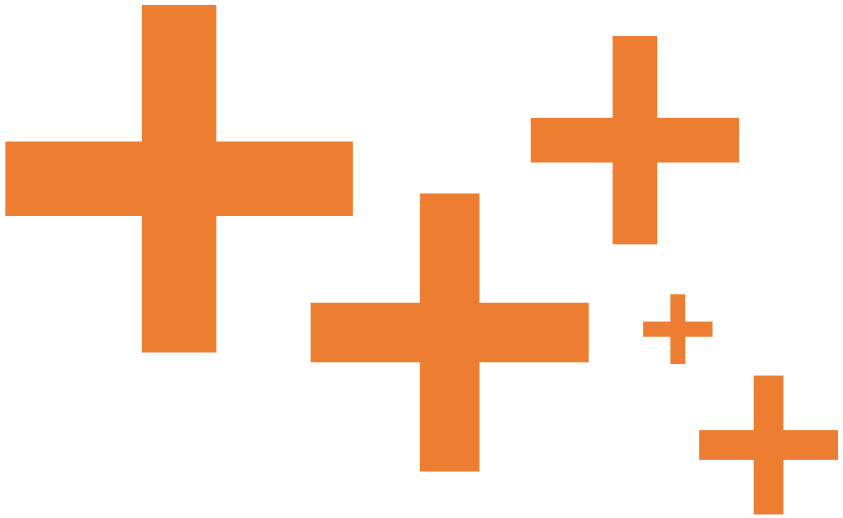
SPACE TRANSPORTATION

Development of the deorbitation motor under ESA projects

1. *CleanSat: Technology assessment and Concurrent engineering in support of LEO platform evolutions - "Solid rocket motor for deorbit" (finished)*
2. *Pre-Qualification of Aluminium-free Solid Propellant (finished)*
3. *Solid Rocket Motor for Deorbitation Engineering Model Development (in progress)*
4. *TVC System for Deorbitation SRM (future)*
5. *Solid Rocket Motor for Deorbitation with TVC Qualification Model Development (future)*
6. *Solid Rocket Motor for Deorbitation Flight Model Development (future)*
7. *In-orbit Demonstration*

Advantages of Solid Rocket Motors

- Simple construction
  - Compact size
  - High reliability



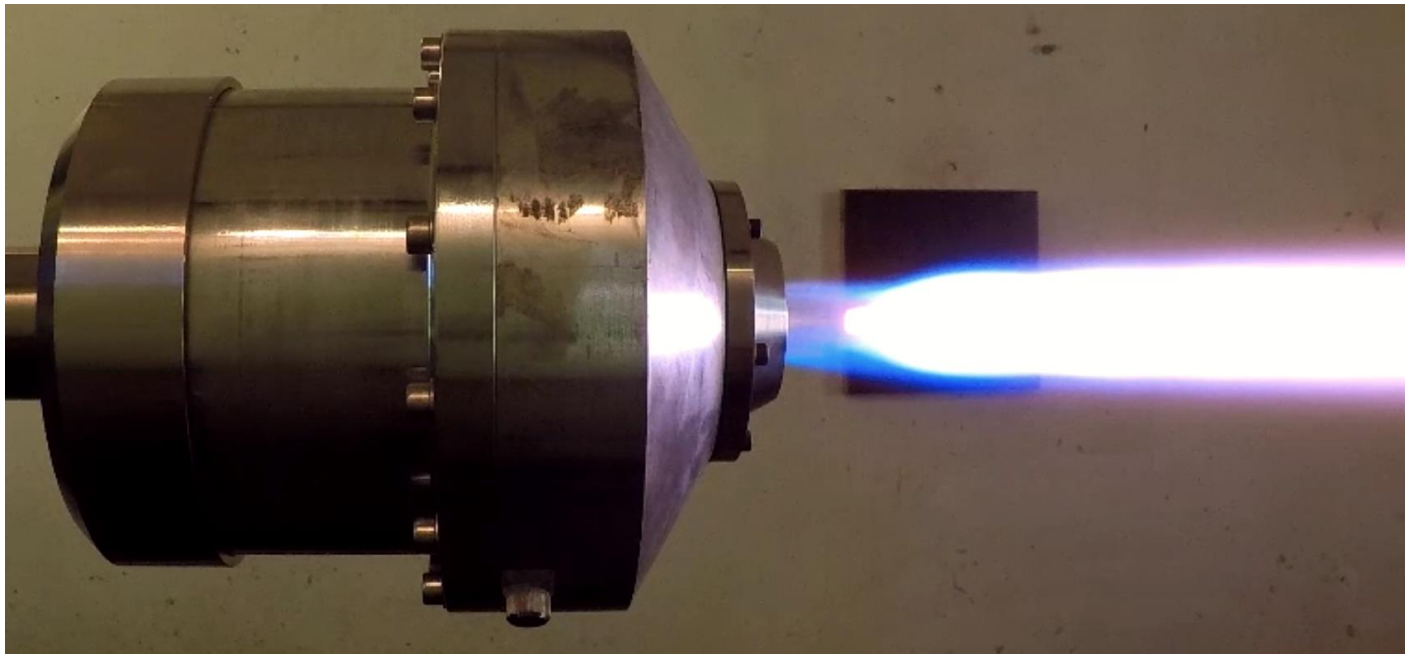
- Direct deorbitation capabilities
  - On-ground casualties risk elimination
- Wide range of thrust levels and profiles
- Relatively high performance
  - High density specific impulse
- Proven storability (on-ground)

Propellant development

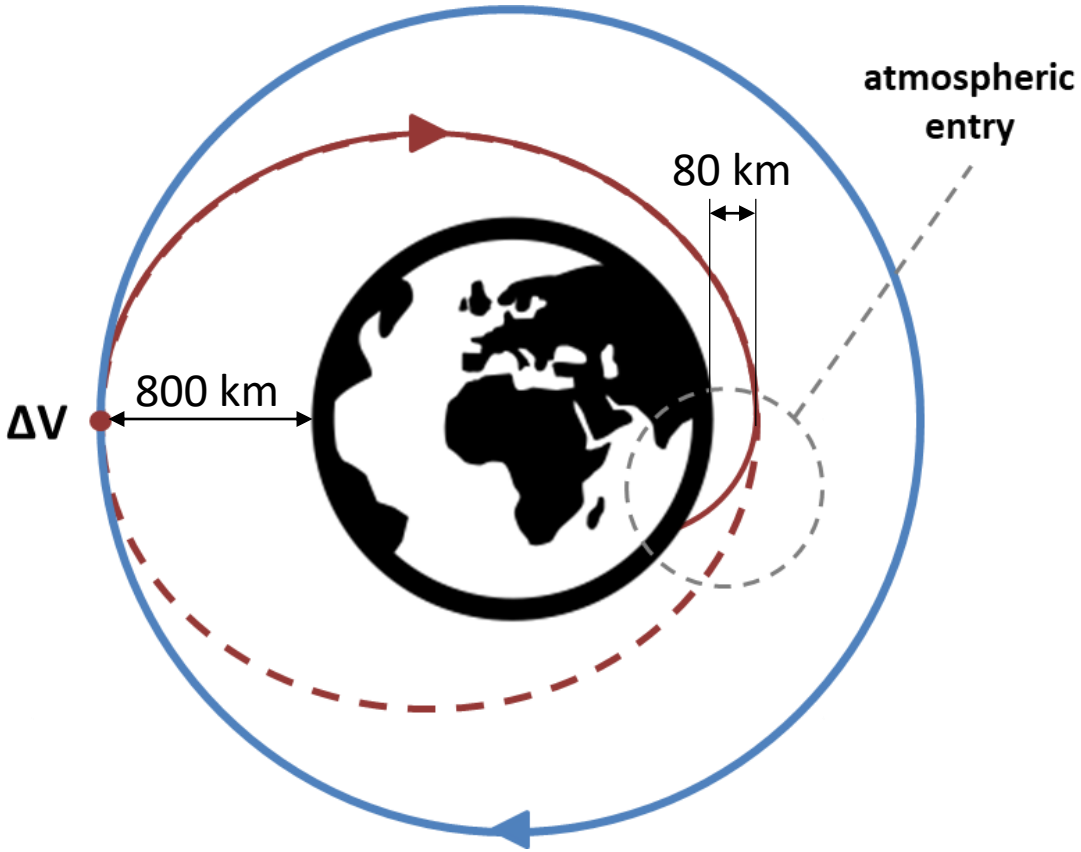
Challenges	***New propellant composition***
• High total impulse for direct deorbitation	• AP/HTPB system • Optimized oxidizer-fuel ratio
• Limited acceleration (long burn time)	• End-burning grain • Low chamber pressure • Burn rate moderators • Multimodal AP
• Solid particles generation	• Aluminium-free propellant
• Storability	• Vacuum, accelerated aging, radiation testing

Propellant testing

- Safety assessment
- ADR classification
- Vacuum stability
- Accelerated aging
- Radiation testing
- Test Motor
  - Performance confirmation
  - Solid particles detection
  - Materials screening

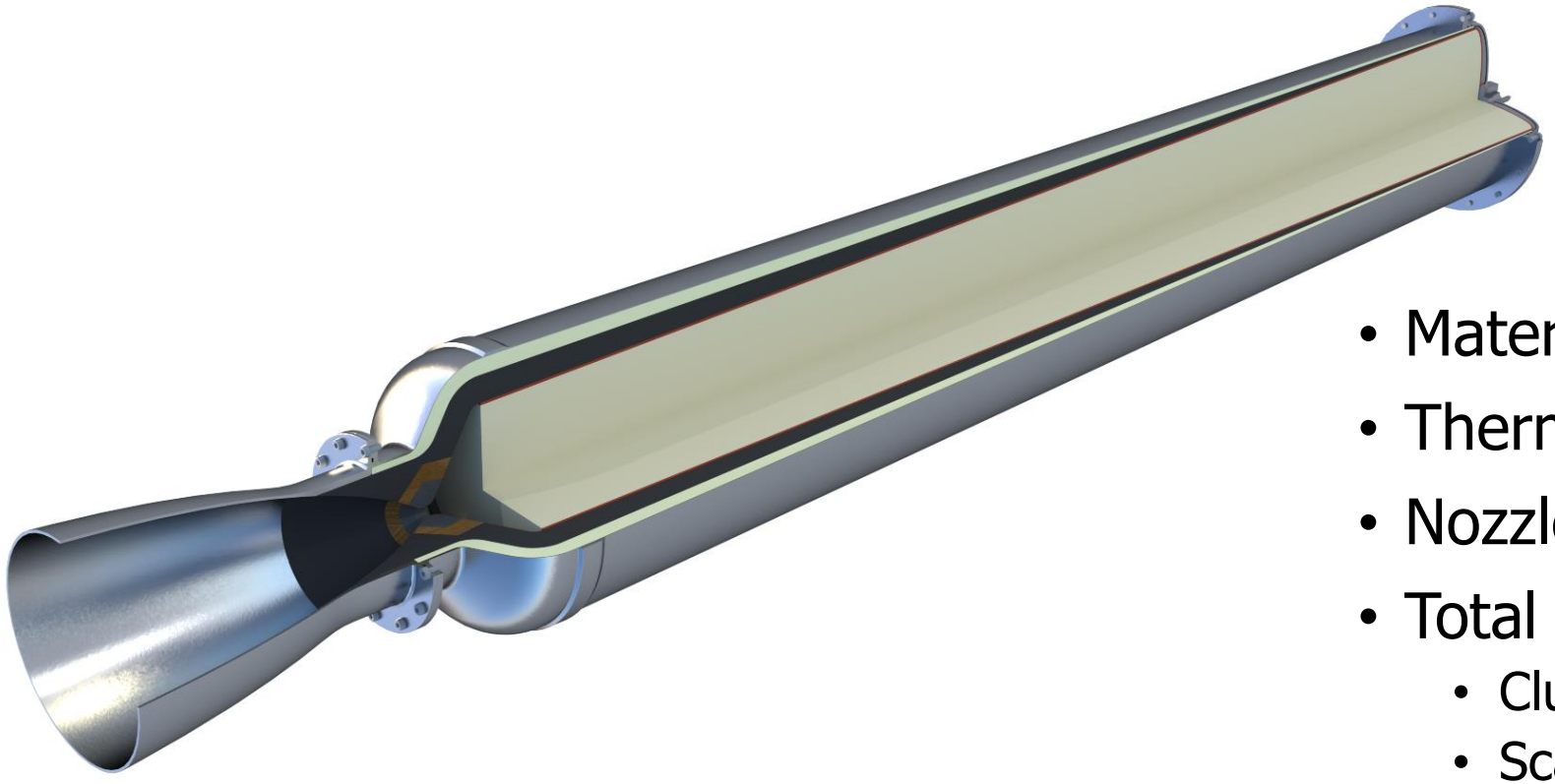


Nominal mission



Satellite	
Mass	1 500 kg
Initial orbit	SSO
Propulsion System	
Number of motors / fried simultaneously	4 / 2
Maximum acceleration	0.04 g
Total required ΔV	200 m/s
Motor	
Maximum thrust	250 N
Propellant mass	31.0 kg
Total impulse	82.5 kNs
Nozzle expansion ratio	200
Specific impulse	272 s

Deorbitation SRM Engineering Model



- Materials selection
- Thermal insulation
- Nozzle throat regression
- Total impulse adjustment
  - Clustering
  - Scalable design (length reduction)
- System Level integration
- Full-scale testing

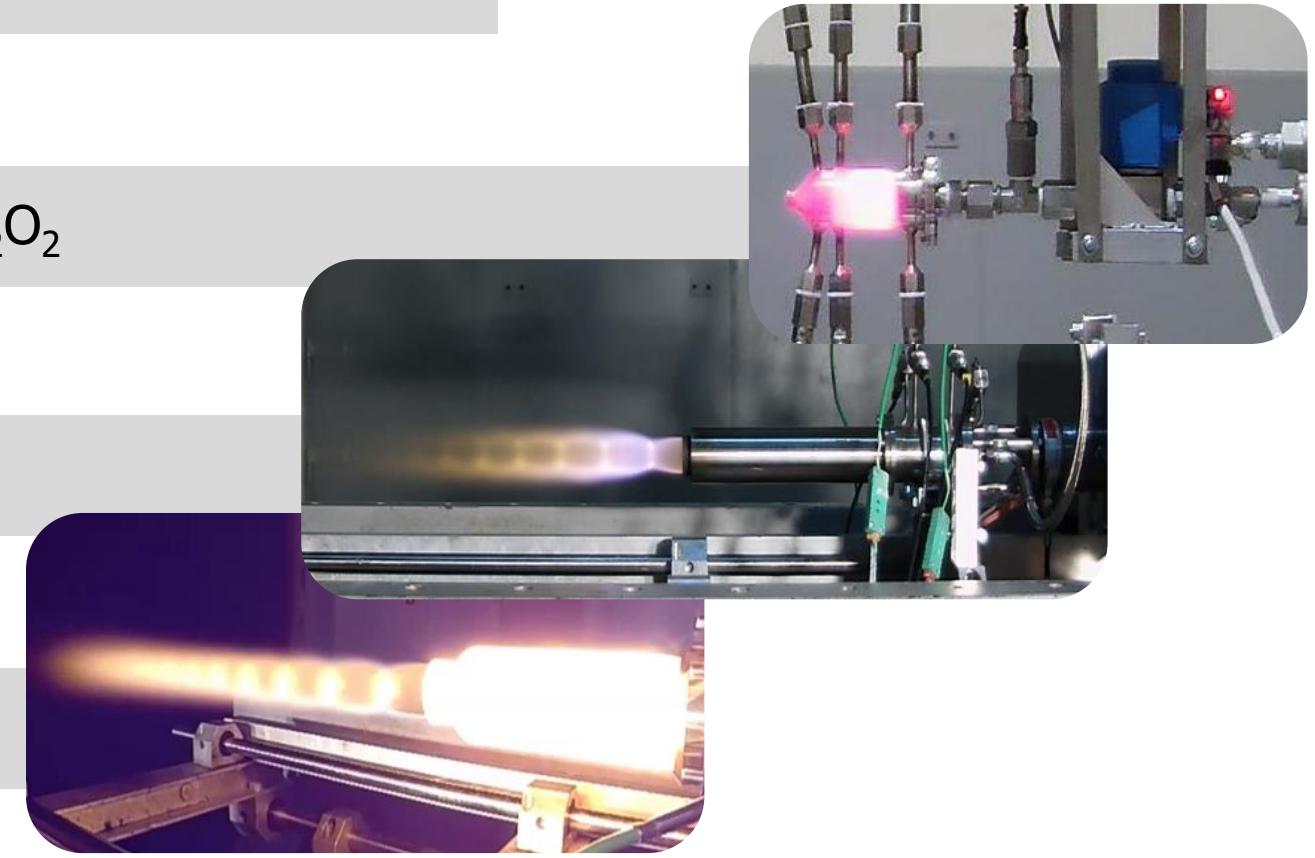
Alternatives – liquid green propulsion

Highly concentrated **Hydrogen Peroxide** (over 98%)
Various solutions designed and tested at the Institute:

Monopropellant thrusters using H_2O_2

Hybrid rocket motors using H_2O_2

Liquid rocket engines using H_2O_2



Conclusions

- Institute has over 50 years of experience in rockets and chemical propulsion development
- Dedicated Solid Rocket Motor for deorbitation is under development
- Institute is one of the leaders in liquid green propulsion design and testing
- Institute provides solutions for end-of-life disposal in line with the Space Debris Mitigation Guidelines

Acknowledgements

I would like to offer my special thanks to Prof. Piotr Wolański and Dr Leszek Loroch for valuable advice and support of this work.

Thank you for your attention

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