μ-PPI
The smallest Hall effect thruster for Cubesats

Deorbit Device Competiton – UNISEC 2016

Paul Lascombes - Exotrail

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ÉCOLE POLYTECHNIQUE UNIVERSITÉ PARIS-SACLAY

Summary

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1. The rise of space junk

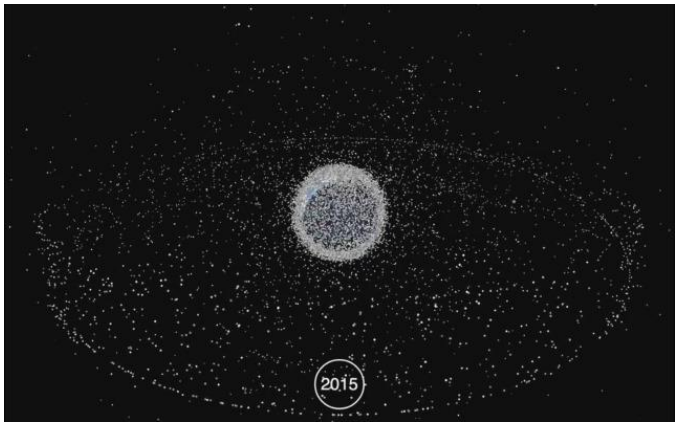
Rising number of space junk and satellite launches in the recent years

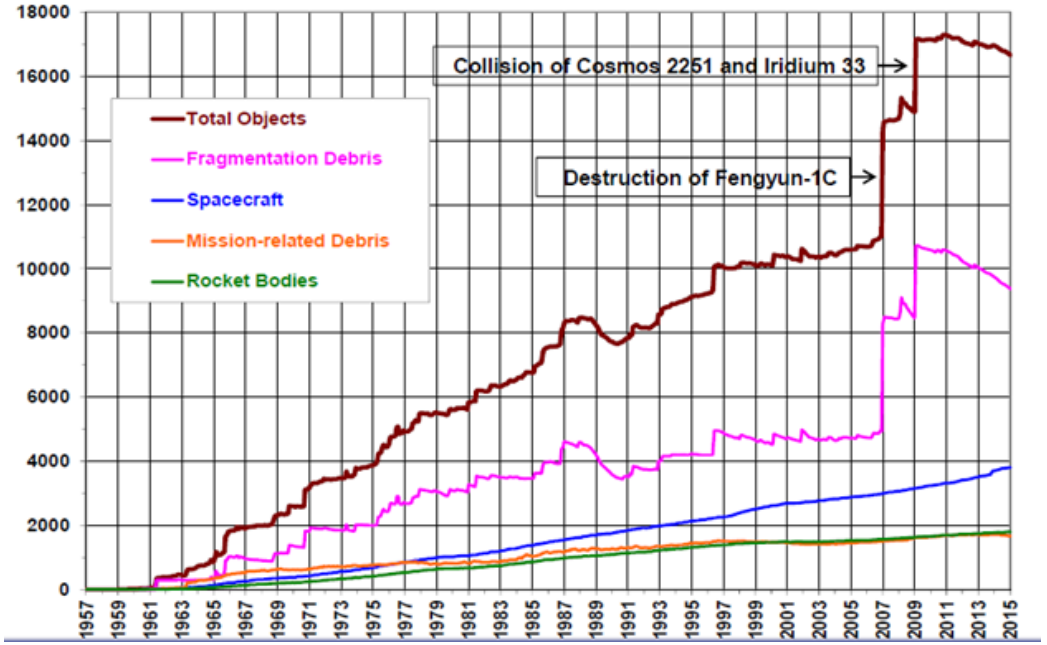
Dramatic increase in the number of space debris due to **collisions**

Steady increase due to more **frequent launches**

Key facts about space junk:

- **Exponential increase** due to the number of satellites in orbit
- **Slow natural decay** at altitudes higher than 500km
- Very **dangerous for satellites** with relative speed up to 15km/s
- Stronger flux of **man-made space junk** than of natural objects (micro-meteorites)
- Complicated to track: 1cm in LEO, 10cm in GEO





2. Consequences of debris

Space junk is a major concern for the future of the space industry

All Earth Observation satellites are located on **the same orbit**

Satellites are a key feature of **modern intelligence** agencies

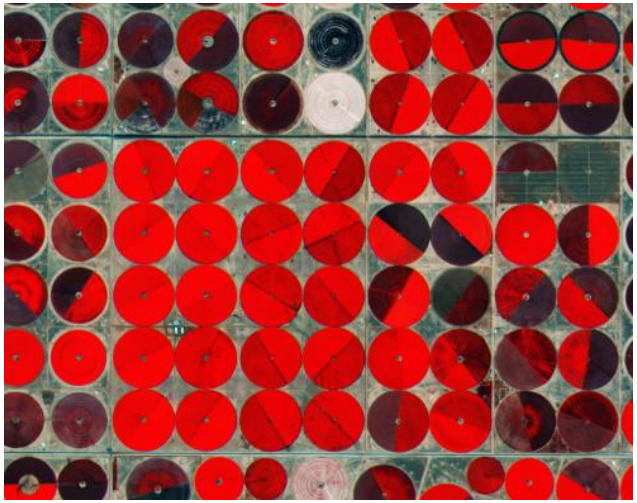
Loss of business opportunities and socially important services (constellations for Earth Observation in agriculture or for GPS)

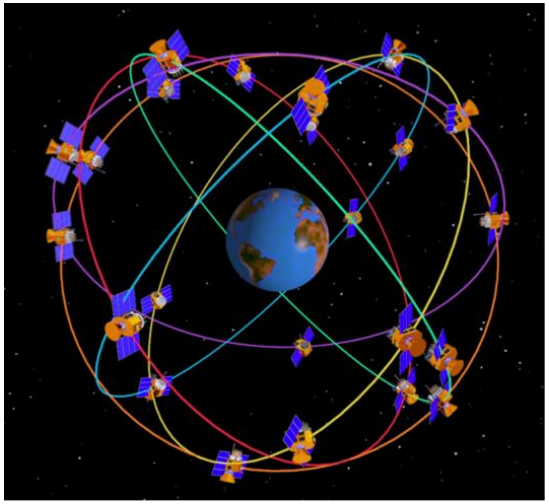
Economic rationale

- Overloaded orbits : sun-synchronous between 500km and 800km, geostationary orbit
- Loss of business opportunities for future space-based applications
- Impossibility to launch large constellations (e.g. OneWeb or SpaceX telecommunications constellations)

Strategic consequences

- Loss of **global imagery coverage**, necessary for intelligence agencies
- **Additional risk** for launches on higher altitudes





3. Solutions to mitigate risks

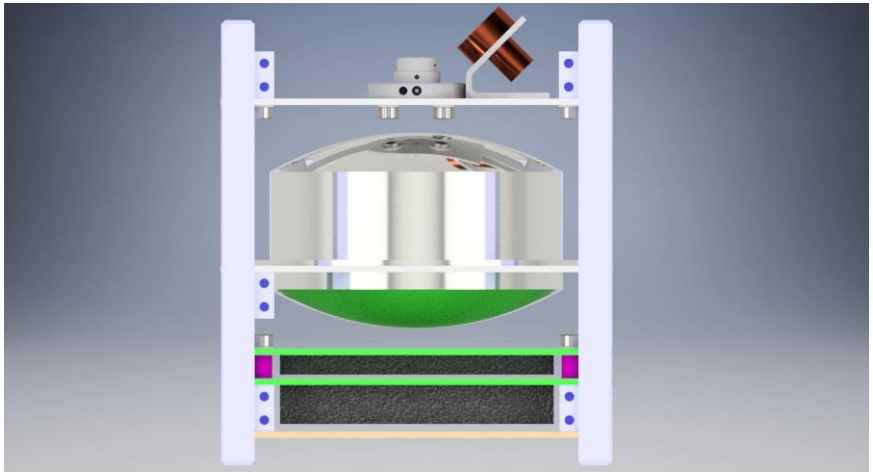
General overview of solutions to mitigate risks that space debris constitute

At the institutional level

- Deorbit **in less than 25 years** is mandatory if the satellite was launched from the U.S.A. or France
- Projects funded by space agencies to **study deorbit**

For satellites owners

- Ensure **reliability** of the thrusting system and keep **fuel reserves**
- **Satellite agility** to avoid known and mapped debris



Need for a **new efficient thrusting device** to meet the industry's demand

4. Exotrail propulsion unit

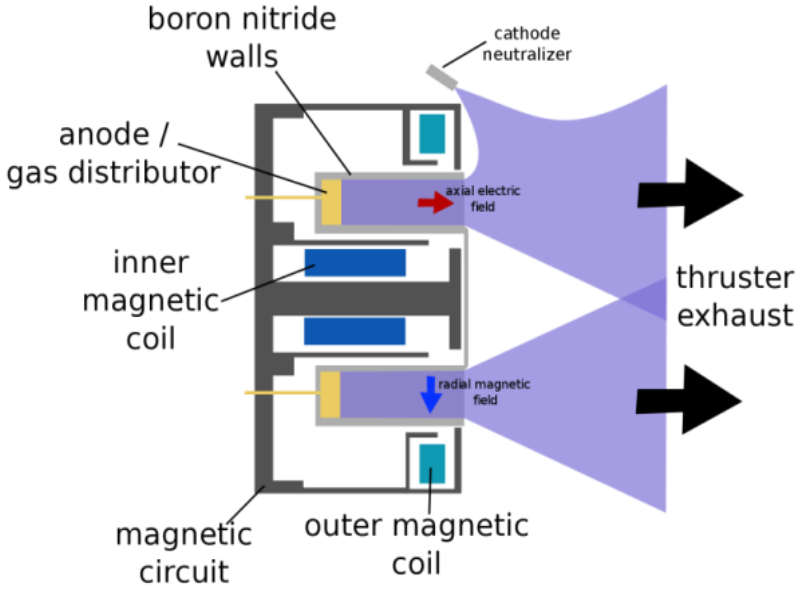
HET overview

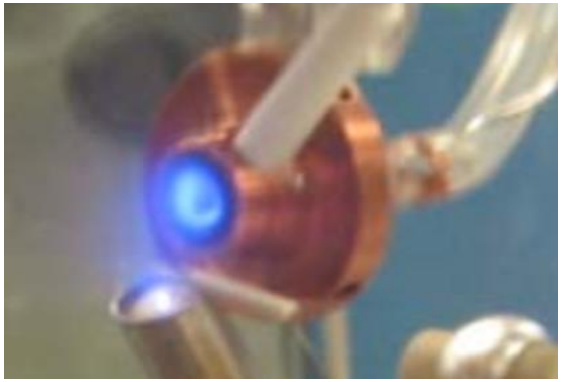
Space-proven technology

- ✓ Electric, high-Isp, low power consumption technology
- ✓ First flown by the USSR in **1971**
- ✓ More than **240 HET** have been successfully fired in space

Our patented innovation

- ✓ Use of a full-ceramic design
- ✓ No need for power-hungry and complex coils
- ✓ Scalability towards smaller thrusters





5. Exotrail propulsion unit

Description of our propulsion unit

Main characteristics

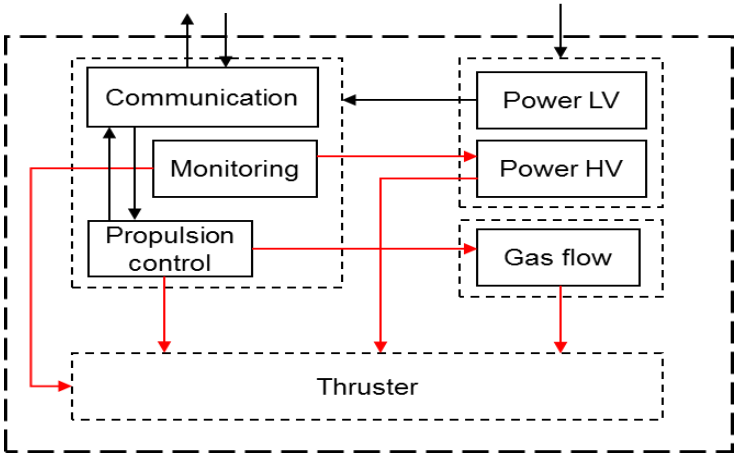
- ✓ Thrust: 100 – 150 µN
- ✓ Power: 5 – 10 W
- ✓ Isp: 1000 – 1500 s
- ✓ Delta-V: 100 – 500 m/s
- ✓ Weight: <1kg with propellant
- ✓ **Full-ceramic design**

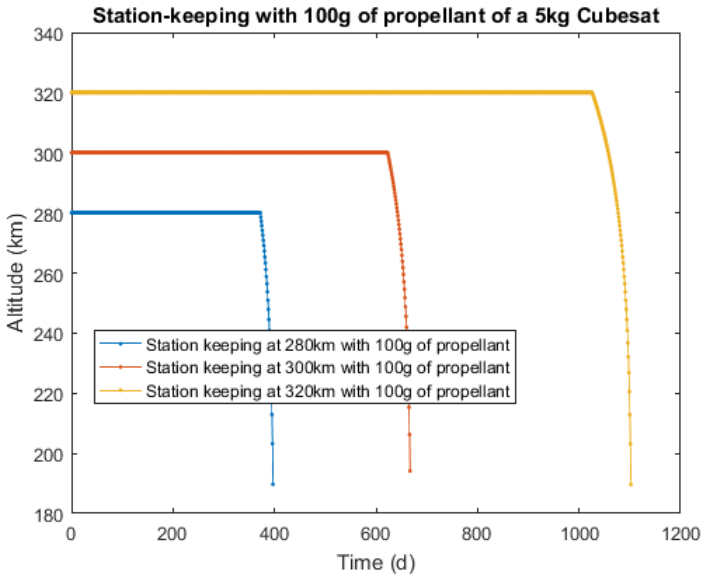
Integrated solution

- ✓ Fully-integrated unit
- ✓ Standard power input
- ✓ Standard data interface
- ✓ <1U size format

Reliable solution

- ✓ Safety standard from the traditional space industry
- ✓ 5 years minimum lifespan
- ✓ Space-proven technologies
- ✓ Extensive testing in a state-of-the-art facility





6. Exotrail propulsion unit

Propulsion unit performances

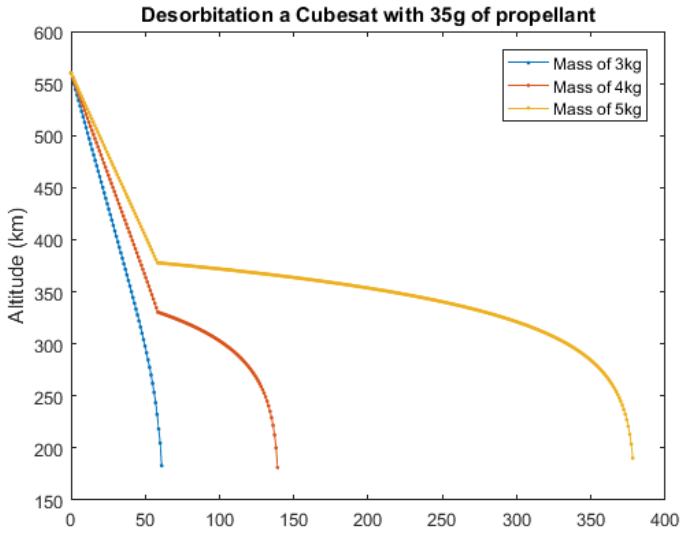
Deorbit performances

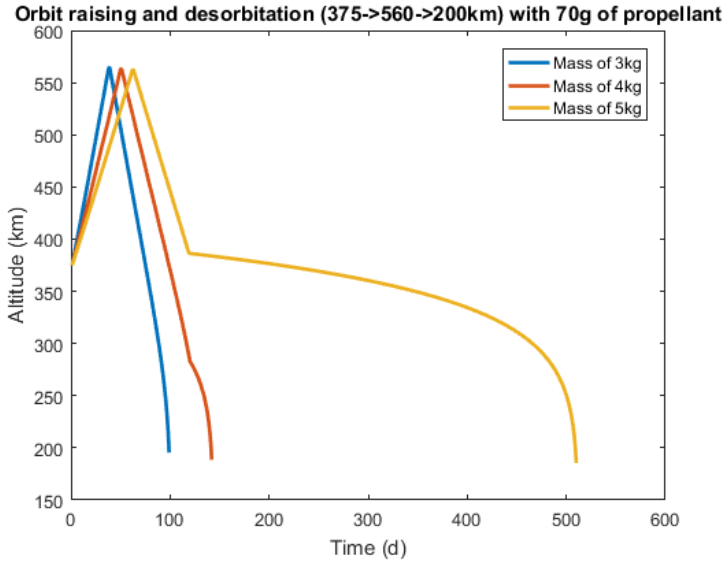
- ✓ Deorbit of a 5kg Cubesat in **less than 400 days** from an altitude of 560km
- ✓ Only uses **35g of propellant**

New capabilities, new missions

- ✓ Perform **debris avoidance** manoeuvers → limits the risk of new space debris
- ✓ **Orbit raising** to access more interesting orbits
- ✓ **Constellations deployment** from a unique launch: phasing
- ✓ **Redeployment** after a failure of a satellite
- ✓ Deep-space missions

→ Increase **satellite agility** to perform **new missions** and successfully deorbit afterwards



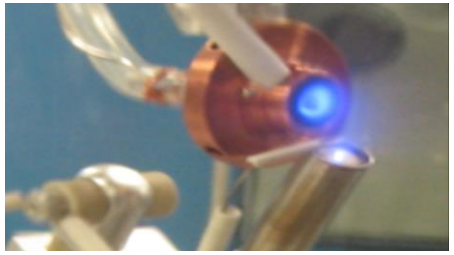


7. Exotrail develops a set of constellation management services

Turnkey hardware & software solutions in satellite control and management

Exotrail Thrusting Hardware

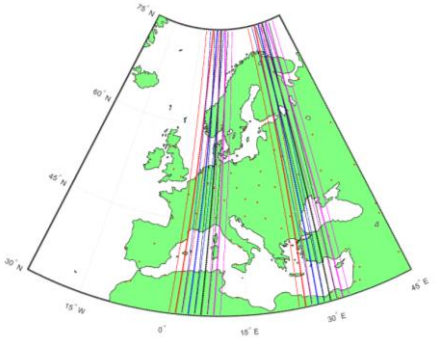
Hall Effect Thruster ('HET')



- Our HET is **the smallest in the world** and boasts major patented simplification innovations
- HET technology **used in space since decades**, known for its great performances, reliability and efficiency
- **High efficiency**, **low power consumption**, **high total impulse**, **low-cost strategy**

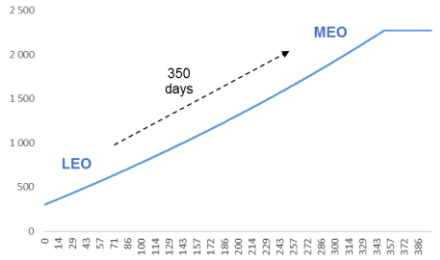
Exotrail Orbitography Services and Software

Mission design



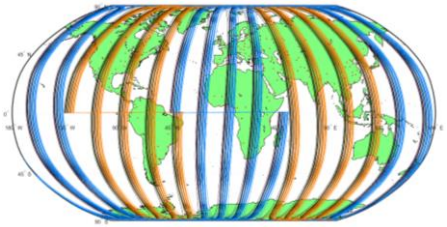
- Assist the client in designing its mission and **determining the optimal trajectory, altitude and orbit**
- Implement our thruster's **on-board control software** accordingly
- Adapt our thruster's design to fully fulfil the mission (e.g. amount of fuel)

Mission control



- **Real-time remote control** of the thrusting unit, while in space, to fully fulfil the mission
- Post-launch manoeuvres such as **satellite positioning** and **orbit injection**, **station-keeping**, shift in altitude in Low Earth Orbit, shift from Low to Medium Earth Orbit, deorbiting

Constellation management

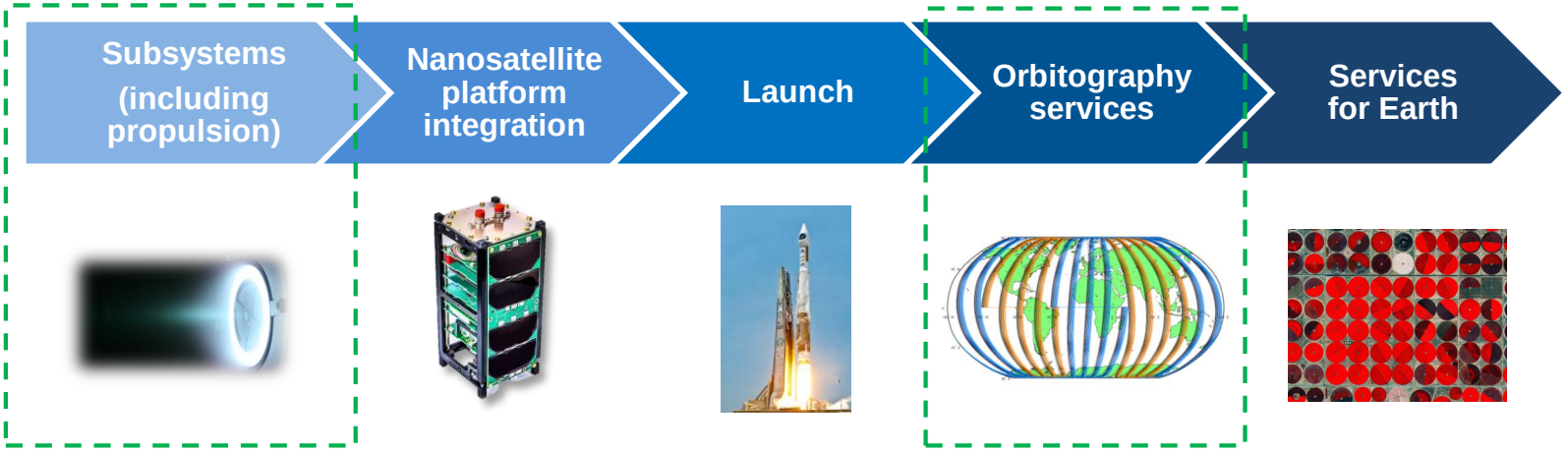


- **Mission design**, at the constellation scale
- **Automated mission control** thanks to a dedicated constellation management software
- **Optimal repartition** of the constellation around Earth, to enhance performances

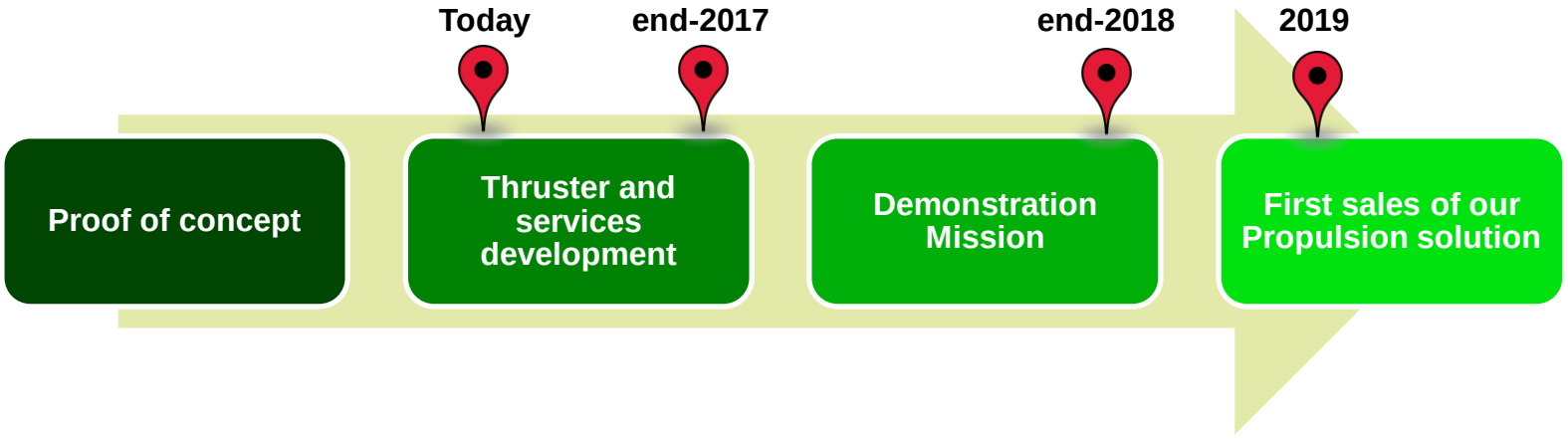
8. Roadmap

Where we are, where we go and when we will get there

Exotrail delivers turnkey services in constellation management, building on its HET and orbitography know-hows



Our roadmap



Conclusion

We propose a solution dedicated to bring agility to a Cubesat

1. That reduces the risk of debris creation by enabling avoidance manoeuvers

2. That successfully deorbits a Cubesat in a short and controlled duration

3. That enables to design complex manoeuvers

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QUESTIONS ?

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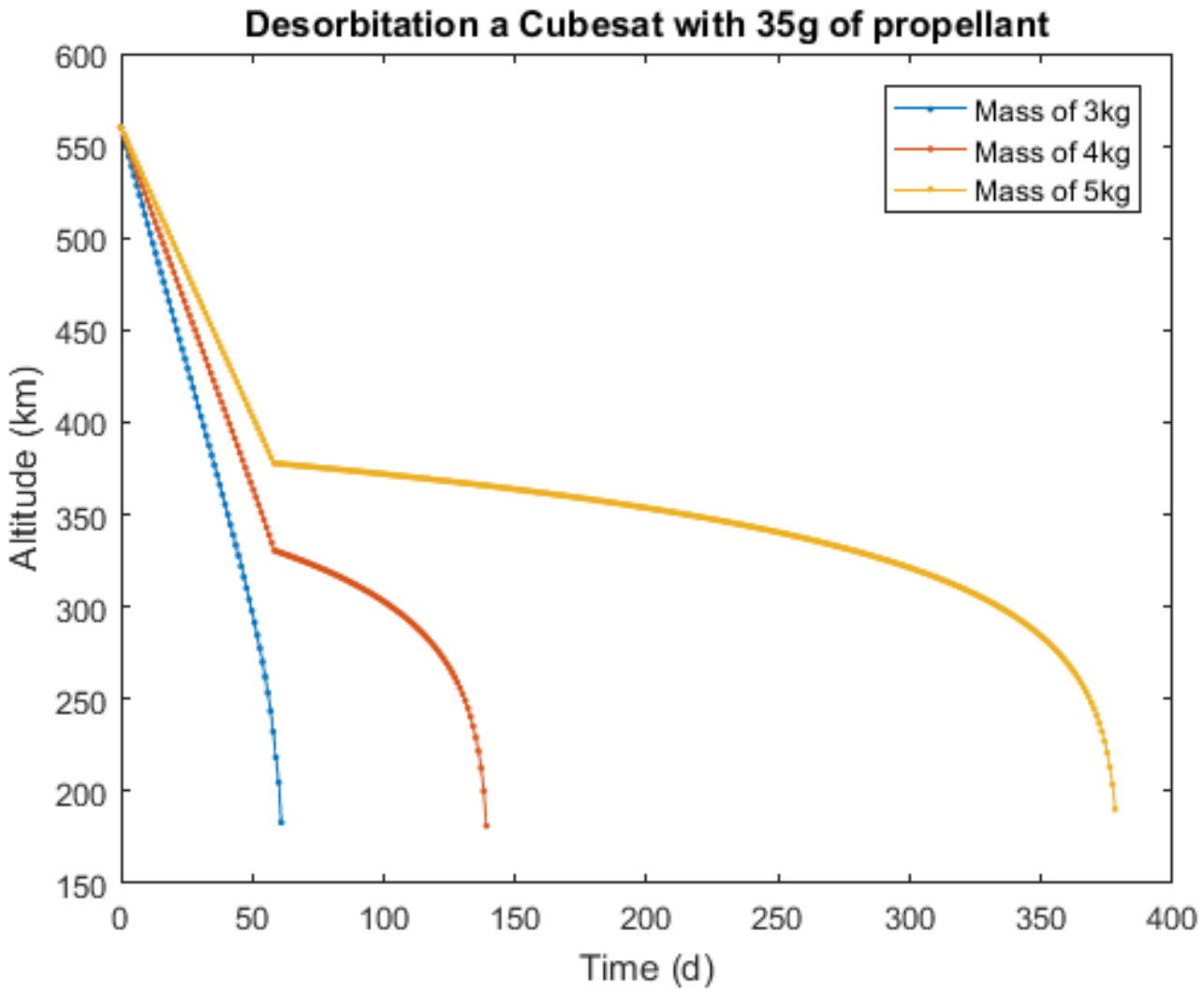
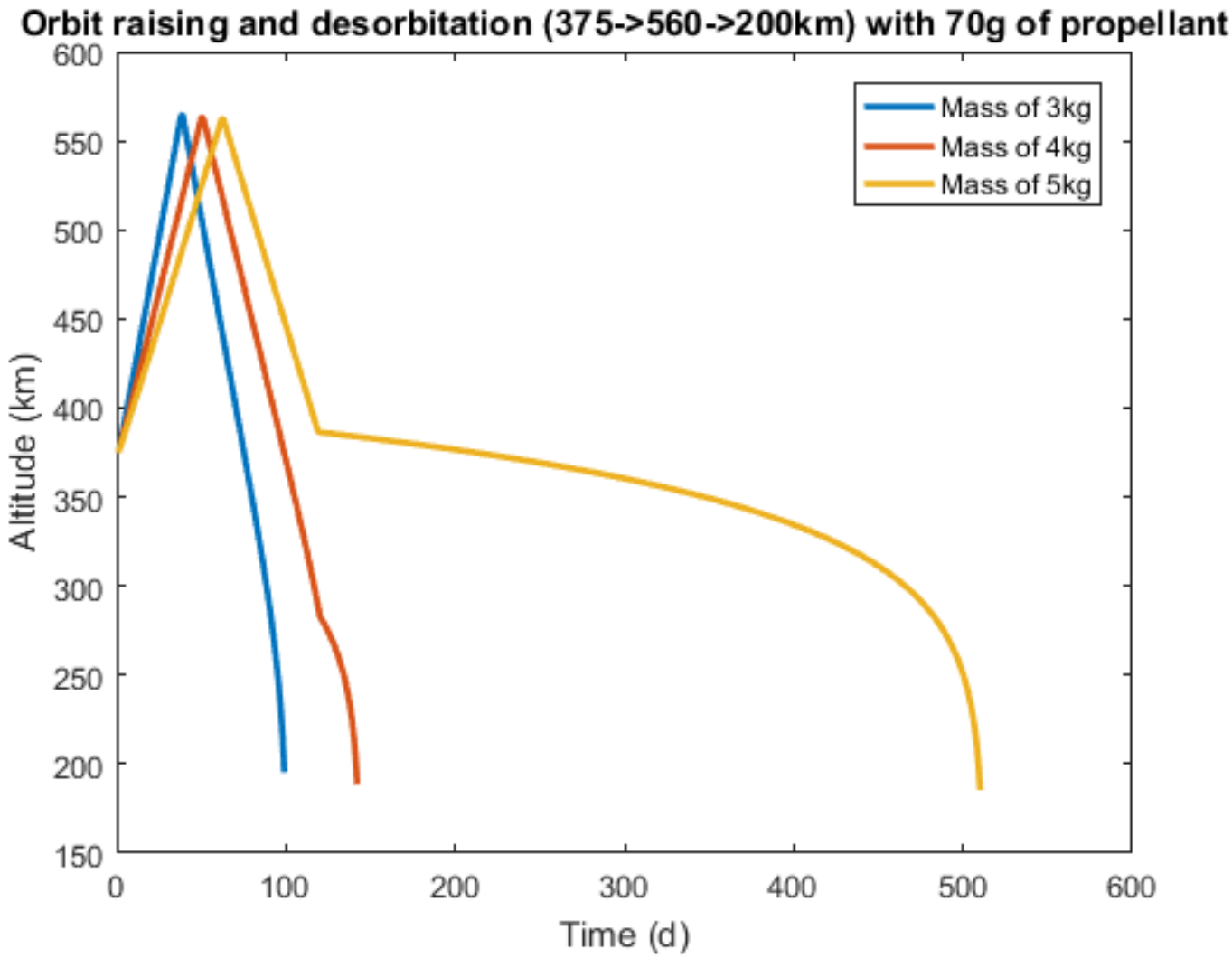
Annexes

Graphs



Annexes

Graphs



Annexes

Graphs