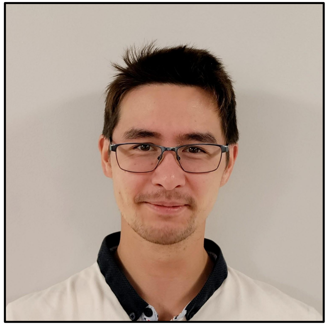
Hermes CubeSat - Speakers

Martí Pujol Gasulla

Téo Lenormand

Paul Michel



Arnold Hellin

Hermes Cubesat

On-site data gathering for accurate mapping of the Main Asteroid Belt.

Martí Pujol Gasulla, Arnold Hellin, Teo Lenormand, Paul Michel

La SEINE

Kyutech
Kyushu Institute of Technology

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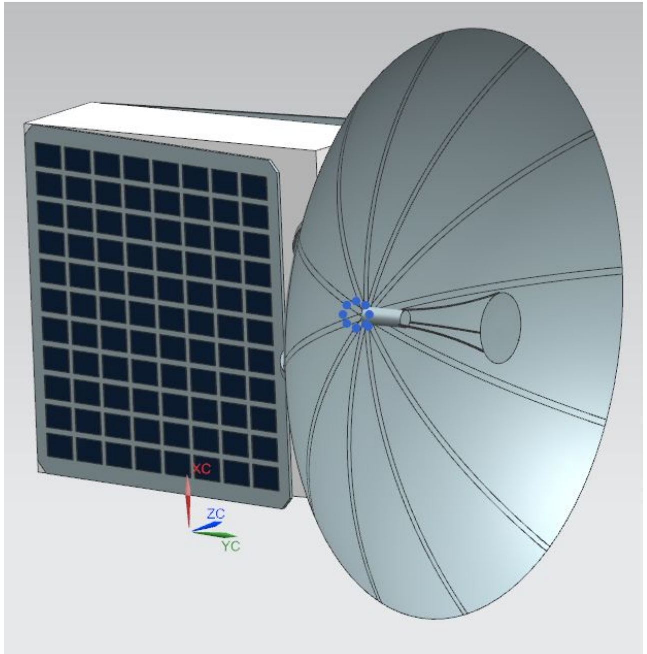


Motivation

Key Advances

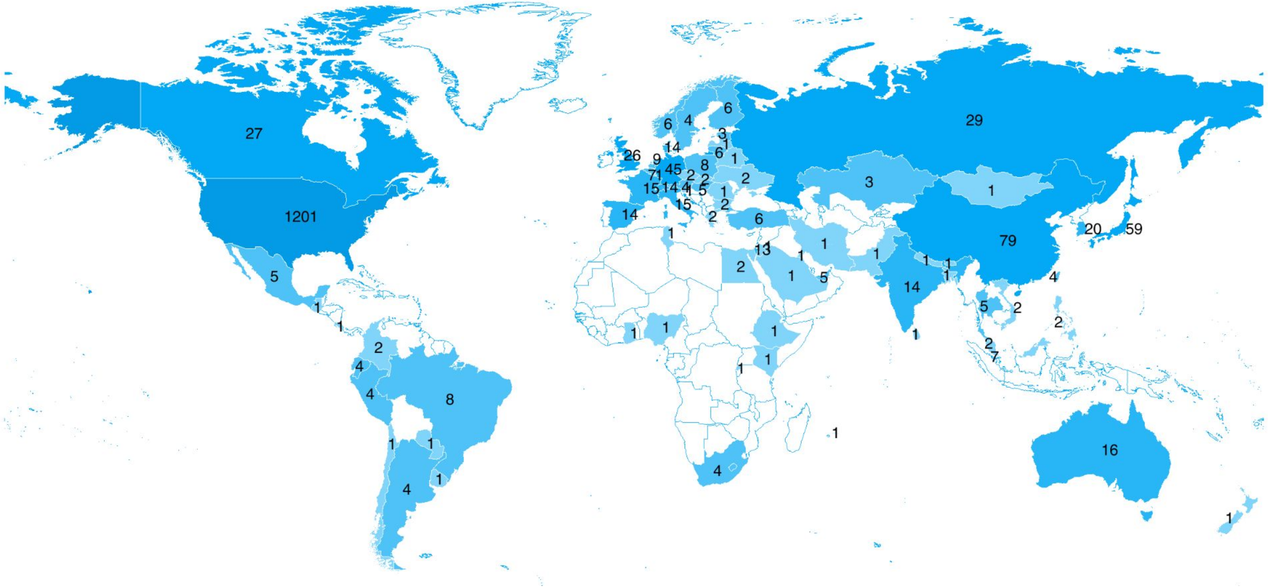
- Technology miniaturisation
- Energy efficiency
- Power Capabilities

Democratisation of LEO

↓

Democratisation of Deep Space

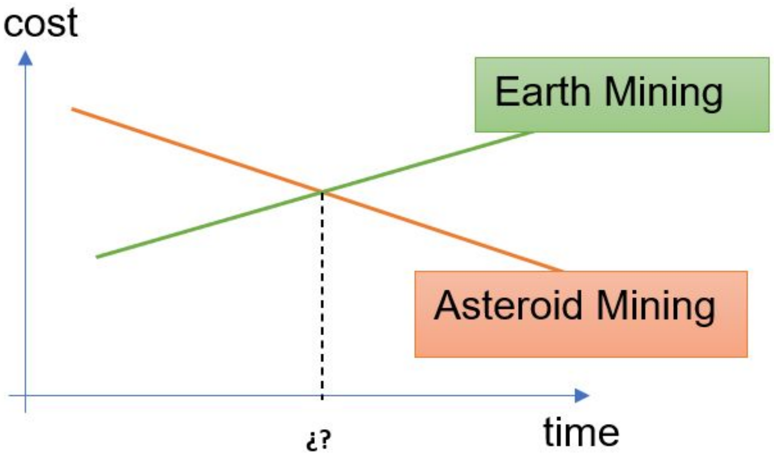
Launched nanosatellites



www.nanosats.eu

Motivation

Asteroid Mining



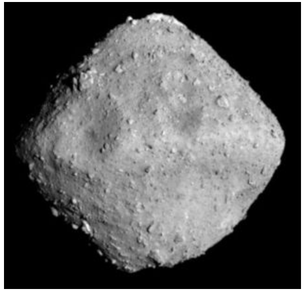
Currently, it does not make economic sense.

The vision: once it is economically viable, have an extensive database for asteroids.

Why?

Ground observations of asteroids are not 100% reliable

Recent examples: Ryugu and Ultima thule.

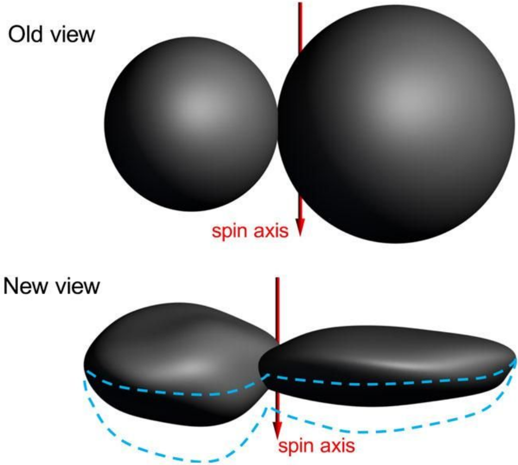


Ryugu asteroid

Current numbers for asteroid population are based on indirect estimations.

Extrapolation methods

Surface impacts on moons



Ultima thule

NASA/JHU APL/SwRI

How? The cubesat & Orbit

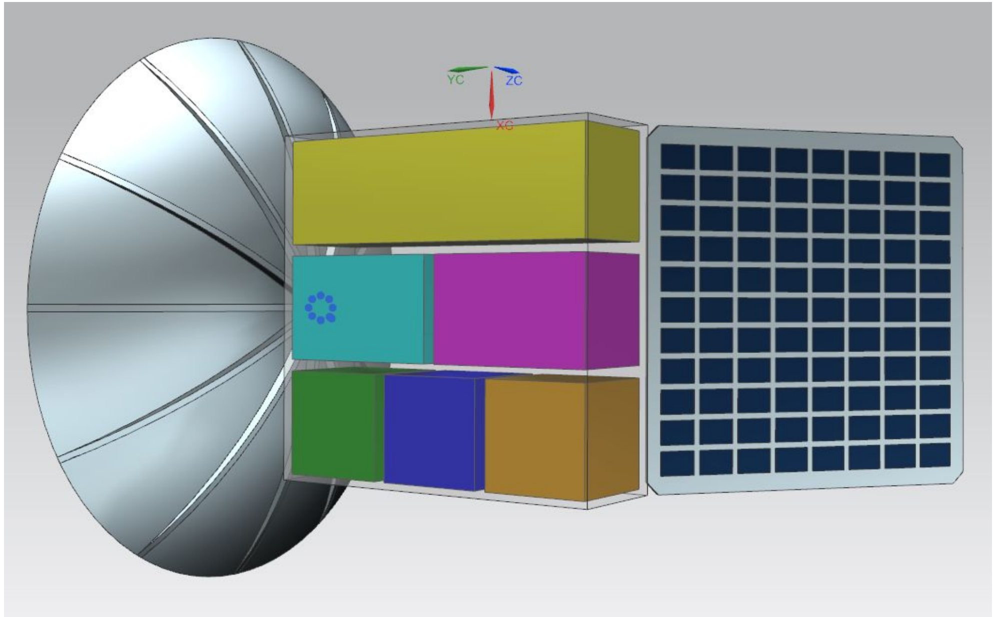
Main Spacecraft Constraints:

Less than 100 kg and $1m^3$.

Launcher can reach deep space.

Deep Space Network ground stations.

Launch must be before 2030.



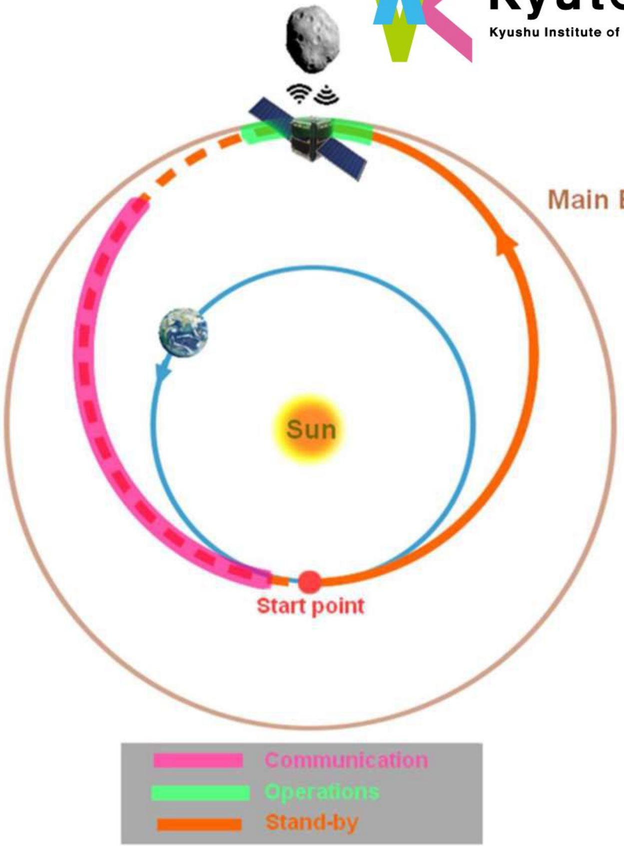
Hermes Cubesat concept.

How? The cubesat & Orbit

Highly elliptical orbit around the Sun.

3 mission phases:

- Communication
- Operation
- Stand-by



Orbit diagram, not to scale.

2. Mission objectives

Phase O: Radar detection

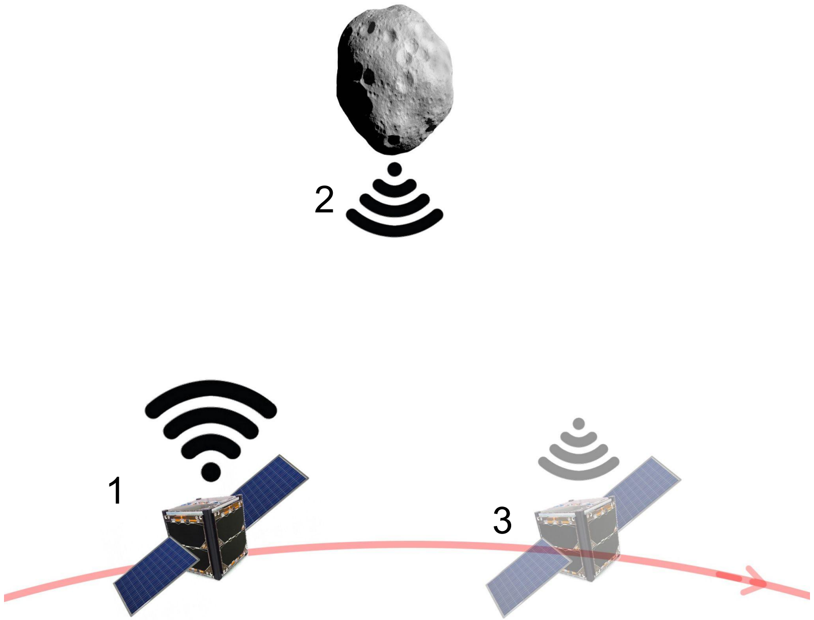
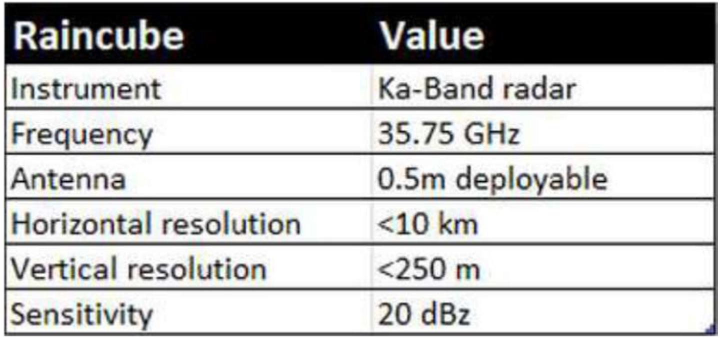


Table 1: Characteristics of Raincube's radar.



Raincube	Value
Instrument	Ka-Band radar
Frequency	35.75 GHz
Antenna	0.5m deployable
Horizontal resolution	<10 km
Vertical resolution	<250 m
Sensitivity	20 dBz

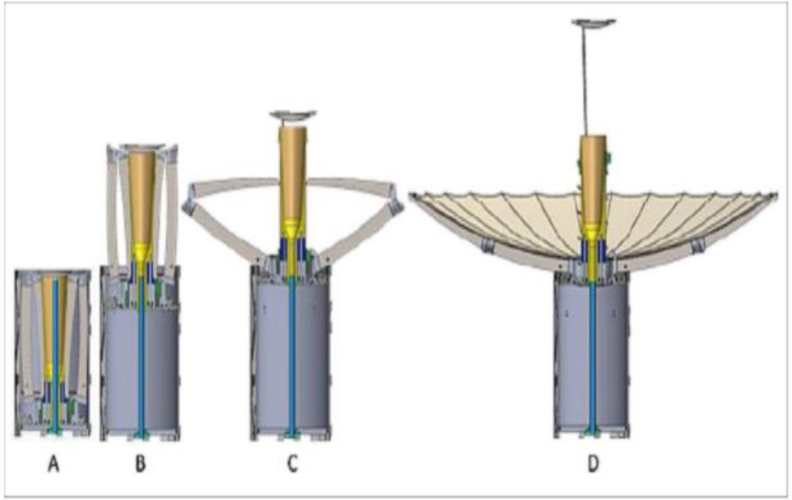
Collected information:

- Doppler effect;
- Time delay;
- Magnitude.

Phase O: Radar detection

Example: Raincube mission’s deployable radar (not commercially available, under development).

Deploys from 1.5U to 2.5U. Very small and lightweight.



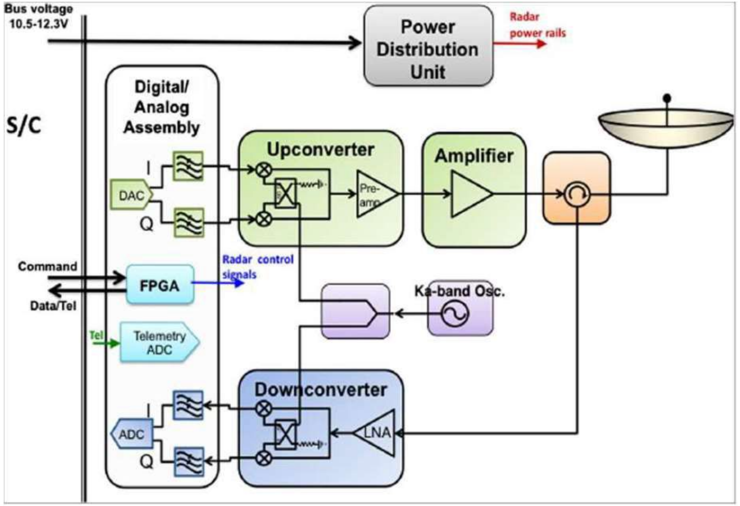
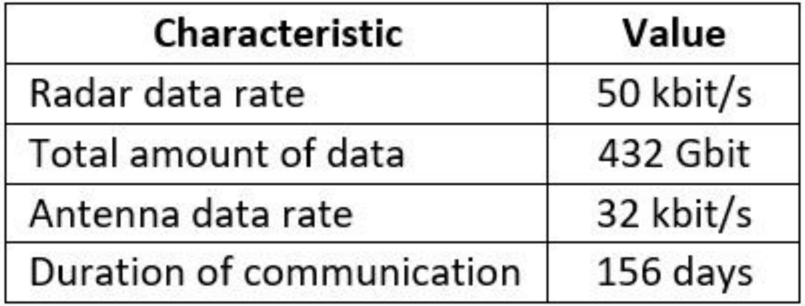


Figure 1: Deployment sequence of the Raincube radar.

Figure 2: Block diagram for the Raincube radar.

Phase T: Earth communication

Table 2: Communication data characteristics.



Characteristic	Value
Radar data rate	50 kbit/s
Total amount of data	432 Gbit
Antenna data rate	32 kbit/s
Duration of communication	156 days

X100 days for the phase O

Figures in table 2 correspond to the unprocessed data.

The total amount of data can be reduced with onboard treatment (void suppression, compression…).

3. Concept of operations

Inclination range of the orbit (Figure 4): [0 ≤ i ≤ 20°]

Eccentricity range of the orbit (Figure 3): [0.05 ≤ e ≤ 0.3]
→ No specific launch window

Wide asteroid belt and large population of small bodies
→ Empty regions between asteroids: low probability of collision risk with asteroids

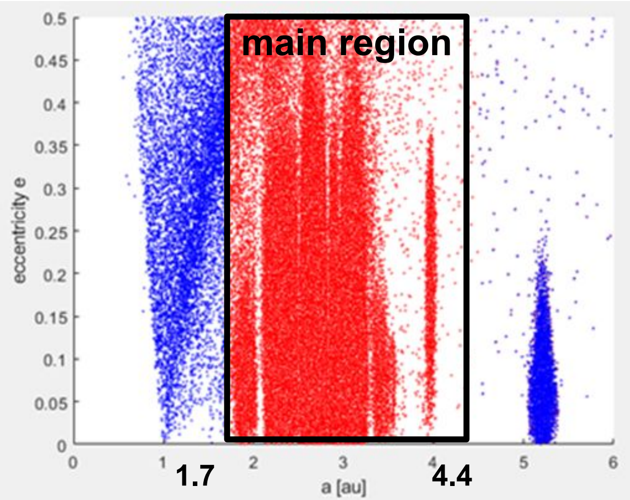


Figure 3: eccentricities of 1,048,514 numbered minor planets versus their distance to the Sun.

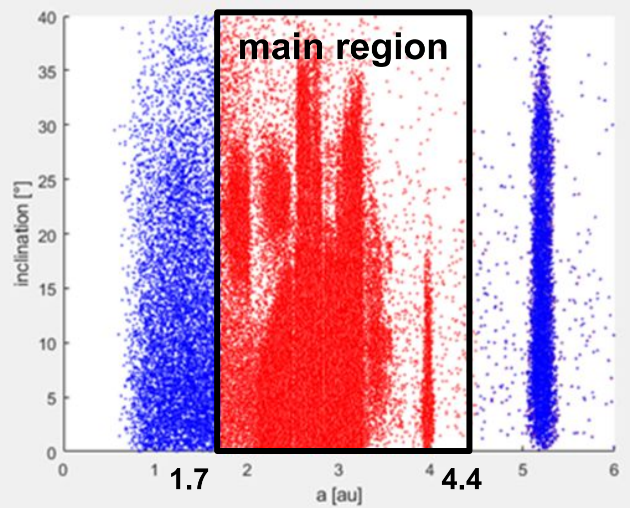


Figure 4: Inclination of 1,048,514 numbered minor planets versus their distance to the Sun.

The satellite will be able to fly-by multiple times on the orbit shown in figure 4.

The fly-by zone is a corridor thick by **2%** the distance from the sun (**between 2.2au and 2.24au**)

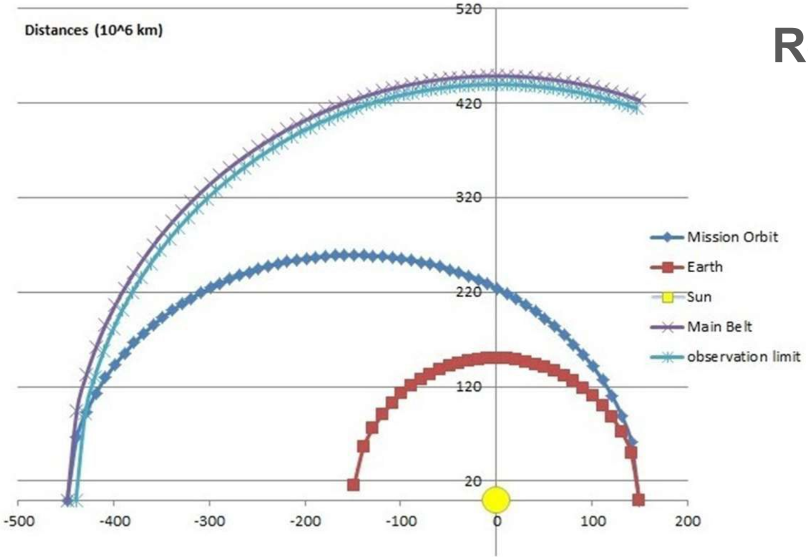


Figure 5: Limit for the observation orbit.

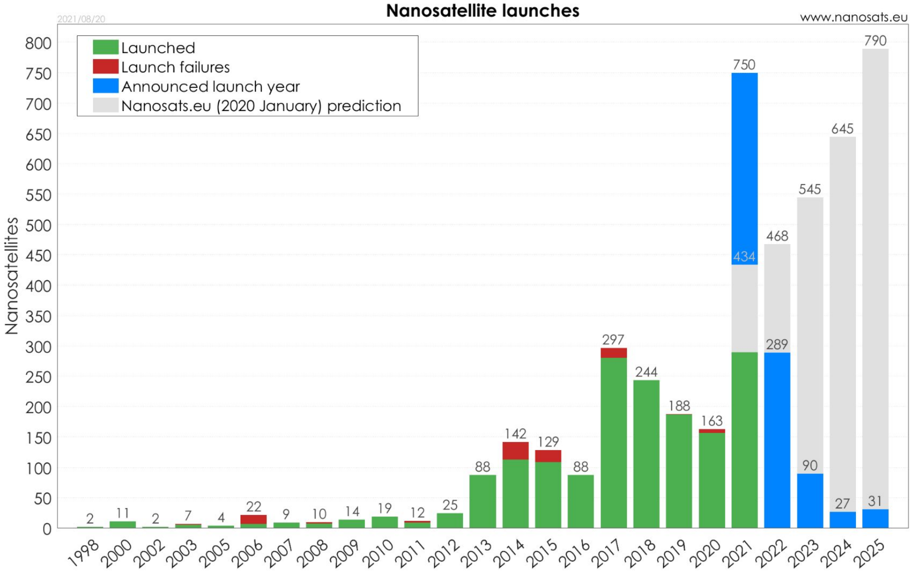
Required ΔV : [5.14; 5.20] km/s

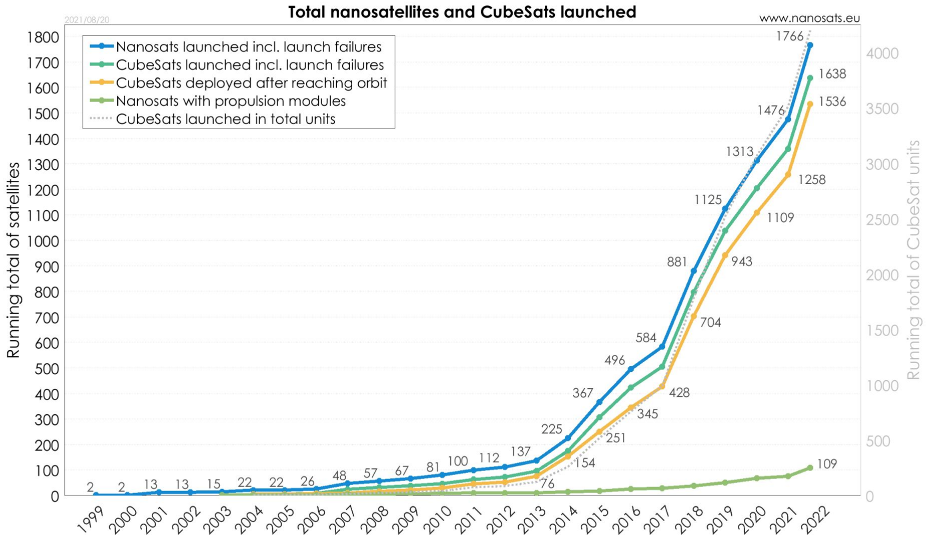
Table 3: Parameters of the orbit.

a	2.99x10^8	*km*
b	2.59x10^8	*km*
e	0.5	-
T	2.83	*years*

4. Cubesat architecture

Cubesats: spearhead of space development





Equipment and sub-systems

Cubesats’ main attributes are their off-the-shelf components allowing:

- Faster development time
- Cost reduction
- Repeatability

Figure 6: Off-the-shelf cubesat reaction wheel and IMU.

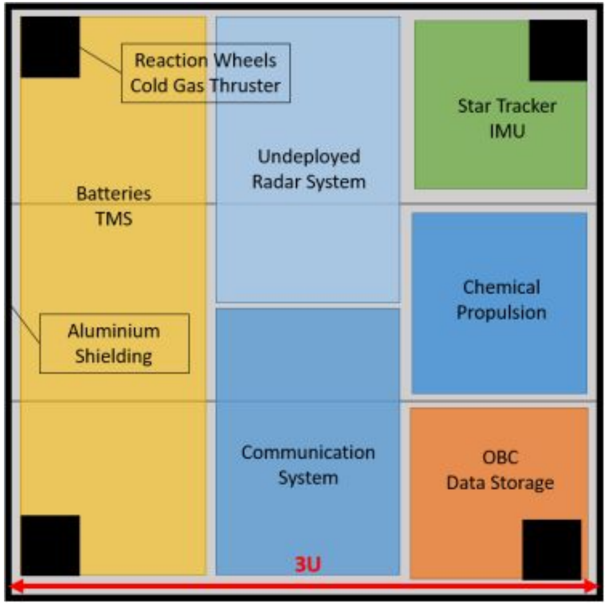


Figure 7: Proposed cubesat architecture for Hermes.

The architecture of the cubesat

9U cubesat, 3x3U

Main hardware:

- Aluminium Structure
- Radiation shielding
- Thermal management
- Solar panels
- Battery
- OBC and data storage
- IMU
- ADCU
- Asteroid Radar Detection System
- Communication system

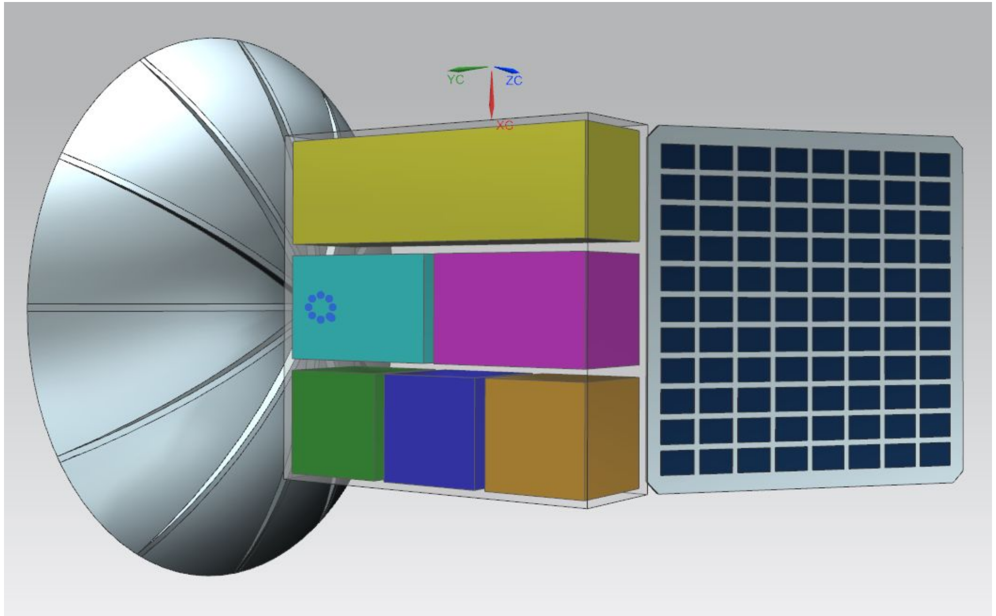
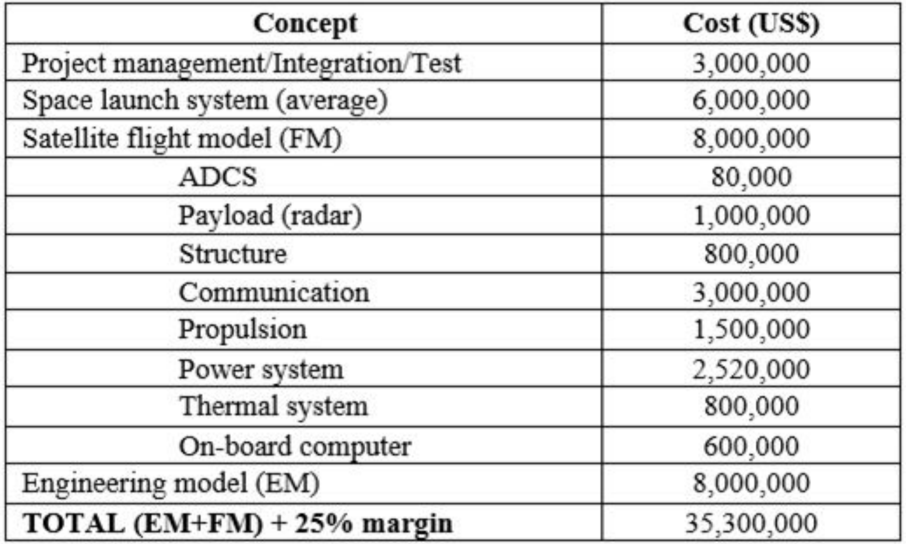


Figure 8: Hermes Cubesat concept.

5. Implementation plan

Total life cycle cost

Table 4: Estimation of the total cost.



Concept	Cost (US$)
Project management/Integration/Test	3,000,000
Space launch system (average)	6,000,000
Satellite flight model (FM)	8,000,000
ADCS	80,000
Payload (radar)	1,000,000
Structure	800,000
Communication	3,000,000
Propulsion	1,500,000
Power system	2,520,000
Thermal system	800,000
On-board computer	600,000
Engineering model (EM)	8,000,000
TOTAL (EM+FM) + 25% margin	35,300,000

Few existing projects of CubeSats in deep space (e.g. MarCO, 6U, 13.5 kg, 18.5 M$)

Total life cycle cost including design, development, component assembly, integration, testing, launch, and operations

Cost maximised: on the shelf components requiring some modifications

Facilities

Campus of Kyushu Institute of Technology (Kitakyushu, Fukuoka, Japan)

➔ Operations related to the assembly and tests

Purpose: development time, cost, and mission risks factors

Project organisation

32 people:
- 9 people in the mechanical team
- 8 people in the thermal team
- 5 people in the solar array team
- 4 people in the onboard computer team
- 3 people in orbit and altitude control team
- 2 people for management
- 1 expert in payload

Scientists and engineers incited to work together

Monthly meeting between the supervisor of scientific/engineering teams

Project schedule

Maximise team collaboration

Minimise development time

Total duration: 1400 days

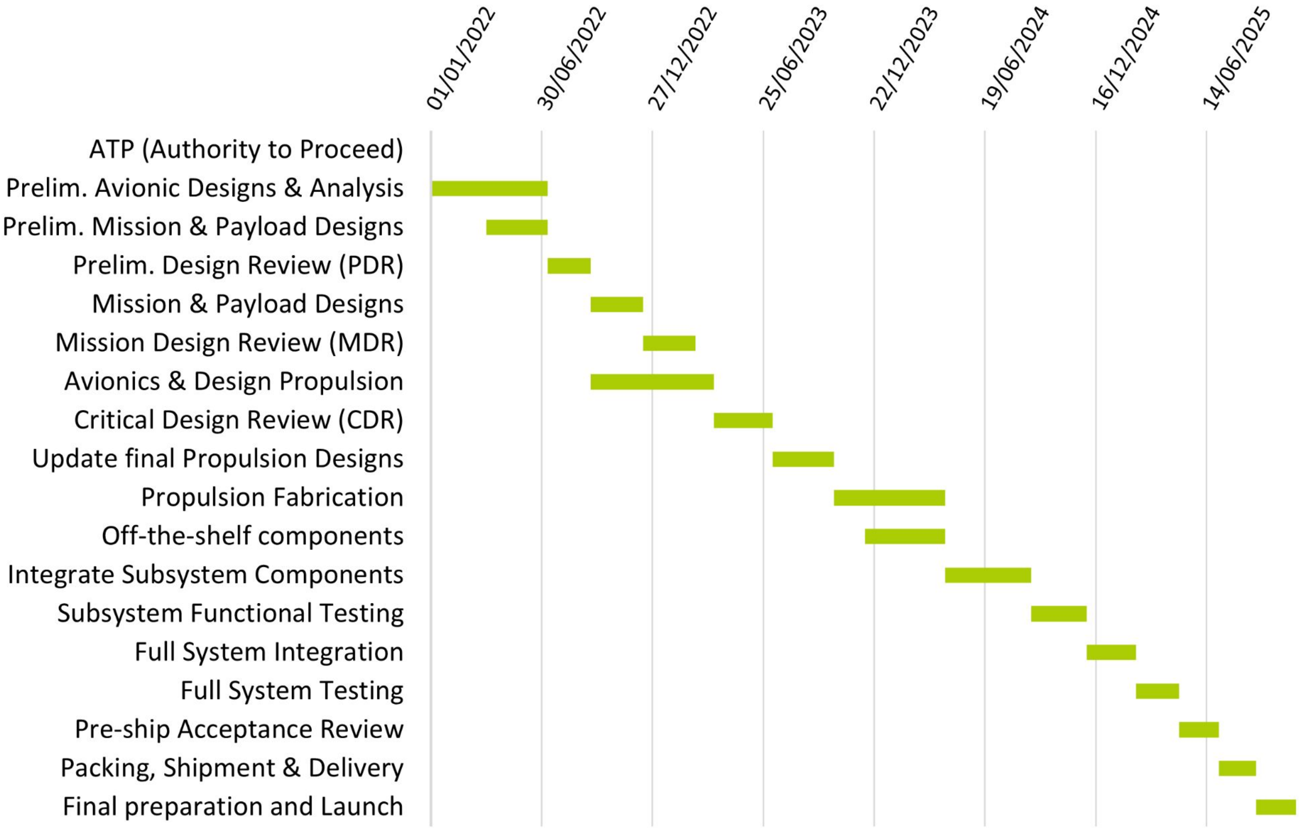


Figure 9: Gantt Diagram of the project.

Conclusion

Hermes Cubesat

On-site data gathering for accurate mapping of the Main Asteroid Belt.

Thank you for your attention