# Possible CubeSat Approaches for a Europa Mission

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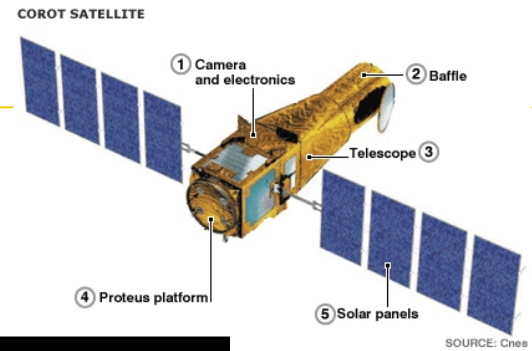
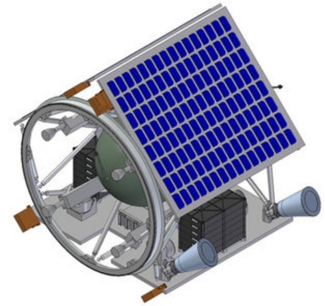
# What is a Cubesat ?

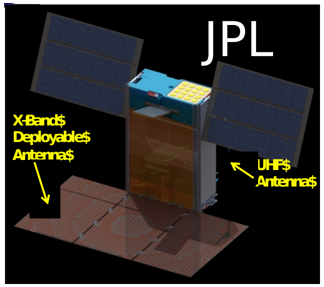
- A cubesat is a type of **standardized form of microsatellite**, with a volume of one liter (Cube 10x10x10 cm), born in Stanford, CA. It typically uses "off the shelf" electronic components and systems (i.e. not subject to the rigorous qualification procedures to space environment).
- From an academic point of view, they represent a very interesting educational element since Cubesat are primarily a highly integrated avionics system (all functions of a satellite and its payload in a very small volume, with a reduced power consumption).
    - From a scientific point of view, the **low cost** of their implementation and **compactness** prefigures the deployment of **distributed payloads** for scientific purposes :
        - unique/complementary vantage points
        - distributed measurements
    - Their low volume, low mass is reminiscent of the “faster cheaper” strategy : it enables **more risky, very focused science**
        - Probe can be **“sacrified” quickly**

# Class of small satellites

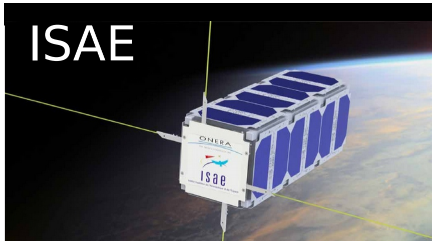


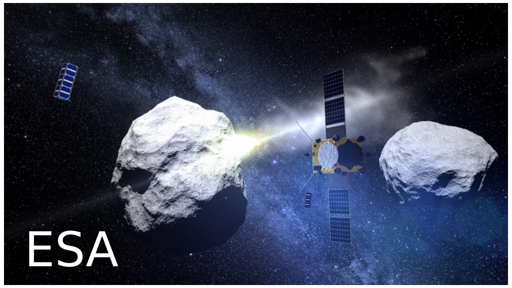



1. MiniSats (100 – 500 kg)



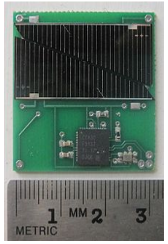

2. MicroSats (10 – 100 kg)

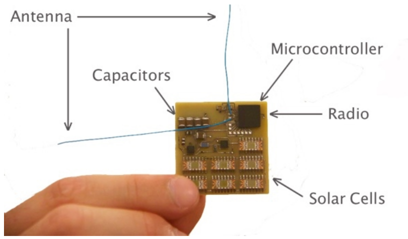



3. NanoSats (1 – 10 kg)

4. PicoSats (0.1 – 1 kg)

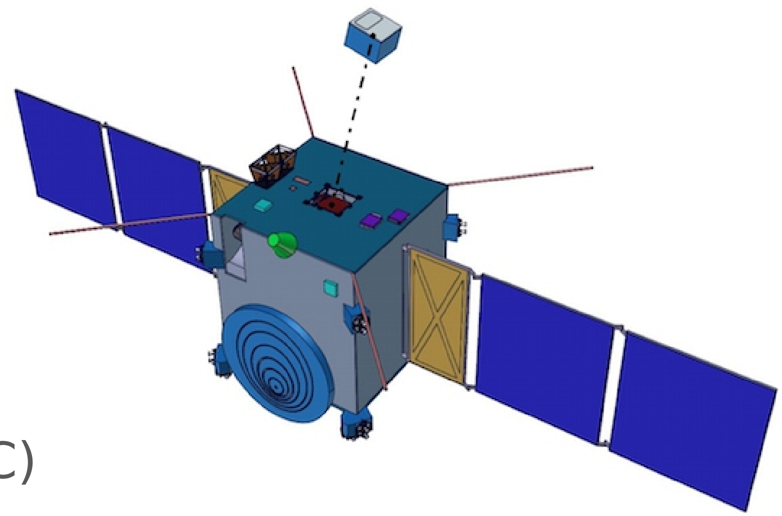


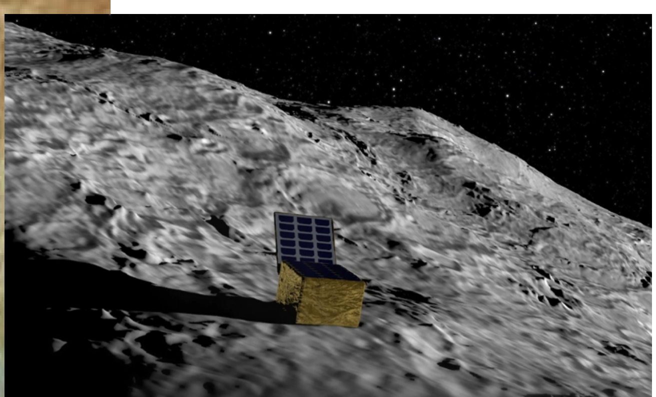



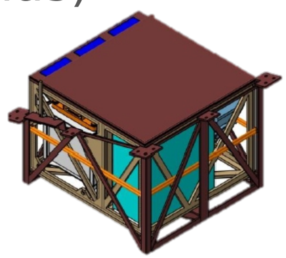

©Kicksat

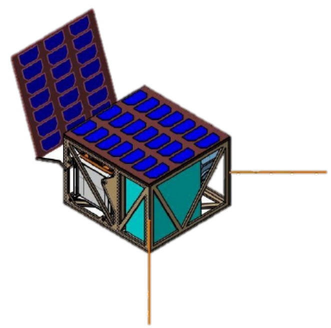
# MASCOT-2 LANDER

- Size: 30 x 30 x 20 cm
- Deployable solar generator cover (supports orientation and protects solar cells during touch-down)
- 3 months operational lifetime
- Landing site: Lander targeting equatorial region of Didymoon (TBC)
- Carries low-frequency radar transmitter
(deployable antennas)

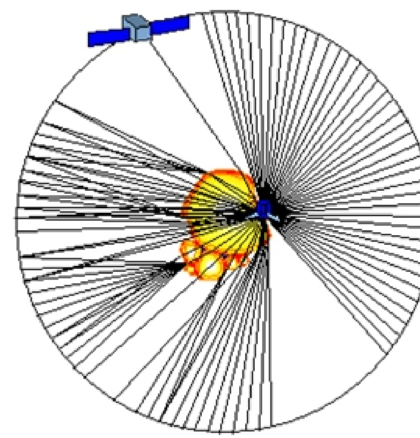






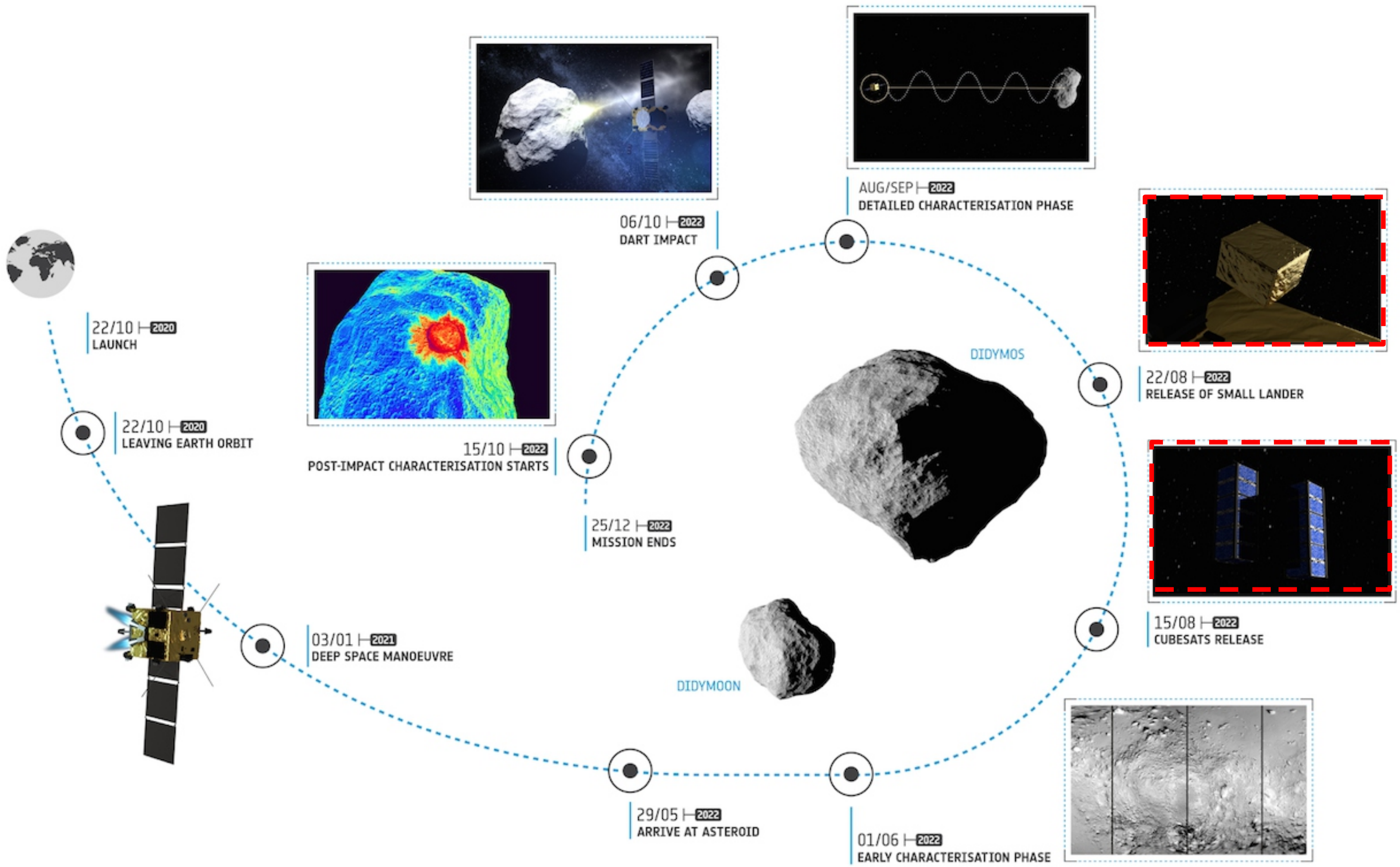


Signal to be captured by the AIM spacecraft will enable understanding the interior structure of the asteroid



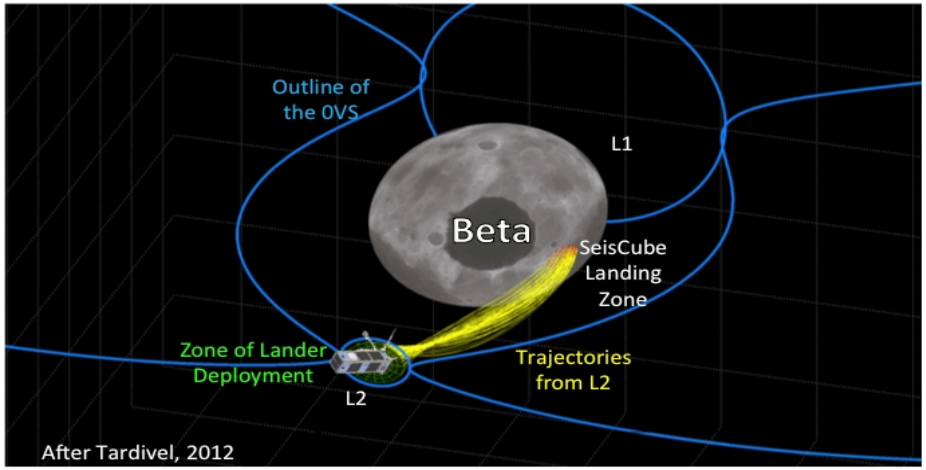
*(Modified from I. Carnelli, ESA)*

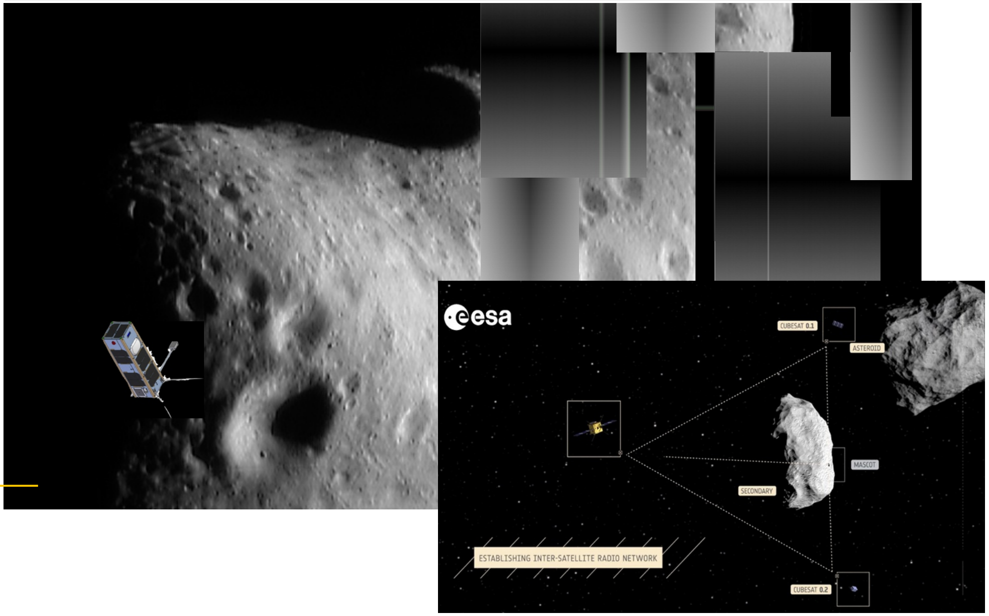
# Interplanetary Cubesats in Europe: the AIM/AIDA mission

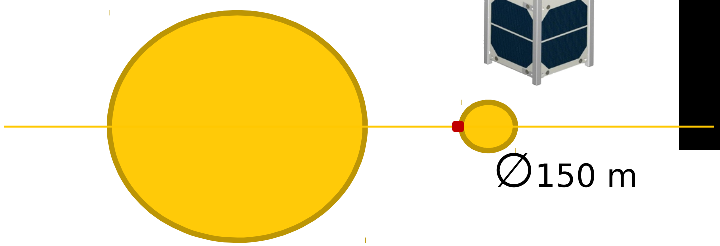


# Asteroid Geophysical Explorer: CubeSat use

1. SEIS Cube (3U cubesat) will be deployed before MASCOT
2. It will test the MASCOT landing strategy
3. It will deploy a geophone /accelerometer assembly to investigate the secondary internal structure
4. It will test the ESA Intersatellite links experiment

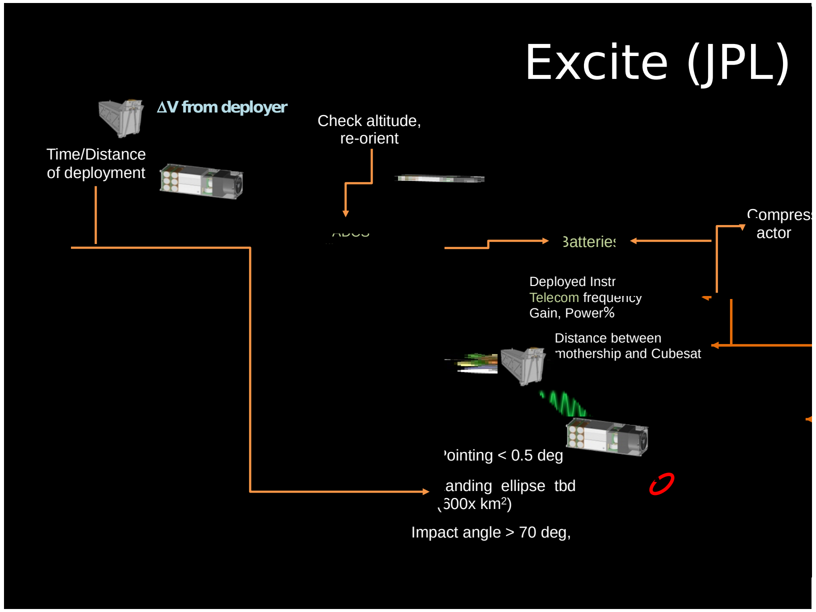


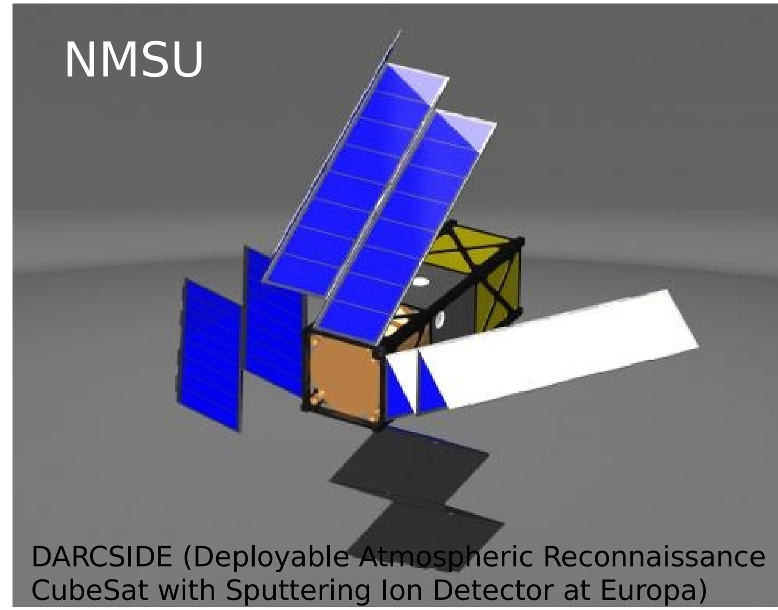



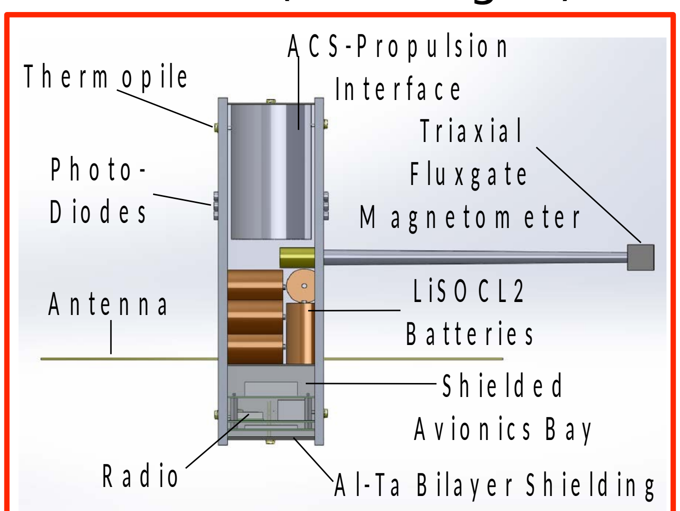

Didymos binary system to scale

# Europa Cubesat Concepts

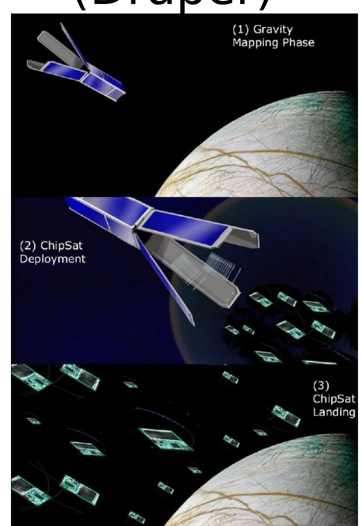


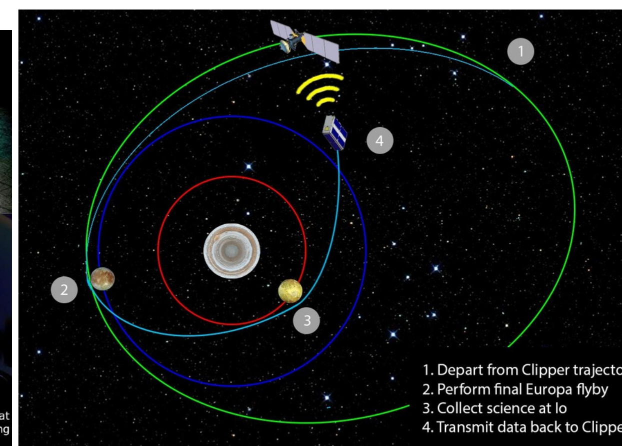




MINOS (U Michigan)




(Draper)



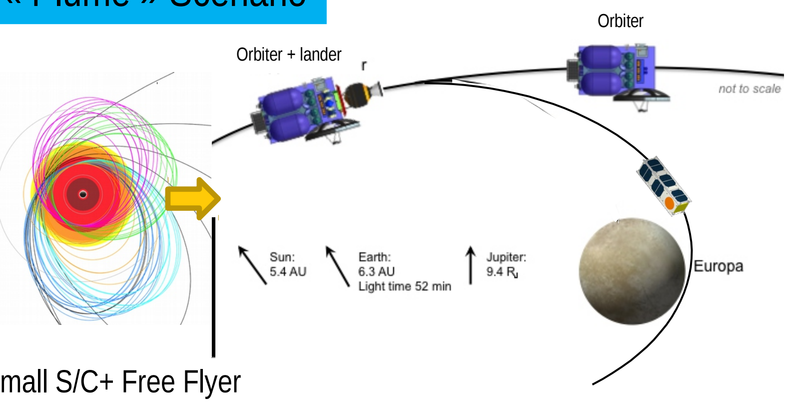




Atmosphere & Plume Explorer 6U

# Europa Initiative :Possible Cubesat Scenarios

ISAE Institut Supérieur de l'Aéronautique et de l'Espace SUPAERO

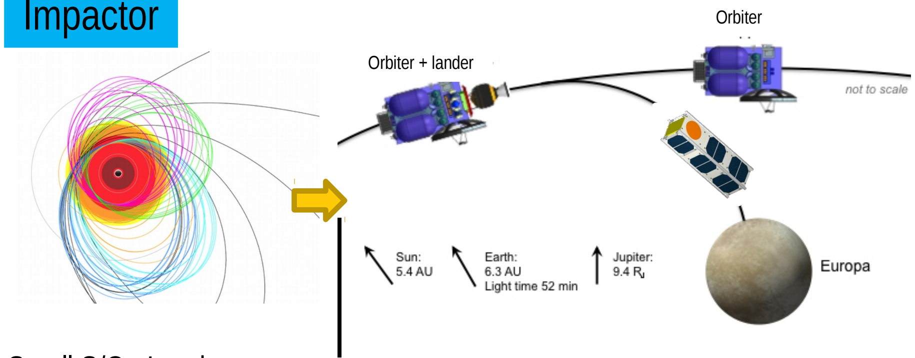
## « Plume » Scenario




Small S/C+ Free Flyer
Jupiter Orbit Insertion

Close fly-by (plume, dust ...)

## Impactor



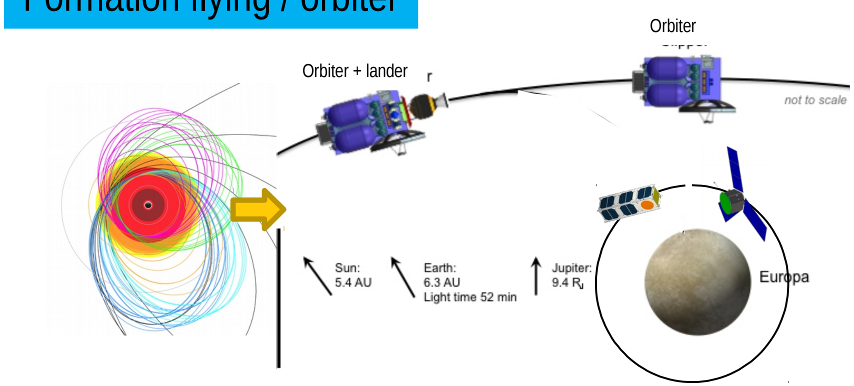

Small S/C+ Lander
Jupiter Orbit Insertion

Impactor

Possible Cubesat addition must ideally complement the science objectives in a UNIQUE way

Science augmentation must be worth the mass spent ....

## Formation flying / orbiter




Small S/C+ Free Flyer
Jupiter Orbit Insertion

« Formation flying with Europa orbiter »

"preferred" option

# Potential Cubesat Science

- Selected on the basis of science, risk, and cost
- Potential Cubesat science include :
  - Ocean conductance measurement (radar)
  - Gravity through radio link with orbiter
  - High resolution imagery
  - Magnetic environment and sounding
  - Radiation measurements
  - Plasma measurements

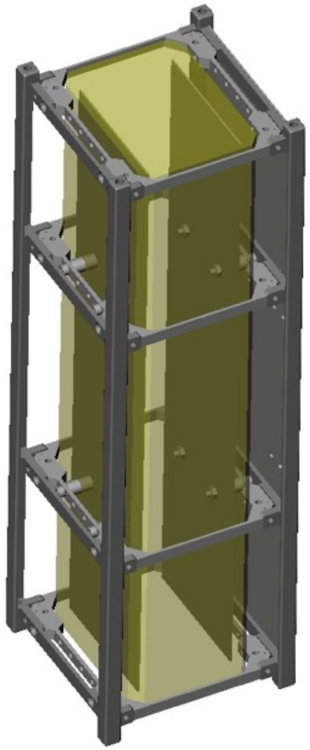
# CubeSat unique advantages

1. The Companion CubeSat can be an « Insurance » policy to be able to analyze phenomena than cannot be studied by orbiter, e.g dust/particle measurements at low altitude
2. The Companion CubeSat can take advantage of multi point measurements
    a. plasma physics
    b. gravity measurements ? (Feasibility TBC)
    c. magnetic measurements.
3. The Companion Cubesat can help with the local geology , with a close-up of a potential interest zone (High resolution imaging < 1 m) without paying the price for a Europa orbit insertion. This could be useful for a landing site assessment ?

| Cubesat Scenario | Scenario 1<br>« Plume » | Scenario 2<br>« Kamikaze » | Scenario 3<br>« Formation flying » |
|---|---|---|---|
| **Major science objectives** | Plume sampling<br>Dust Analysis | High resolution Imaging<br>Sampling ? | Multi Point Geophysics<br>Multi Point Plasma, magnetic field |
| **Connection to the 6 science themes** | F- Exobiology<br>B- Exosphere<br>C- Geochemistry | D-Geology | A- Magnetospheric Interactions<br>E- Geophysics |
| **Connection to Europa science** | Exobiology | Landing site imaging | Geophysics, Exosphere |
| **Preferred Science payload** | Spectrometer,<br>Dust analyzer | High resolution imaging<br>Dust analyzer | Magnetometer<br>Plasma measurements<br>Gravimetry (TBC) |
| **Feasibility of mission scenario** | Good – Insertion strategy and ΔV to be evaluated | Good – Insertion strategy and ΔV to be evaluated | Good |
| **Additional studies needed** | Strawman PL<br>Insertion strategy<br>(ballistic from relay orbit ?)<br>Telecom strategy | Strawman PL<br>Insertion strategy<br>(ballistic from relay orbit ?)<br>Telecom strategy | Strawman PL<br>Mission analysis<br>Gravimetry feasibility |
| **Potential show stopper ?** | Mass ? | Clipper resolution might be sufficient | Mass constraints |
| **Typical Mass** | To be assessed | 6U Cubesat | 3-6U Cubesat |
| **Typical Implementation** | | Excite CubeSat | No example yet |
| **Ranking** | + | = | ++ |

# Challenges of a Cubesat for Europa

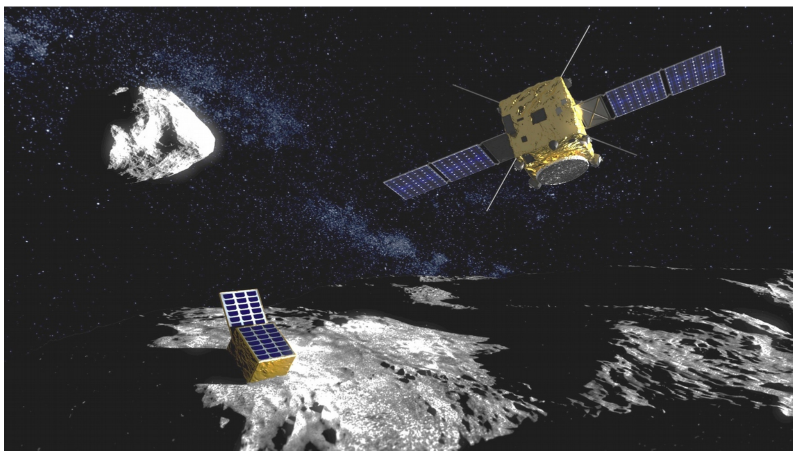
1. Radiations
   a. Hardly compatible with COTS approach
   b. Mass penalty
2. Power, Thermal control
   a. Very limited power available
   b. Use of warm box ? RHU ? Primary batteries only ?
3. Form factor, mass
   a. Standard subsystems
   b. mass < 6U
4. Planetary protection constraints
   a. Must be compatible with DHMR (Batteries ?)
5. Telecommunication, navigation
   a. Limited communication capabilities
   b. Must relay on mothership to communicate with Earth, no orbit contr
6. Deployment strategy
   a. Changing the orbit of mothership ?
   b. No fine GNC, no flexible propulsion system
   c. Cubesat dispenser design (ombilical , shielding ?)

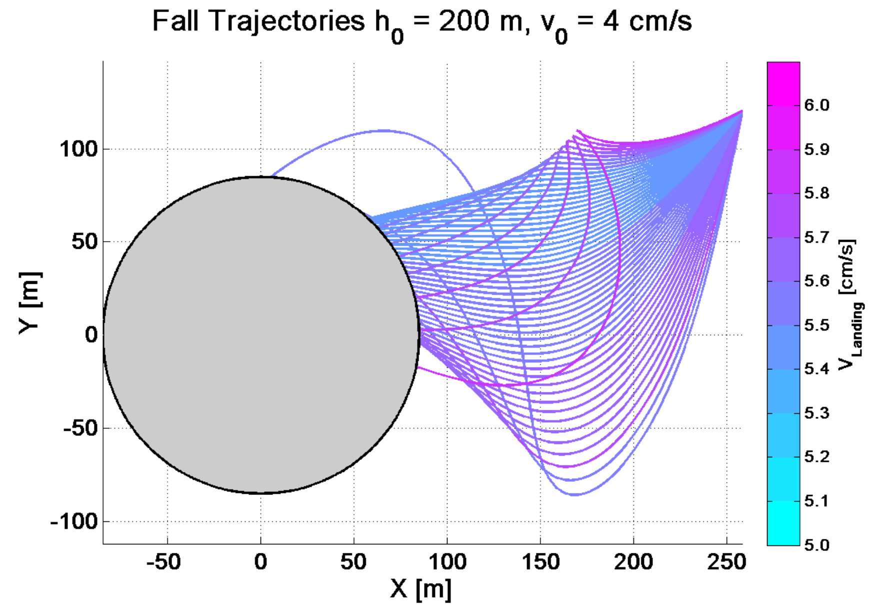


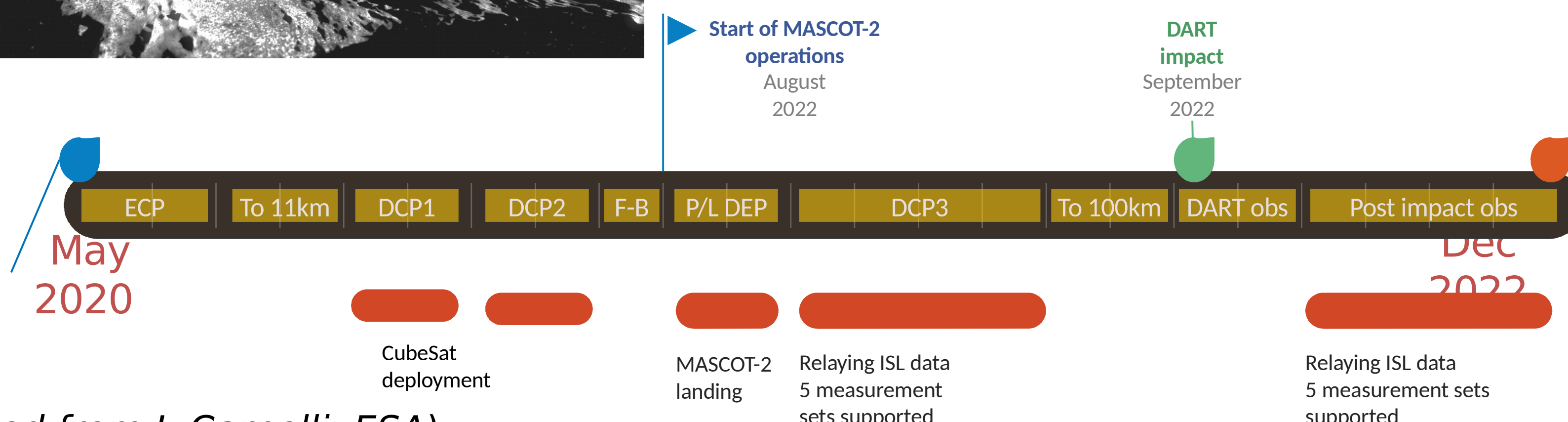
# Backup slides

# MASCOT-2 RELEASE

1. Baseline strategy: release at 200m altitude
2. Intersection at the landing site with velocity below 7.5 cm/s



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