ASPECT

ASTEROID SPECTRAL IMAGING MISSION

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CubeSat missions in deep space

Deep space vs. LEO

- Low-gravity environment
- Reduced set of objects for navigation reference
- Presence of significant orbital perturbation forces (solar radiation pressure, planetary perturbations, and intrinsic heat radiation) relative to the gravity of the orbiting object
- Increased radiation background (outside Earth's magnetosphere)
- Limited direct communication opportunities

Required modifications

- Active propulsion system
- Multi-reference advanced navigation
- Reliable, semi-autonomous mission operation, navigation, and trajectory correction
- Enhanced radiation shielding/tolerance
- Foldable dish antenna or communication utilizing relay spacecraft

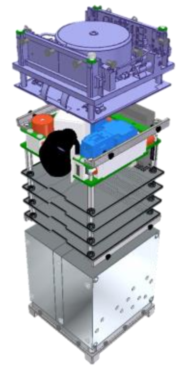
ASPECT

- 3 unit CubeSat

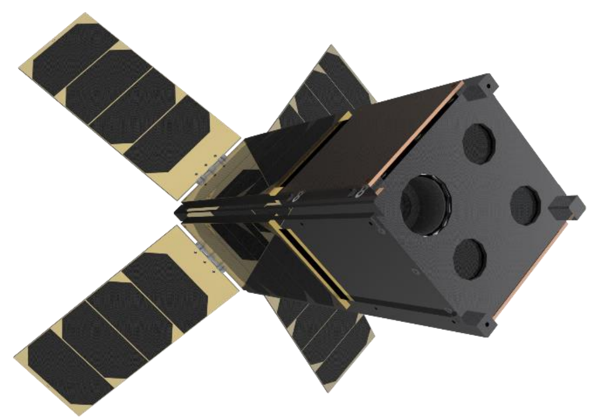
  Radiation-hardened platform

- Semi-autonomous navigation and operations
  - Sun sensor
  - Star tracker
  - Navigation camera
  - ISL

- Aalto-1, Aalto-2, and RSL Hello Wrold heritage



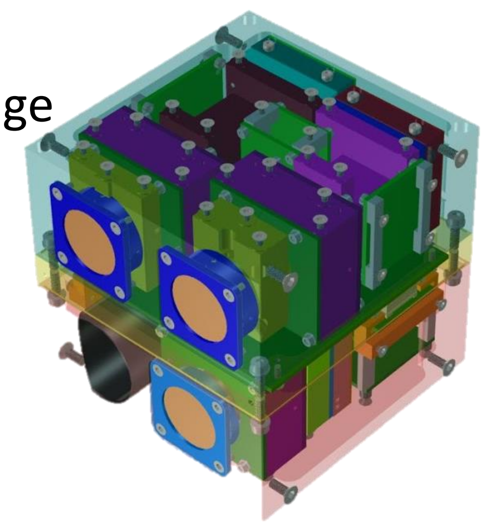
- Propulsion
- Avionics
- Payload: VIS-NIR spectral imager



Spectral imager concept

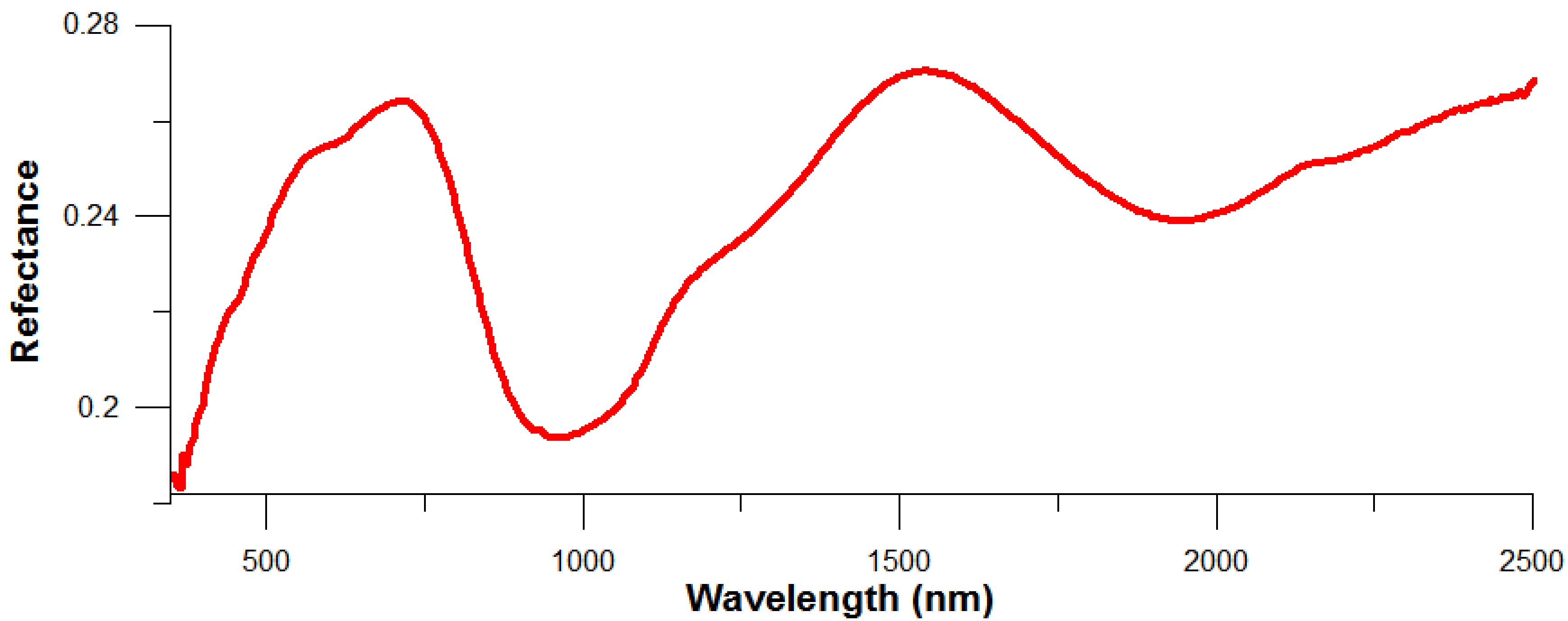
- 1U envelope
- **3 measurement channels**:
  - VIS (500–900 nm) spectral imager (614 x 614 pixels)
  - NIR (900–1600 nm) spectral imager (256 x 256 pixels)
  - SWIR (1600–2500 nm) spectrometer (1 pixel)

- Aalto-1 and Hello World Spectral Imager heritage
- Based on VTT's tunable filter technology (Fabry-Perot Interferometers)
- Freely selectable wavelength bands
- On-board data processing



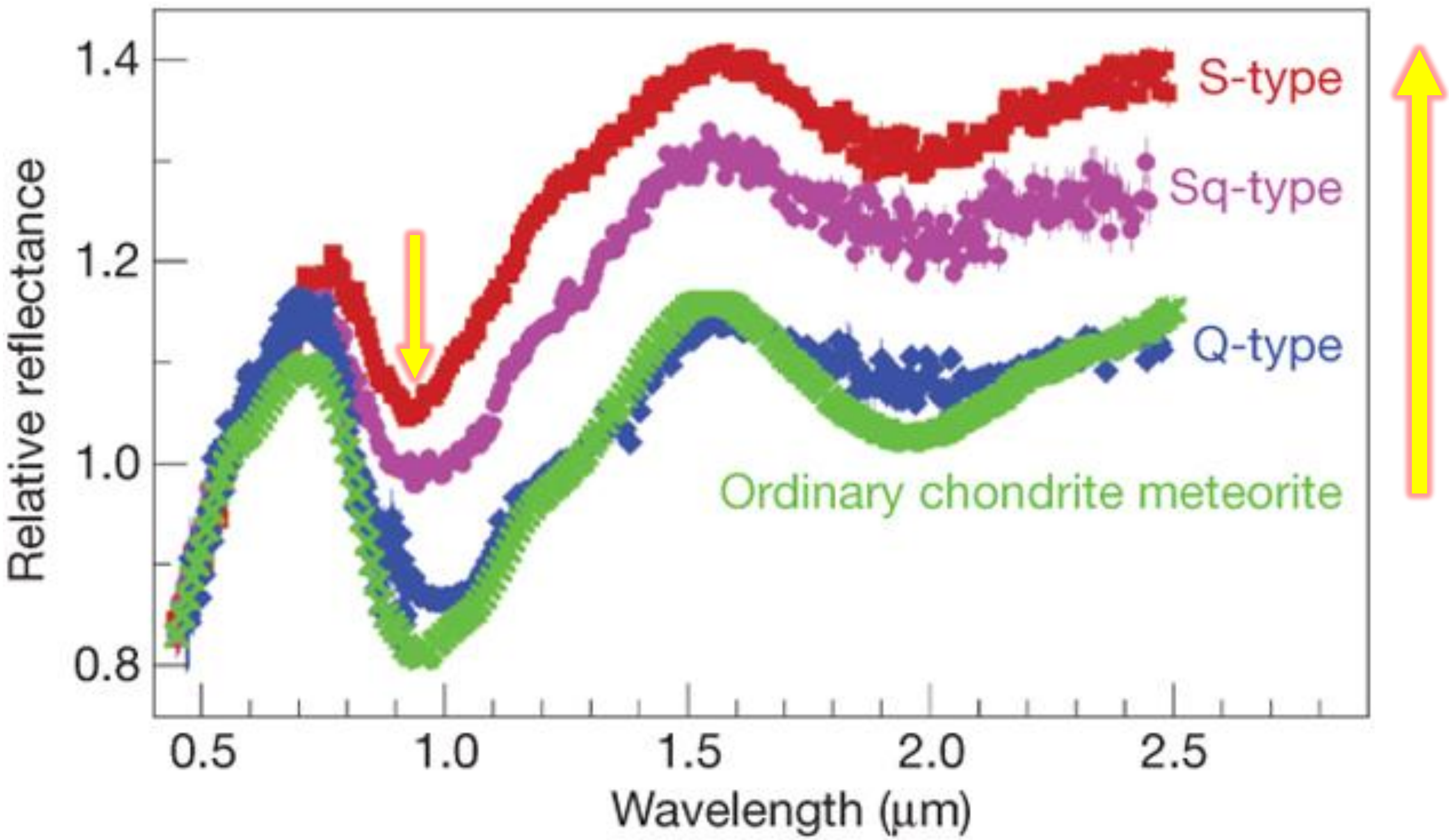
Reflectance spectra of silicate minerals

LL ordinary chondrite (meteorite)



- 1 and 2 μm absorption bands due to Fe^{2+} ions.
- Position of the bands shifts to lower wavelengths with decreasing Fe/Mg ratio.

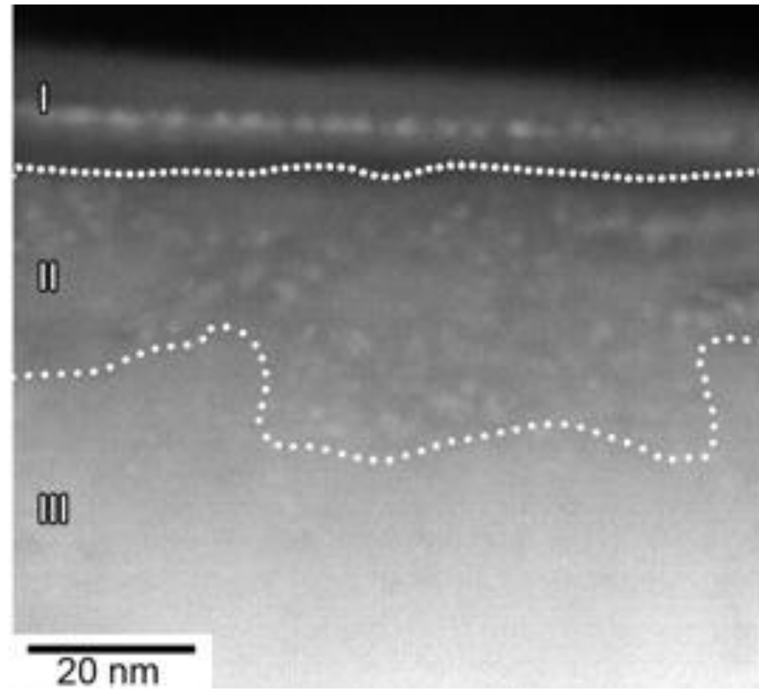
Fresh vs. old surface



Binzel et al. 2010

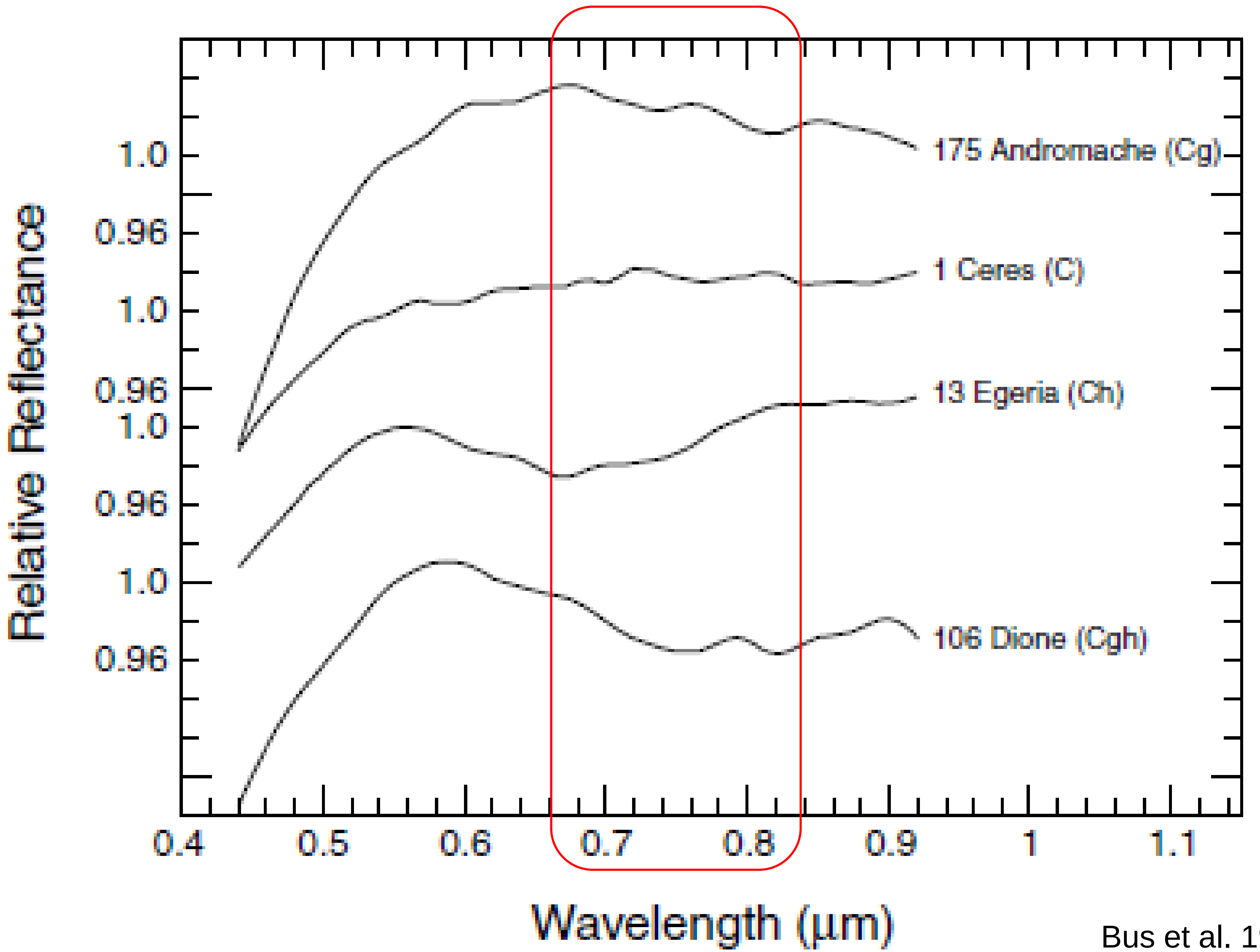
Space weathering

- Material damage/response to interplanetary environment (solar wind, microimpacts, space radiation)
- Spectral changes associated with presence of reduced iron nanoparticles
- Confirmed on the Moon and Itokawa
- Vesta may have distinct space weathering mechanism



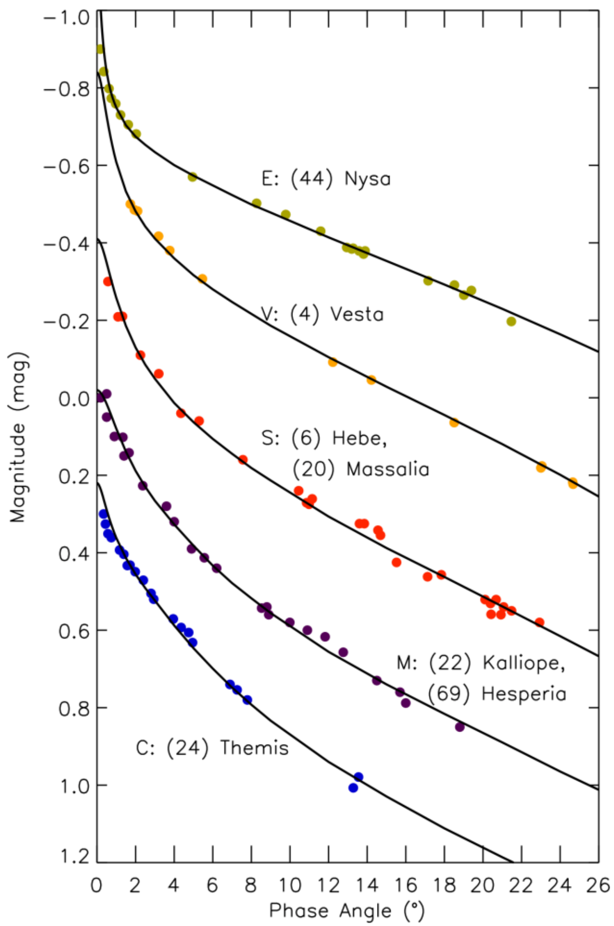
Itokawa - Noguchi et al. 2011

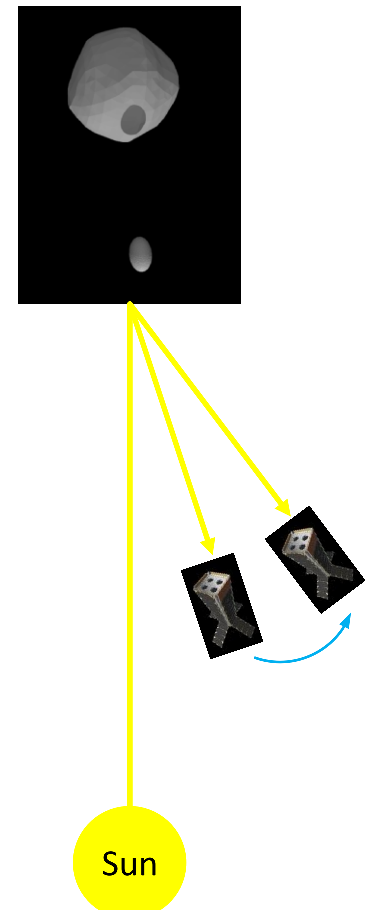
Hydrated features



Bus et al. 1999

Photometric observations and regolith roughness





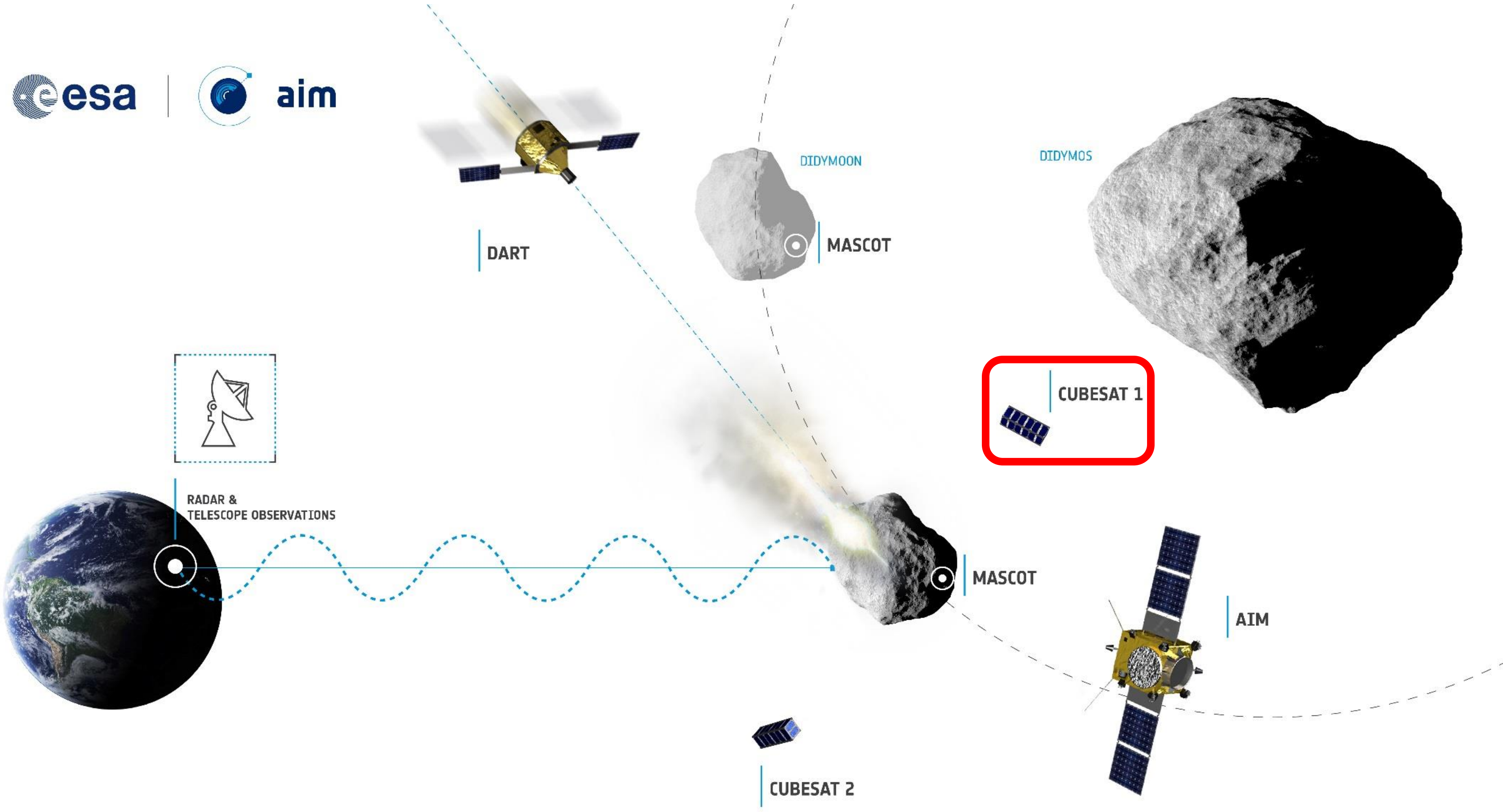
Payload capabilities

- Global compositional mapping and imaging sub-meter resolution
- Detection of common silicate minerals (1000, 1300 and 2000 nm absorption)
- Hydrated minerals as serpentine are detectable through 700 nm absorption feature
- Direct evidence of -OH an H_2O can be detected at 1400 and 1900 nm respectively
- Spectral slope is diagnostic of material maturity (fresh vs. old)
- Regolith roughness can be estimated from phase curve

ASPECT scientific objectives

Objective 1	Map the surface composition of the target
Result	Composition and homogeneity of the target surface
Result	Identification and distribution of volatiles
Objective 2	Photometric observations and modeling of the target
Result	Surface particle size distribution
Objective 3	Evaluate space weathering effects on target by comparing mature and freshly exposed material (crater walls, ejecta, landslides)
Result	Information on the surface processes on airless bodies due to their exposure to the interplanetary environment
Objective 4	Identify local shock effects on target from spectral properties of crater interiors
Result	Information on the processes related to impacts on small Solar System bodies
Objective 5	Characterize possible landing sites
Result	Detailed composition and surface roughness information on potential landing sites
Objective 6	Evaluate surface areas and objects suitable for sample return or ISRU
Result	Identification of areas and objects with scientifically interesting properties

AIDA-ASPECT



Currently other small body mission options for ASPECT are being evaluated.

SmallSats vs. BigSats – new era of exploration

Conclusions

- ASPECT is a 3U asteroid CubeSat with an VIS-NIR imaging spectrometer
- Versatile platform
  - Scalable to 6U
  - may carry additional payloads
- Main science objectives are to characterize target surface composition and identify areas of potential interest (landing, sampling, ISRU)
- CubeSats can complement spacecraft operations by undertaking risky observations
- CubeSats are cheap, simple, and can be deployed in a fleet
- Lets keep them small, simple, and deploy more of them!