- Swedish Institute of Space Physics (IRF)
- V-kvadrat
- Royal Institute of Technology (KTH)
- OHB Sweden

- Reaktor Space Lab
- Finnish Meteorological Institute (FMI)
- Technical Research Centre of Finland (VTT)
- University of Helsinki

- Space Systems Czech
- The Czech Academy of Sciences

- German Aerospace Center (DLR)

APEX
asteroid
prospection
explorer
ESA - NASA - AIDA

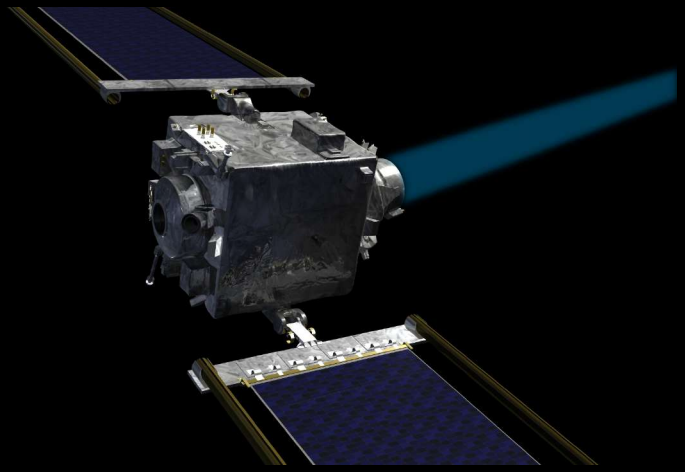
APEX - Asteroid Prospection EXplorer

Aerospace Technology Congress
Stockholm - October 9, 2019
Emil Vinterhav

V-KVADRAT

Asteroid Impact & Deflection Assessment (AIDA)

- DART (NASA)



- Hera (ESA)

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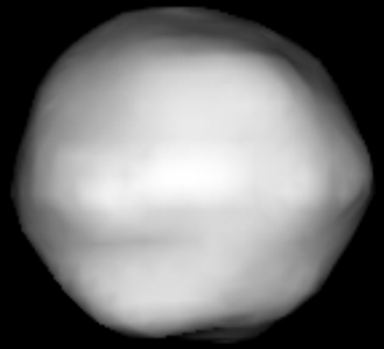
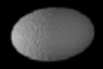
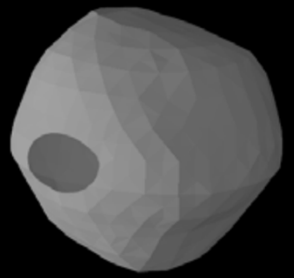
AIDA target –Binary asteroid Didymos



Radar shape, Benner and Naidu





Shape model, Schwartz

- Apollo type NEA (Near-Earth Asteroid)
- S-type composition (ordinary chondrite)
- Primary (Didymain) diameter 780 m, 2.1 g/cm3
- Secondary (Didymoon) diameter 160 m
- Distance between centers 1.2 km, Orbital period 12 h

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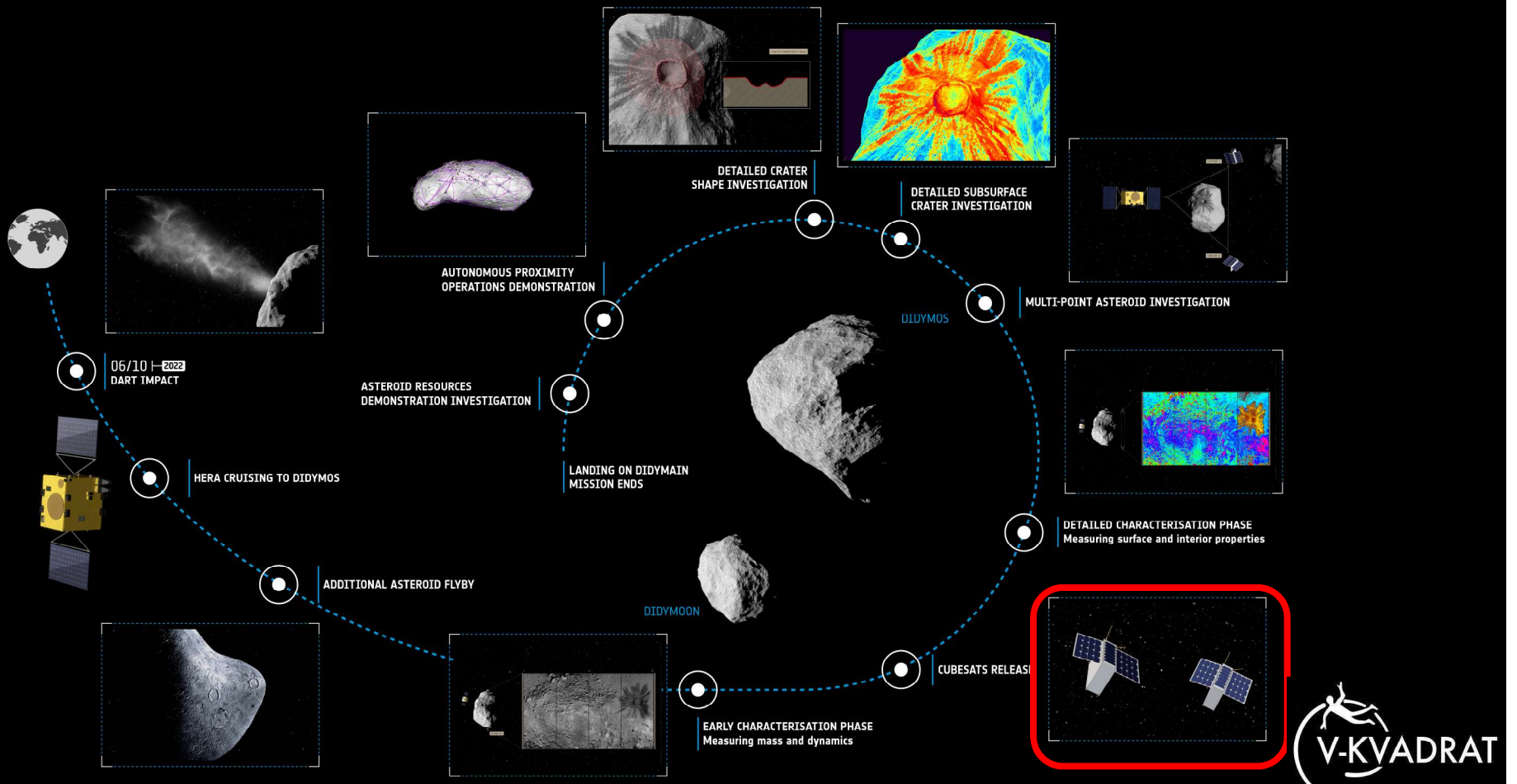
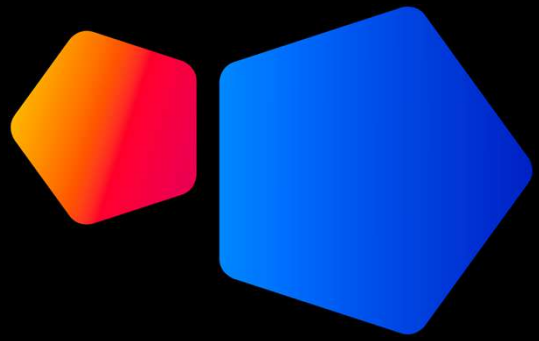
Hera mission timeline



APEX Science Objectives

- Global composition
- Internal structure
- Surface roughness and regolith grain size
- Space weathering effects
- Shock effects
- Interaction with interplanetary environment
- Mass
- Strength of near-surface material



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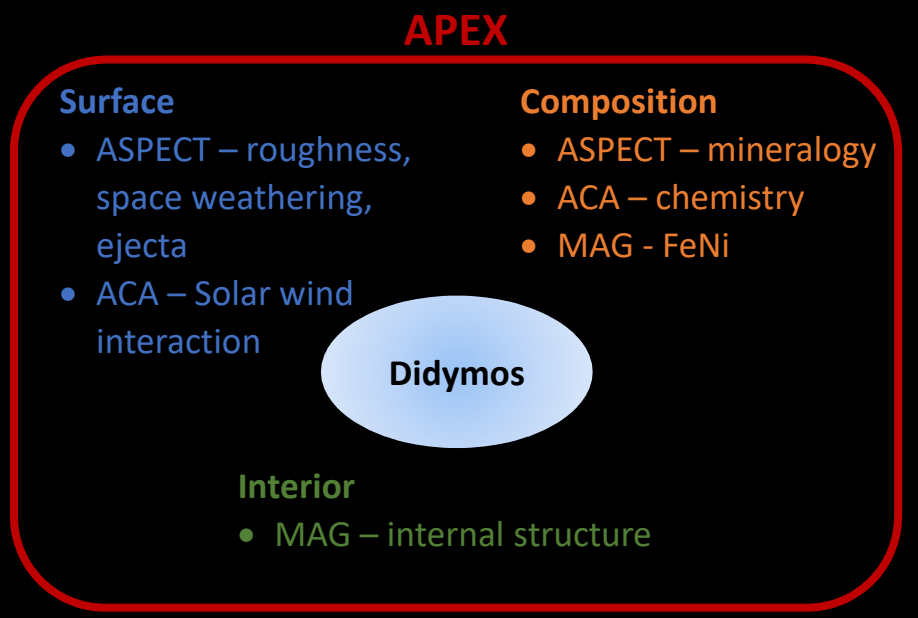
APEX payload

- ASPECT (Asteroid Spectral Imager)
  - VIS-NIR hyperspectral imager
  - VTT
- MAG (Magnetometer)
  - Dual magnetometer
  - KTH
- ACA (Asteroid Composition Analyzer)
  - Sputtered ion mass spectrometer
  - IRF



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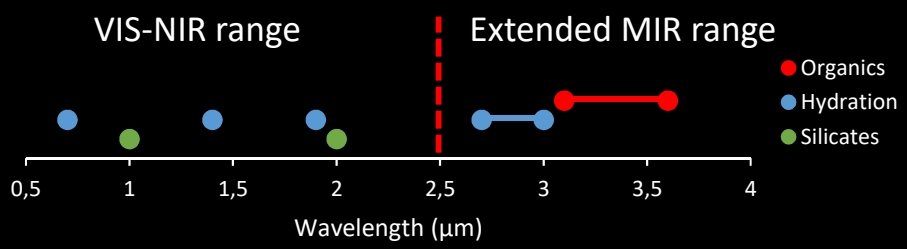
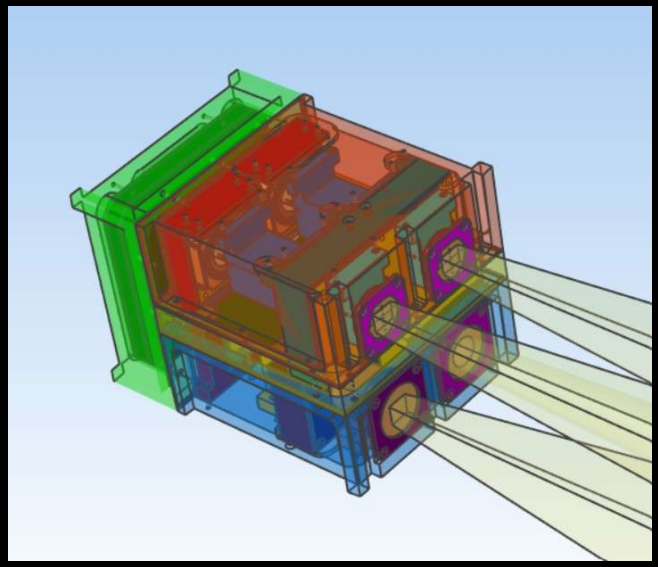
ASPECT Asteroid Spectral Imager

- Hyperspectral imager (VTT)
  - VIS: 500-900 nm (1024 x 1024 px)
  - NIR: 850-1650 nm (640 x 512 px)
  - SWIR:1600- 2500 nm (point)
  - Spectral resolution: 10-40 nm
- Tunable Fabry-Perot interferometer technology
- Detection of common silicate minerals as olivine and orthopyroxene
- Detection of the hydration features
- < 2 m/px at 4 km, 3 cm/px at 200 m
- Global compositional characterization
- DART impact site and ejecta mapping
- Space weathering
- Grain size from observations at varying phase angles (phase curve)





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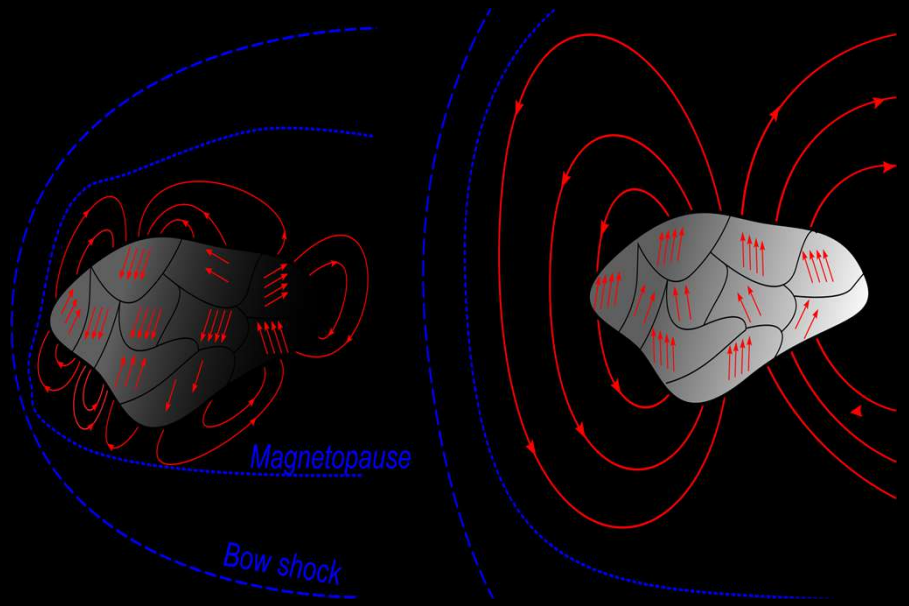
MAG Magnetometer

- Proximity measurements (<500m) can separate the interplanetary (solar wind) δB from intrinsic asteroid magnetization
- Monolithic structures – uniform primordial magnetization (predominantly dipolar magnetic field).
- Rubble pile structure consisting of few, large magnetized blocks will produce magnetic field with dominant low degree, non-dipolar spherical harmonic components.
- Long term impact processing may introduce high-degree magnetic noise or even complete material demagnetization.
- Determination of Fe-Ni content and homogeneity

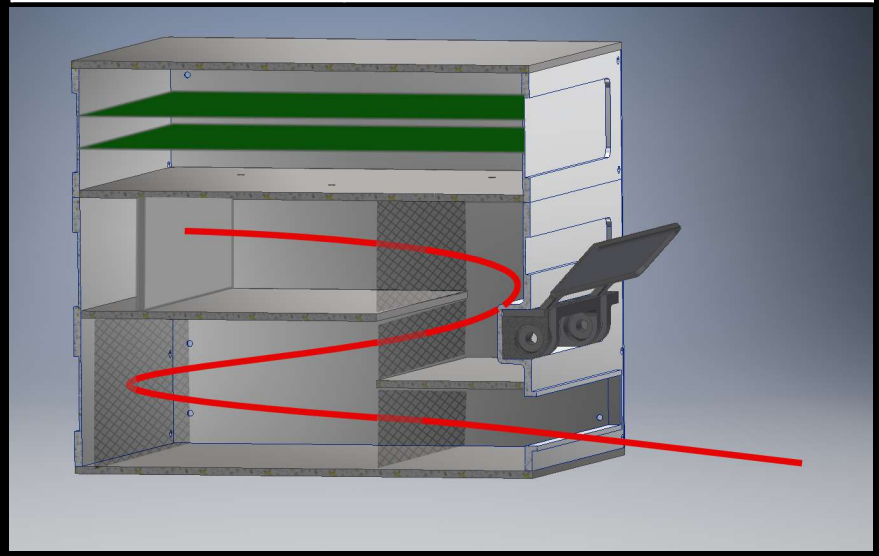


V-KVADRAT

ACA Asteroid Composition Analyzer

- Quantify sputtered ions from the asteroid surface for composition analysis
- Detection of ionized Mg, Fe, Si, Al, Ni, C, N, O, S, H, He, the chondrite-forming elements sputtered by solar-wind ions
- Difference of sputtered material between creator and pristine sides
- Constrain surface & sub-surface “volatile” materials

Energy range	Thermal – 5 eV (ion mass only)
Mass range	1 – 70 amu
Mass resolution (M/dM)	70
FoV	30° full width cone



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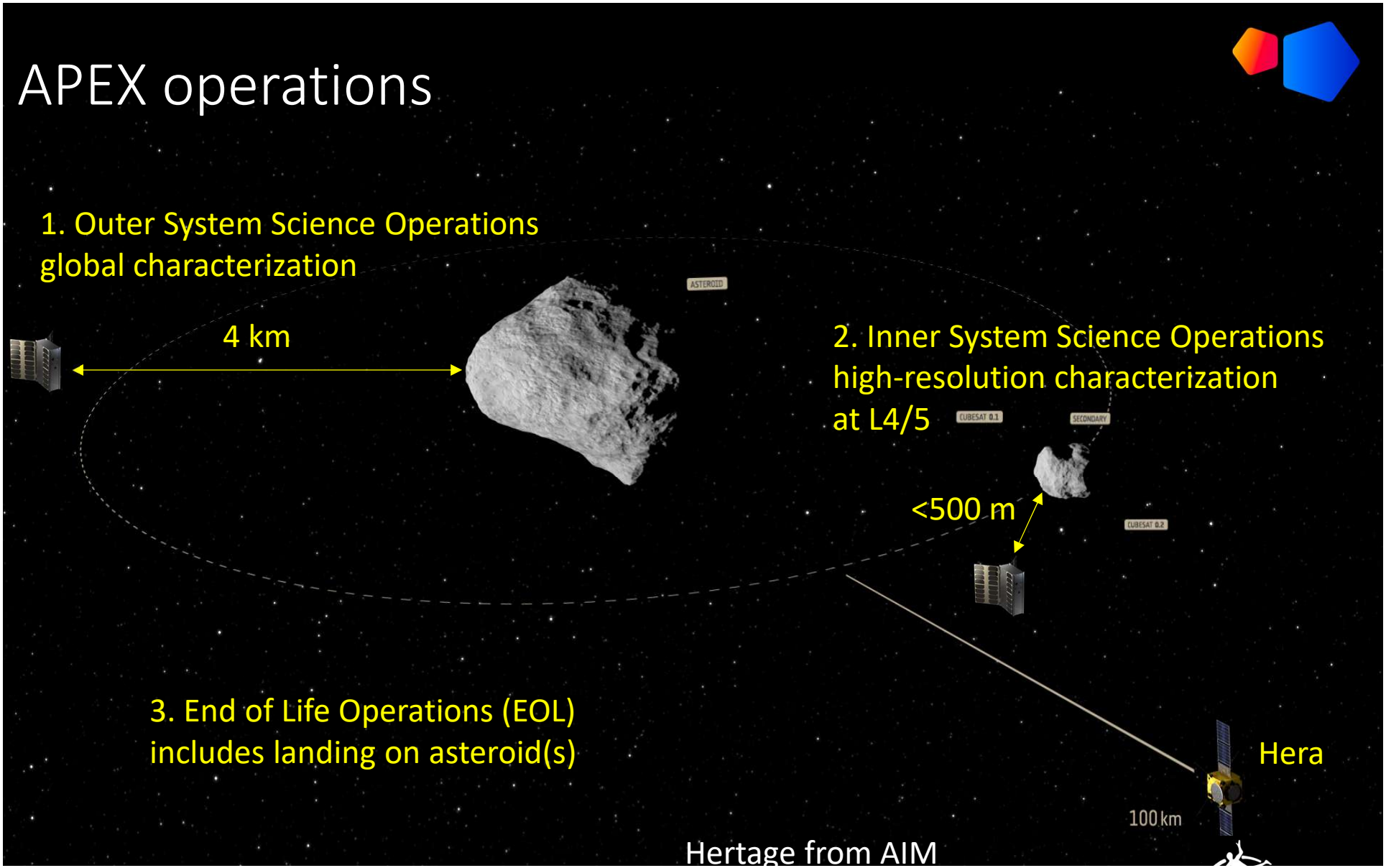
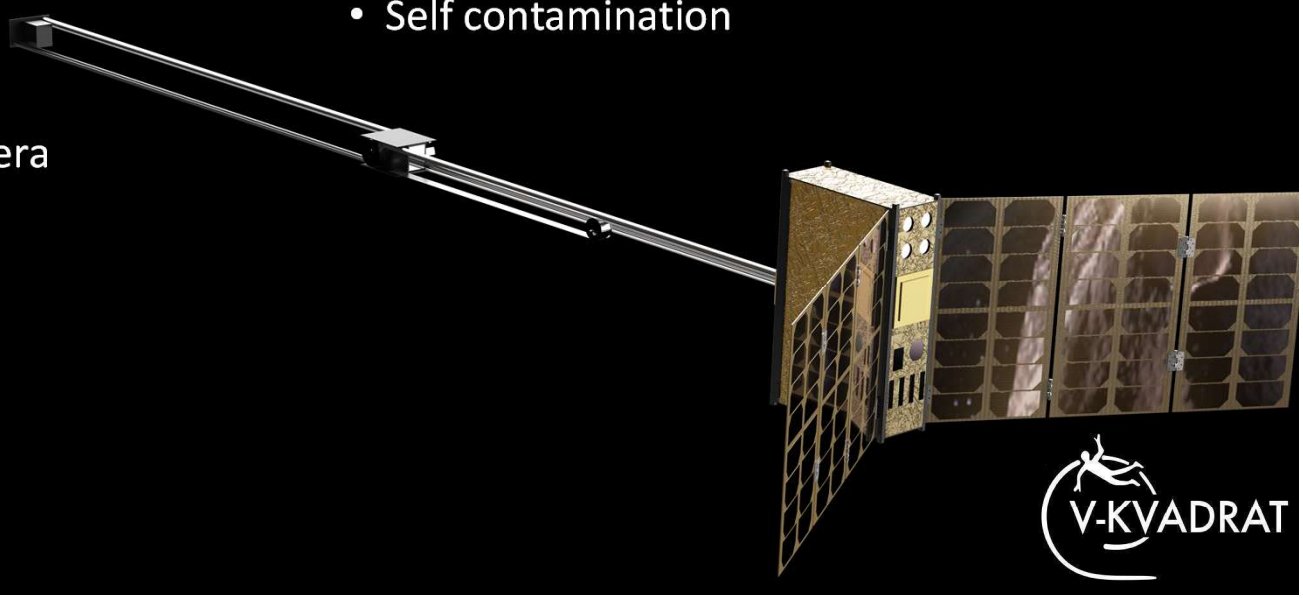
APEX operations



APEX Platform

- SWaP and Comms
  - 6U CubeSat form factor
  - 12 kg wet mass incl. 150g propellant
  - 11 W average power 15W peak
  - 50kbps ISL
  - 3axis stabilized
- AOCS
  - Visual Navigation Camera
  - Laser Ranging
  - ISL ranging
  - Star tracker
  - Reaction Wheels
  - Cold gas propulsion
- System Drivers:
  - Power generation
  - Position navigation
  - Autonomy and System Safety
  - Long interplanetary transfer
  - Self contamination



APEX challenge

- Navigation (proximity operations in deep space)
- Operation environment (binary asteroid, far from the sun)
- Autonomy and system safety (no direct link and sub-system anomalies lead to mission loss)
- Advanced payload and platform technology (miniaturizing)
- Long interplanetary transfer (Technology needs to be updated)
- Cleanliness (Measuning weak magnetic field and traces of elements)
- To succeed, autonomous operation is a need!
- The technology exists, one has just to adapt it for space operations…
- ... And the reward is the possibility to make entirely new science possible

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Conclusions

- APEX is 6U CubeSat for Hera mission
- First CubeSat mission to asteroid, binary asteroid
- Applications in science, planetary defense, ISRU, asteroid resource evaluation

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