10th Interplanetary Small Satellite Conference

April 29th/ May 1°, 2025 – Pasadena (CA)

The role of Small Satellite in Asteroid studies and Planetary Defence mission: The HERA MILANI and RAMSES CubeSat 1

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Need to know our enemy

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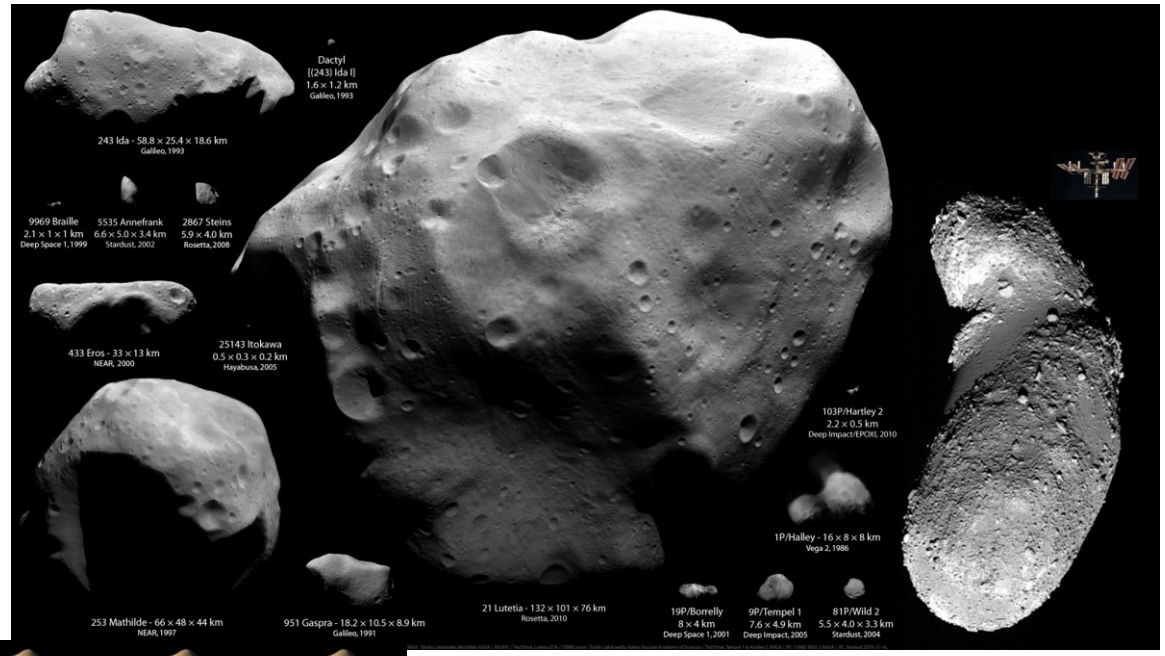
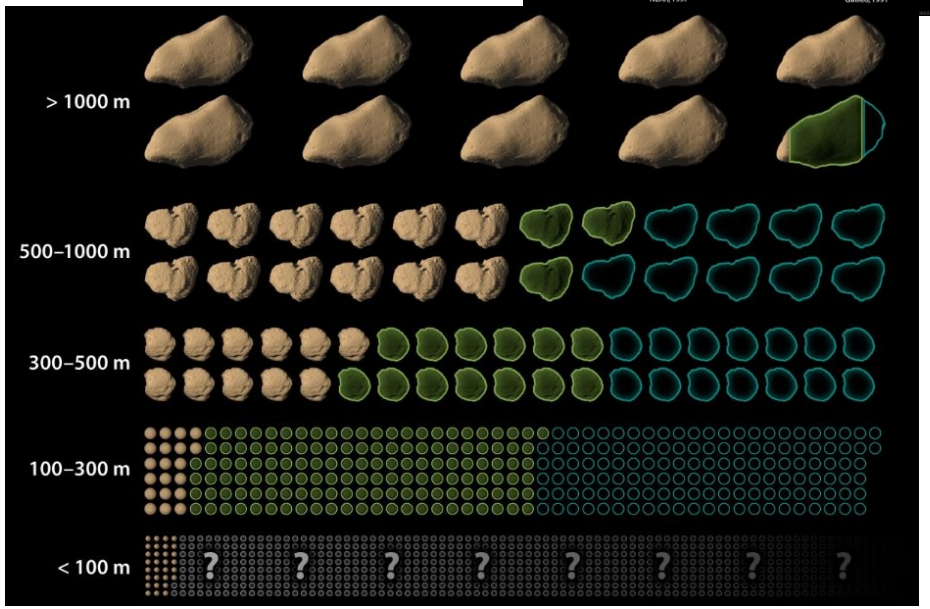
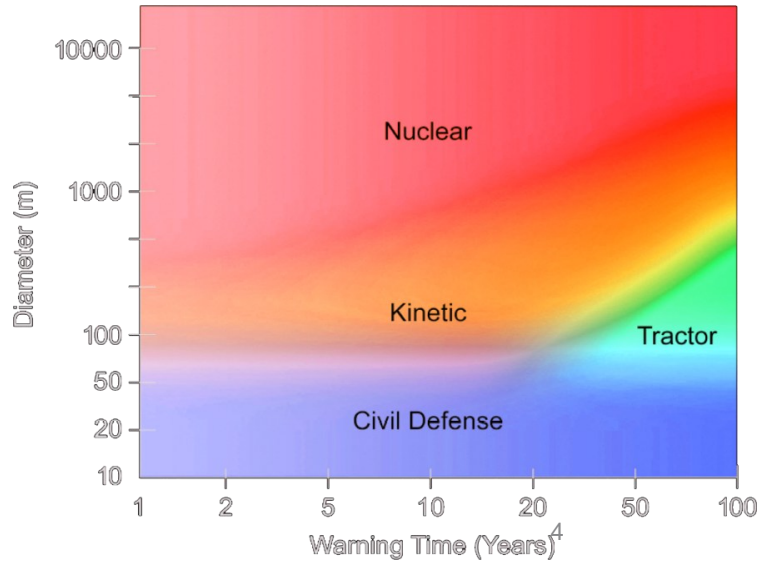
- **In the frame of the last 20 years, the scientific community and space Agencies focused attention and addressed efforts on the asteroid analysis domain, in support of the Planetary Defence roadmap definition and implementation.**
- **Asteroid characterization and analysis**
- **Planetary Defence technique test**







Mission to asteroid

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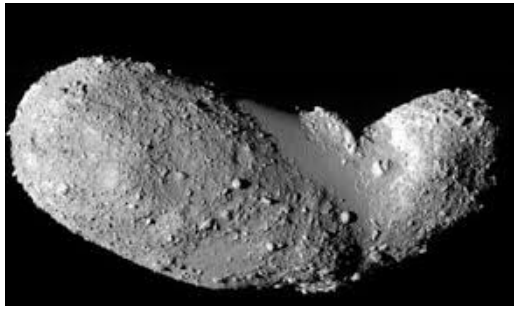
Hayabusa 1 (JAXA)

- Asteroid: 25143 Itokawa
- Diameter: 300 m
- Samples returned To Earth on June 2010

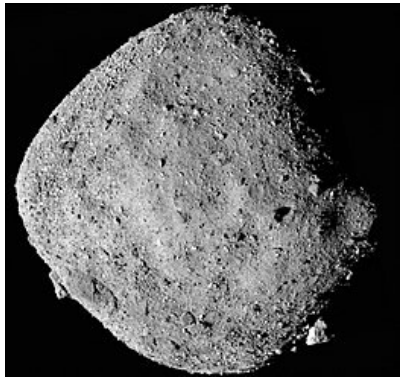


Hayabusa 2 (JAXA)

- Asteroid: 162173 Ryugu
- Diameter: 900 m
- Samples returned to Earth on December 2020

OSIRIS-REx (NASA)

- Asteroid: 101955 Bennu
- Diameter: 500 m
- Sample returned to Earth on Settembre 2023



DART (NASA)

- Asteroid: Didymos, Dimorphos
- Diameter: 780 m – 150 m

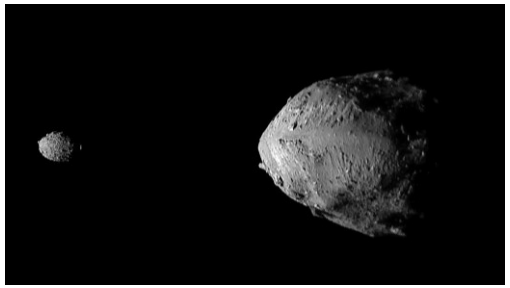
HERA (ESA)

- Asteroid: Didymos, Dimorphos
- Diameter: 780 m – 150 m

RAMSES (ESA)

- Asteroid: Apophis
- Diameter: 330 m

Hera Mission & Milani Cubesat



- **Asteroid Impact & Deflection Assessment (AIDA)**
- **Target: binary asteroid DIDYMOS**
- **Asteroid Impact**
  - NASA Mission “DART”
  - Impact 26 Sept 2022
- **Asteroid inspection post impact**
  - ESA Mission “Hera”
  - Launch 2024
  - Mission 2026/2027
- **Hera mission includes two Nanosatellites**
  - **Milani (Tyvak International)**
  - Juventas (GOMSpace)

esa European Space Agency

TYVAK INTERNATIONAL
PRIME CONTRACTOR
Space Segment Developer

POLIMI
Mission and GNC design

ALTEC
Space-to-Ground Interface

VTT
ASPECT Payload Provider

INAF
VISTA Payload Provider

GLI
DPU software requirements & testing

UNI HELSINKI
ASPECT Calibration

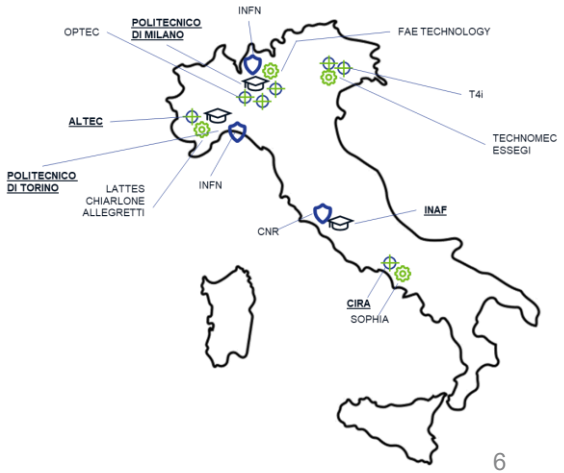
POLITO
Requirements and environmental analysis

CIRA
Environmental Test

KUVA SPACE
ASPECT DPU Provider

HULD
Software Development

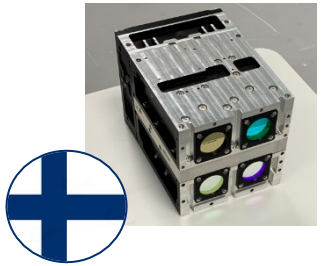
UNI BRNO
ASPECT on board algorithms

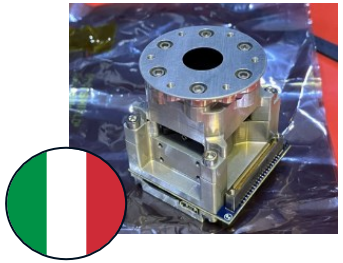


Milani Scientific objectives

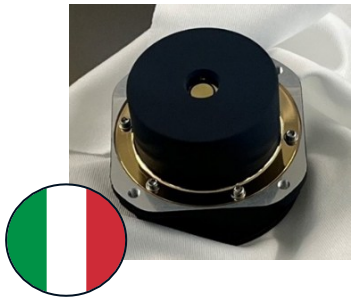
- **Milani aims at enhancing the overall Hera scientific return**
- **Milani scientific objectives:**

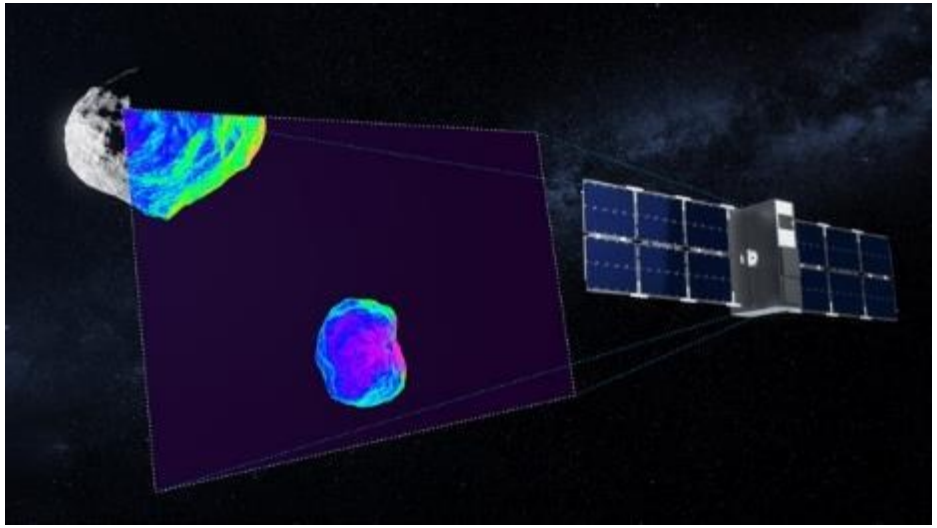
1. **Asteroid imaging - Map the global composition and characterize the surface of the Didymos asteroids**
   - Payload: **ASPECT** and **NavCam**





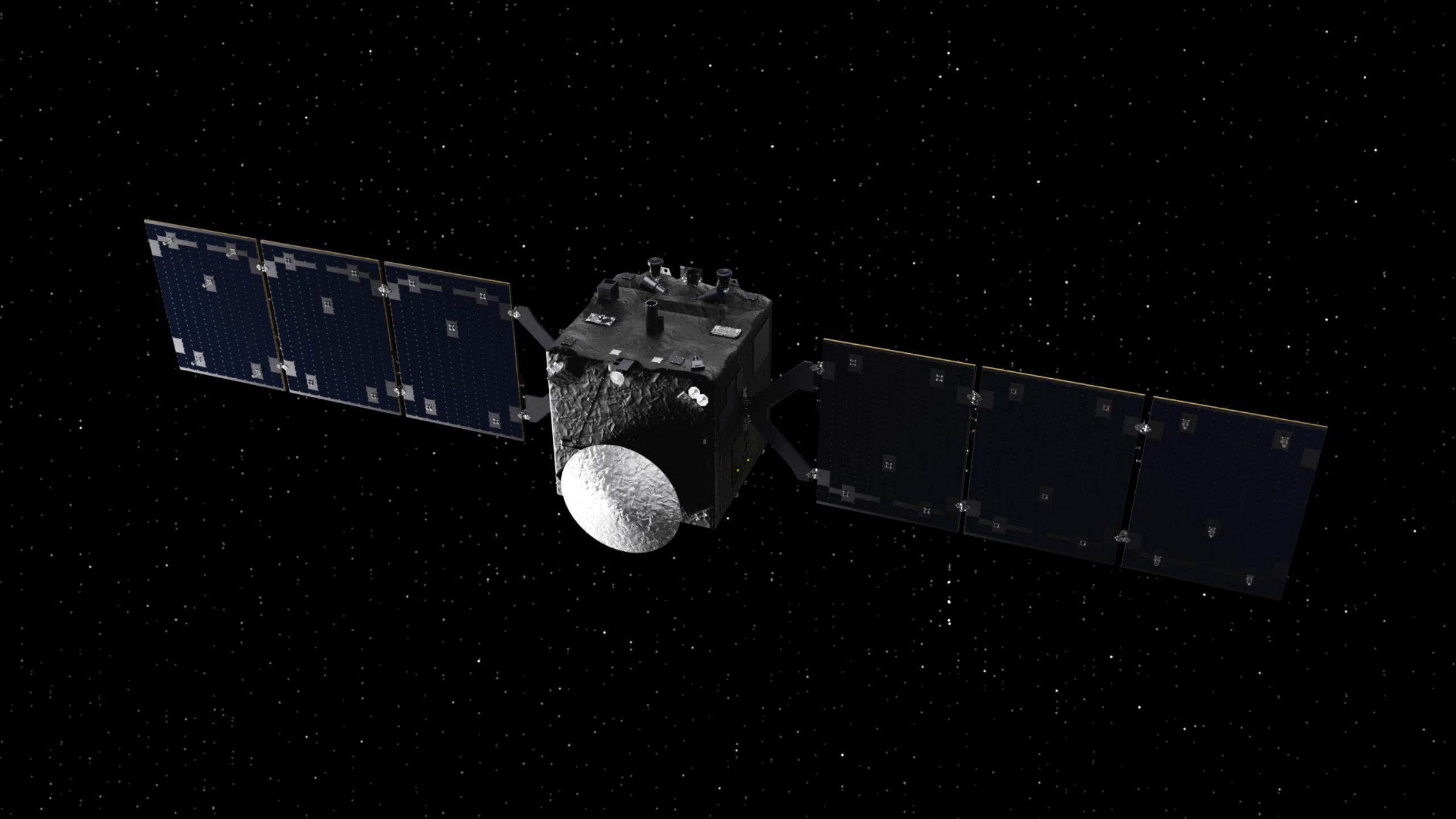
2. **Dust detection - Characterize dust clouds around the Didymos asteroids**
   - Payload: **VISTA**

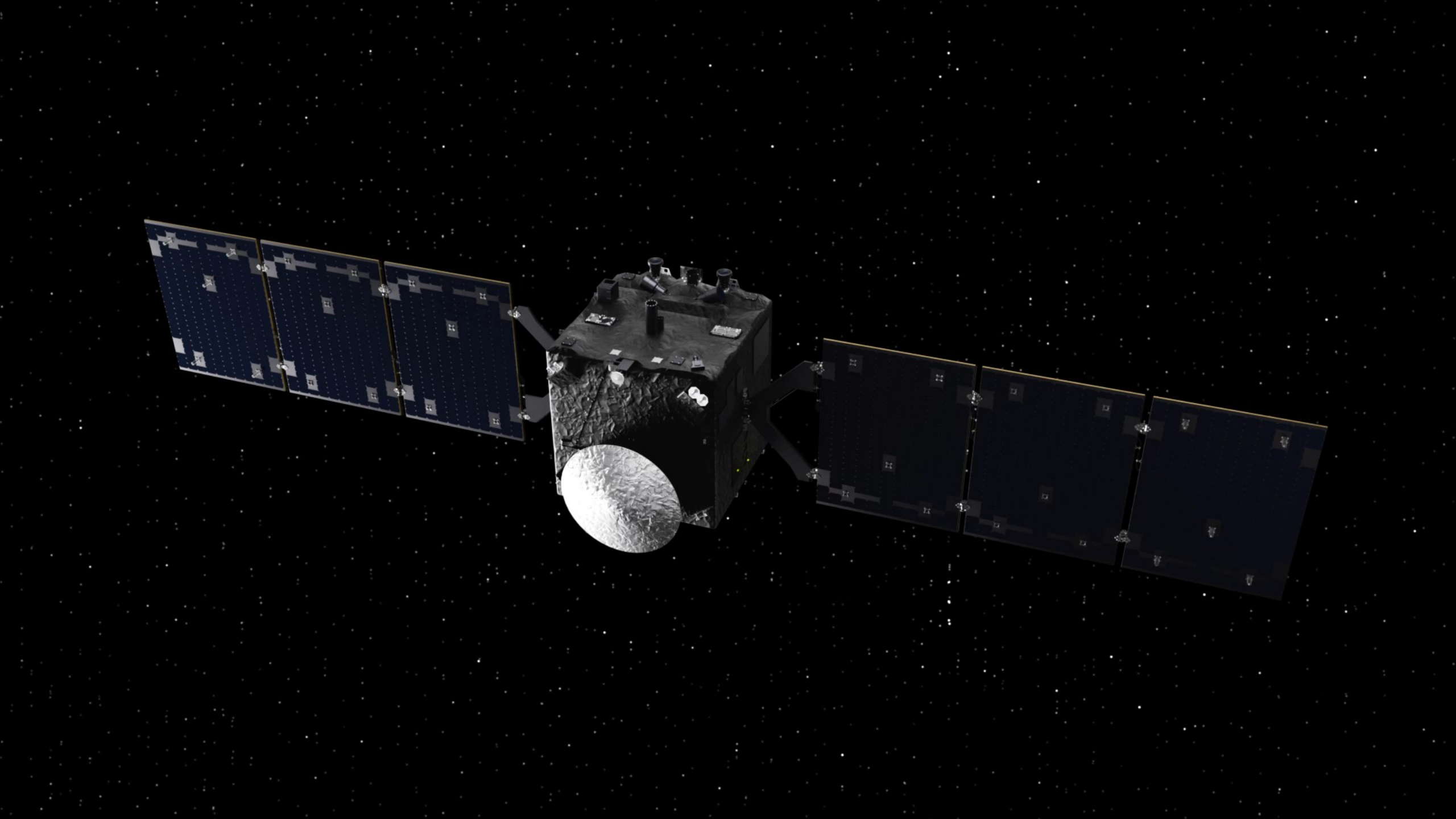


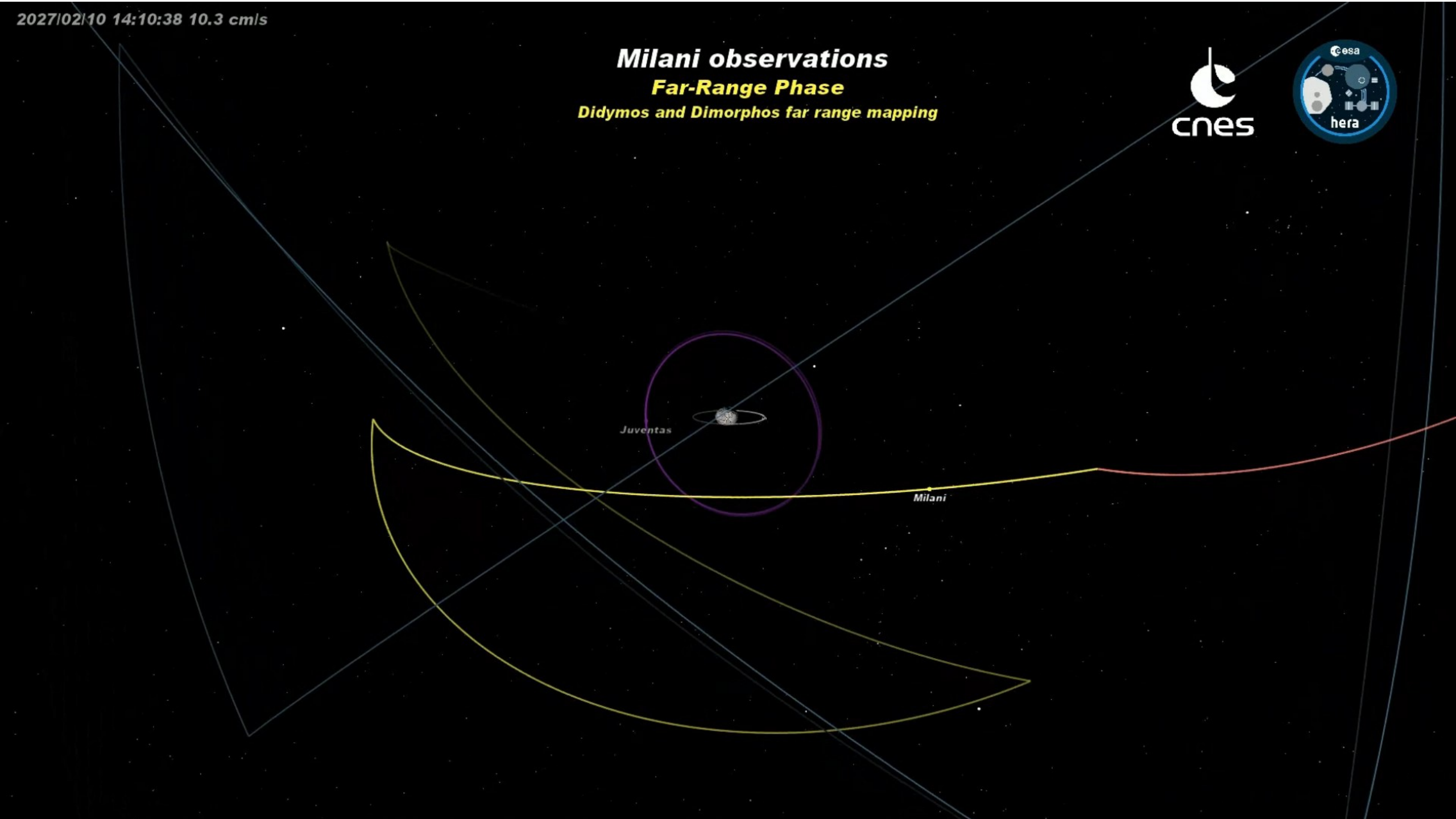


Imaging

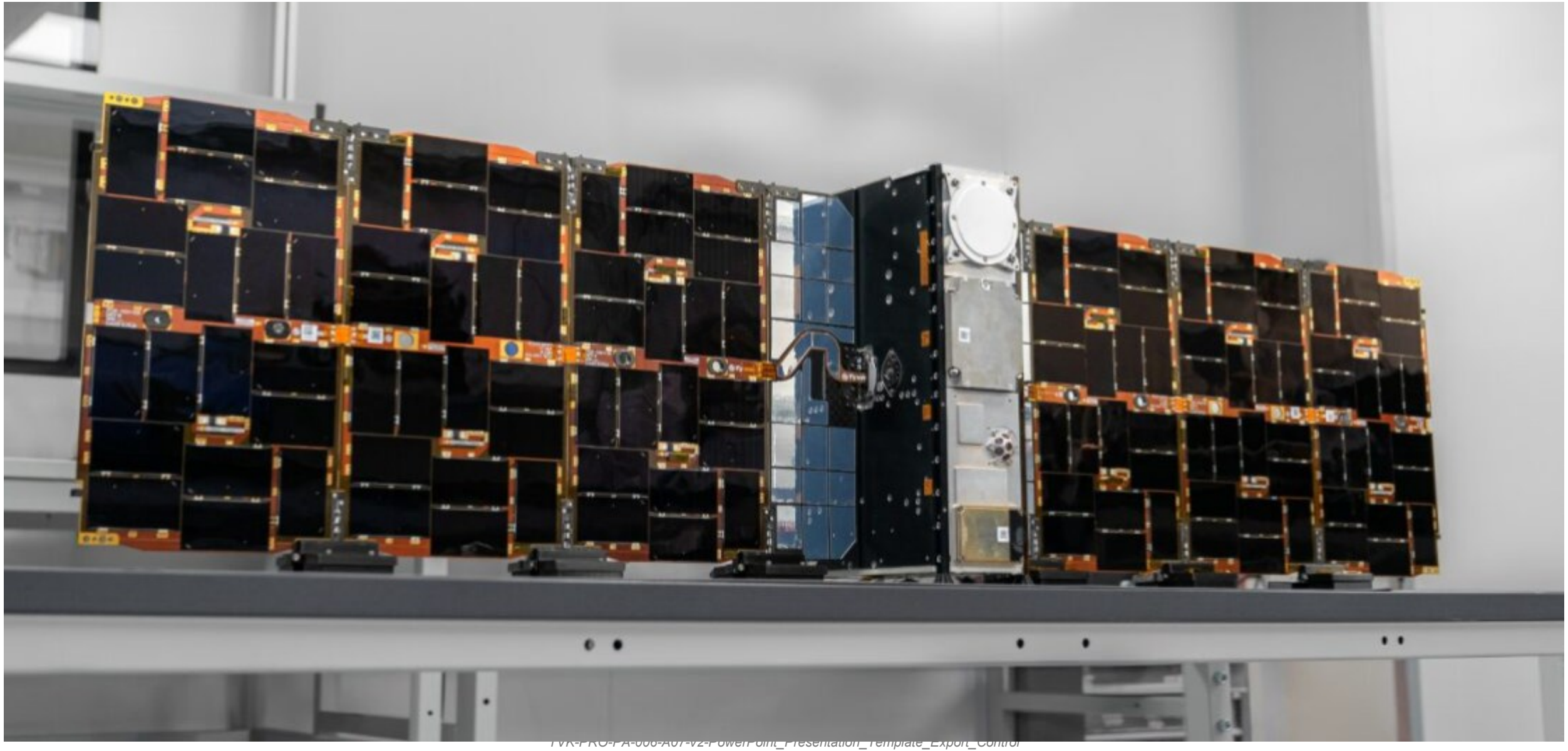
DUST detection






2027/02/10 14:10:38 10.3 cm/s
Milani observations
Far-Range Phase
Didymos and Dimorphos far range mapping
cnes
esa
hera
Juventas
Milani

Milani ProtoFlight Model



Cruise phase ongoing

- **Milani cruise phase will be managed with tentative one pass every two months, mainly aiming at:**
  - Making sure the vehicle is in good health (Checkout Tests), but also
  - Keeping the vehicle in good health

- **A "Baseline" pass plan is defined (mandatory execution ensuring satellite nominal status)**

- **Each pass might include "Additional activities", such as:**
  - Activities to fix issues arose in the previous pass
  - Payload-related activities (requested by Payload PIs)
  - Battery self-discharge assessment
  - Thruster tank pressure and line check
  - AOB, depending on the specific need

Milani operations status

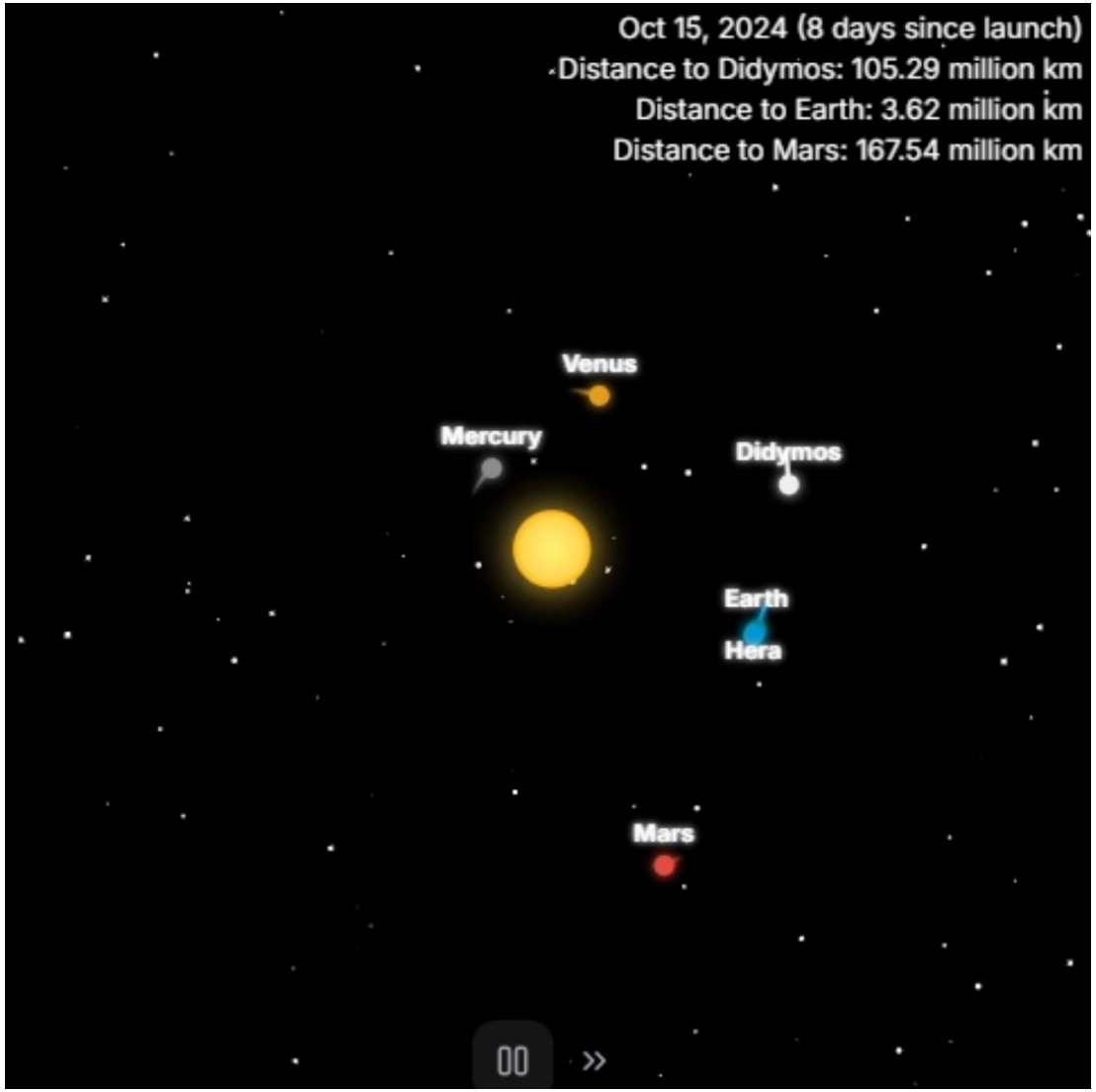
- **Commissioning:**
  - 24 October 2024 **COMPLETED, NECR achieved!**
- **Cruise phase passes**
  1. 16 December 2024 **COMPLETED**
  2. 24 February 2025 **COMPLETED**
  3. 22 April 2025 **COMPLETED**

Spoiler: vehicle (S/S and Payloads) in nominal health status

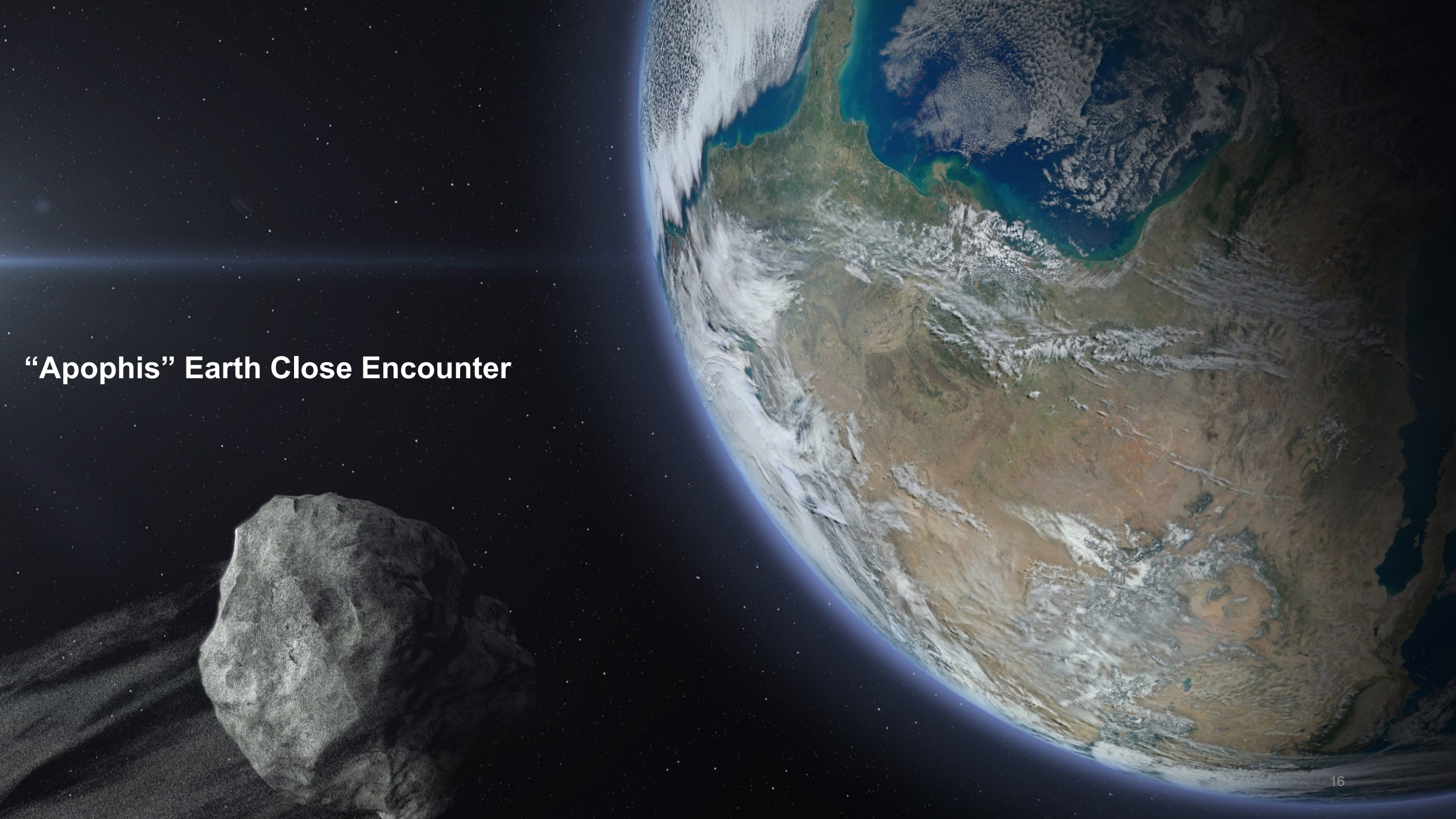


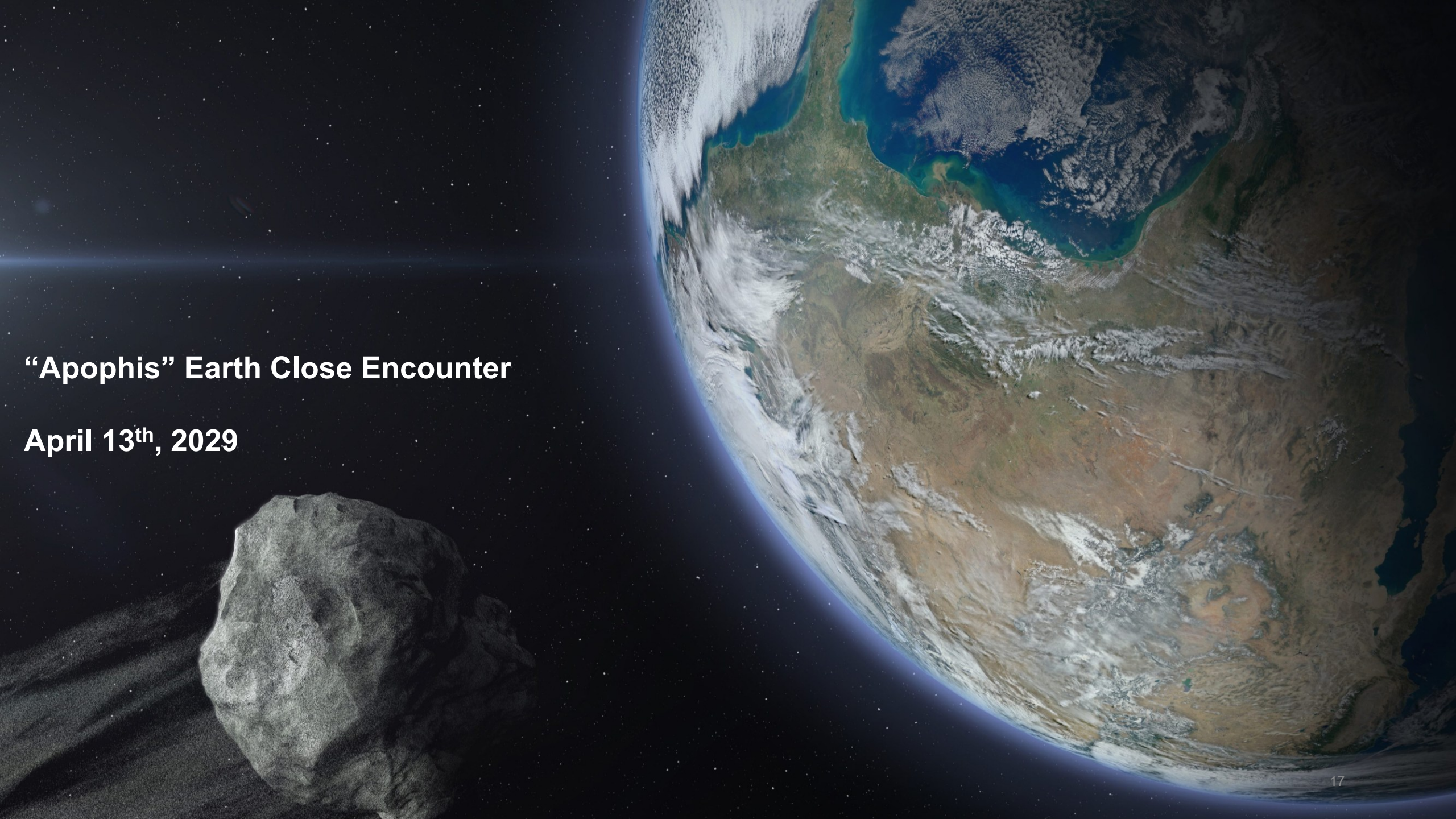

…and then?

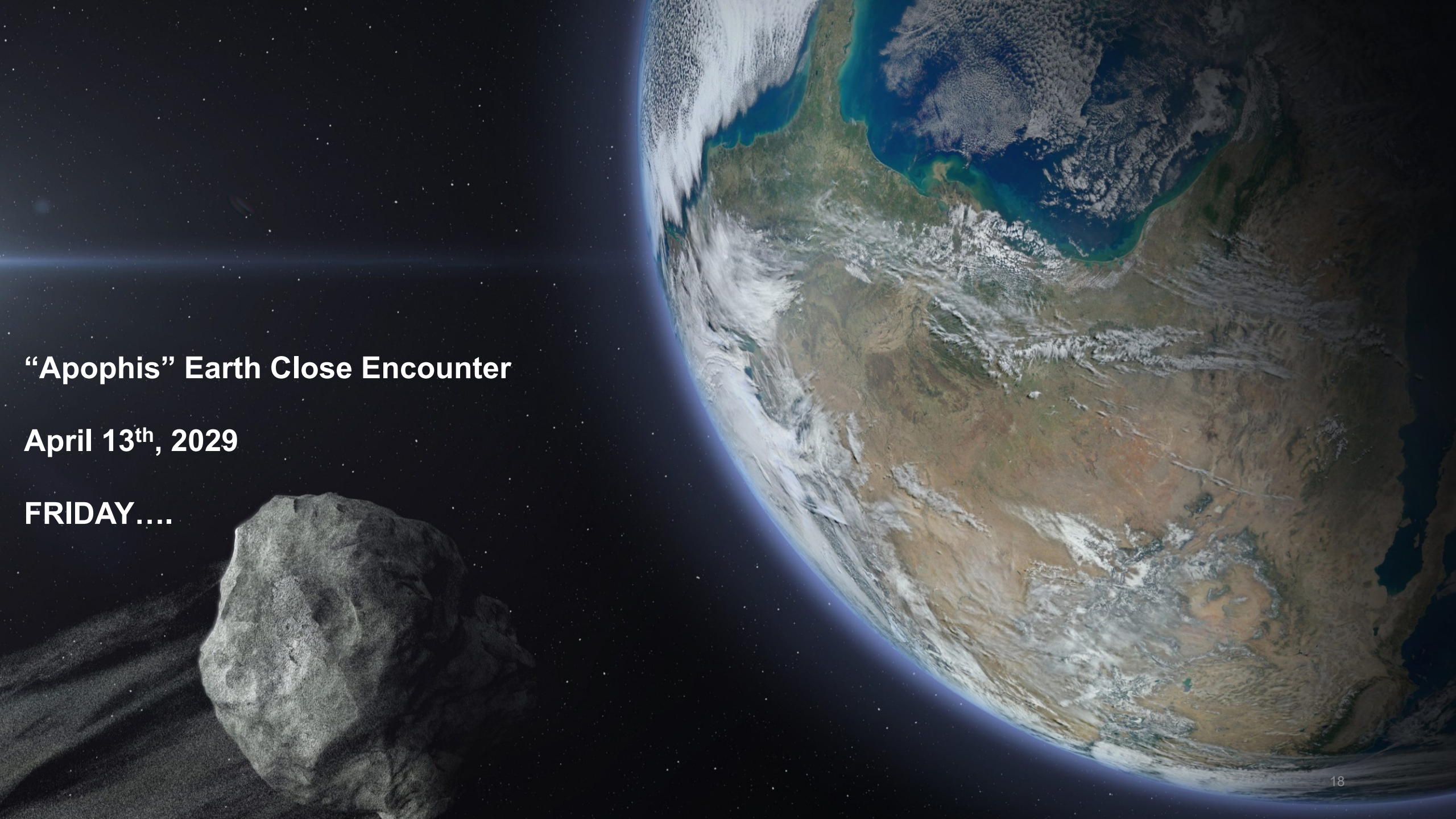
- **Now 250M km from Earth, 60M km from Dydimos**
- **Arrival at the asteroid: November/December 2026**
- **MILANI deployment: January 2027**



“Apophis” Earth Close Encounter

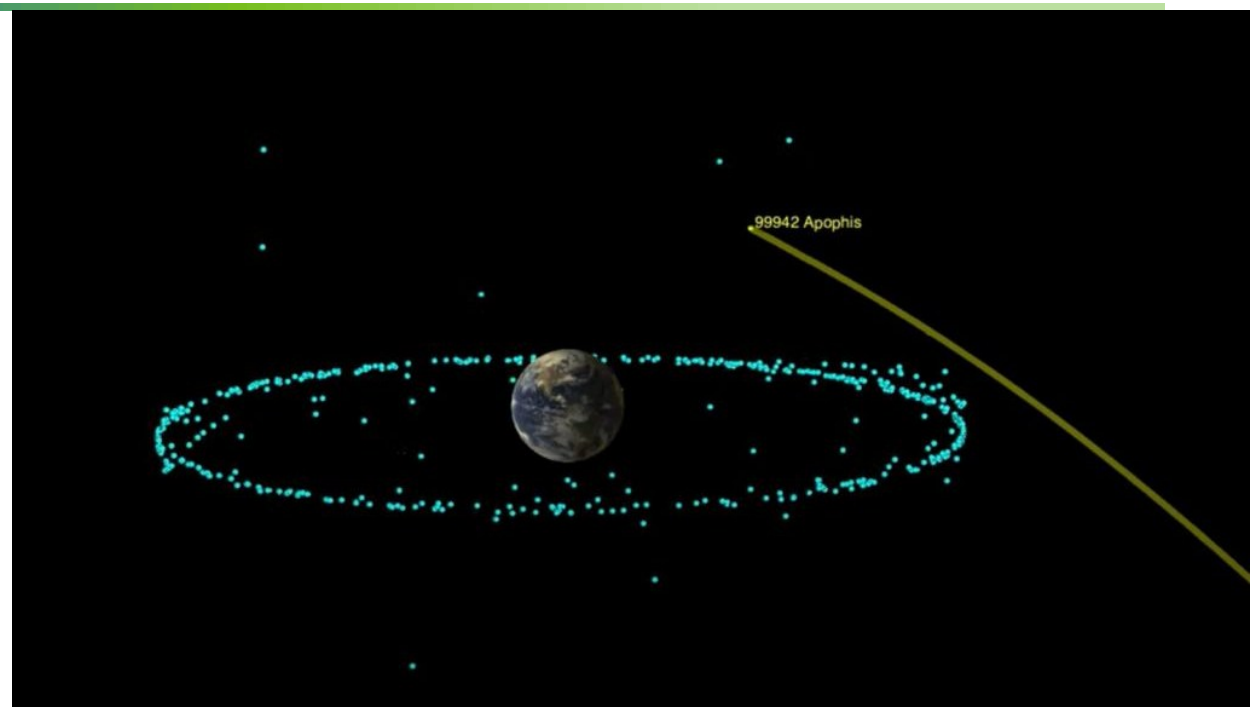



“Apophis” Earth Close Encounter
April 13th, 2029

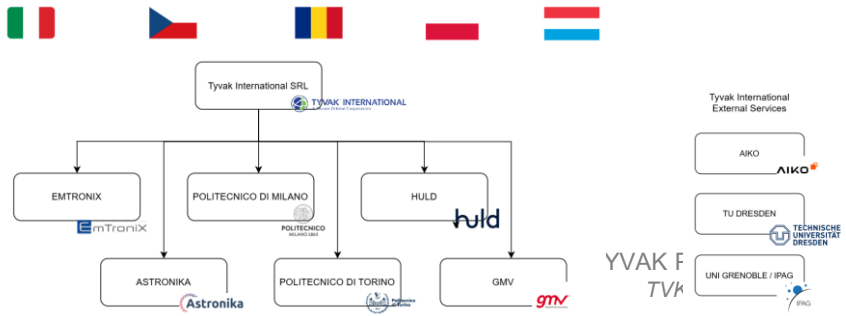

“Apophis” Earth Close Encounter
April 13th, 2029
FRIDAY….

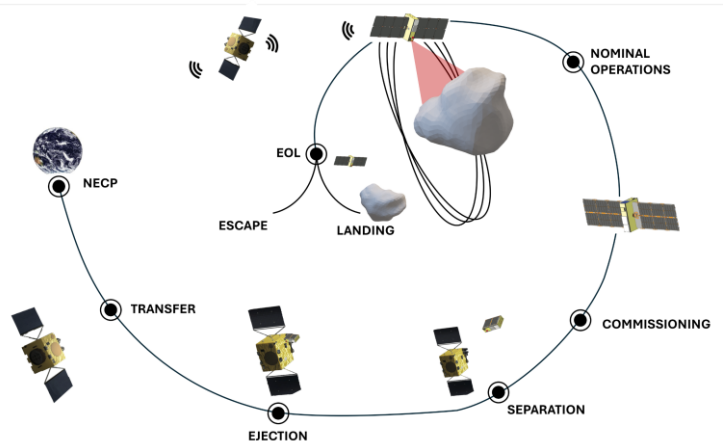
RAMSES mission to Apophis

- **Ramses, or Rapid Apophis Mission for Space Safety, is an ESA mission Apophis.**
- **Based on Hera technology, including the presence of 2x CubeSats (named RCS1 and RCS2)**



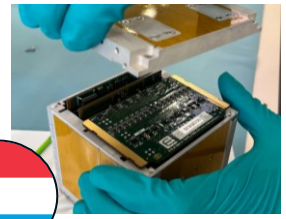
Assigned by ESA to Tyvak International, based on the Milani heritage

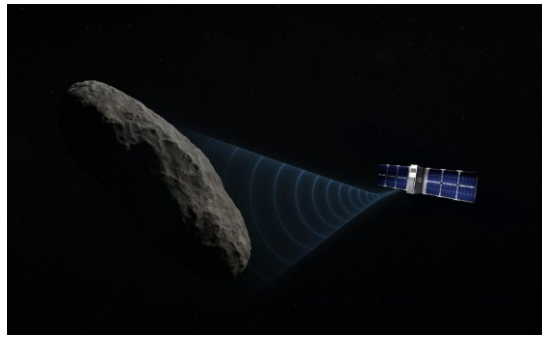




RCS1 Scientific objectives

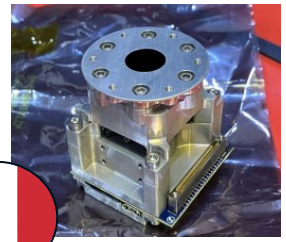
1. **Internal structure - Characterize the internal structure of Apophis**
   - Payload: **Low Frequency Radar (LFR)**

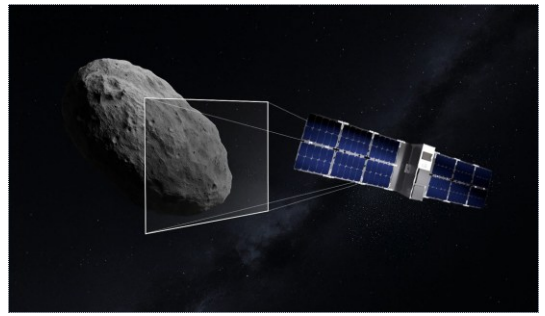




Internal structure

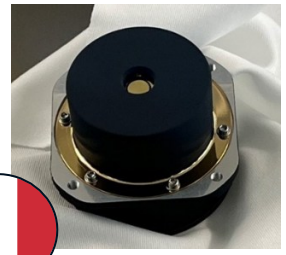
2. **Asteroid imaging - Map the global composition and characterize the surface of the Apophis asteroids**
   - Payload: **Horus**





Imaging

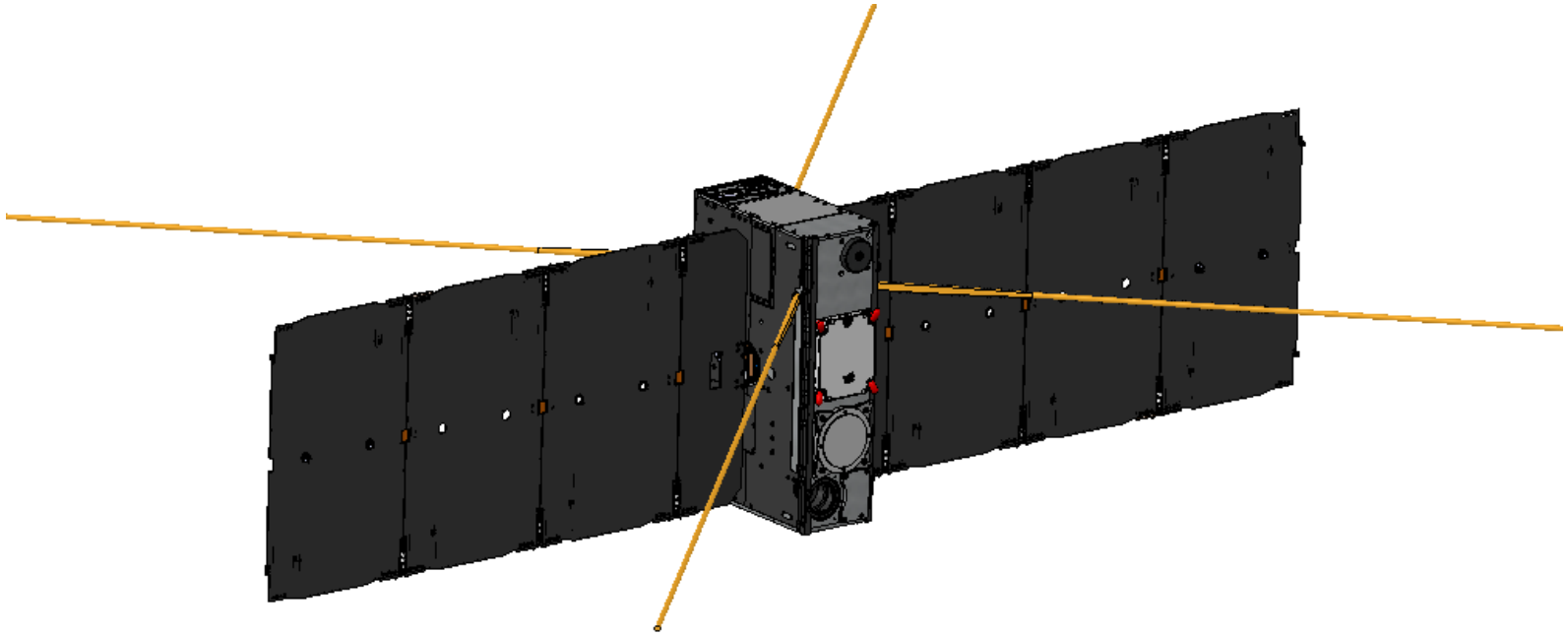
3. **Dust detection - Characterize dust clouds around the Apophis asteroids**
   - Payload: **VISTA**



Dust detection

RCS1 Mission Status

- The RCS-1 baseline design is based on the Milani CubeSat, that in turn is based on a standard Tyvak Triumph bus platform (6U XL platform)
- Just achieved the System Requirements Review
- Launch scheduled for April- May 2028 with Ramses mothercraft



Conclusion

- **Nanosatellites as enablers:** MILANI and RCS1 demonstrate how such small satellites can contribute to complex planetary missions.
- **Heritage and evolution:** MILANI's experience directly informs RCS1 development for RAMSES
- **Planetary defense future:** RAMSES will expand our capabilities for rapid asteroid response.
- **Teamwork pays off:** Success achieved thanks to international collaboration and innovative engineering.


esa
STANLEY
FATMAX
UN 3481

Flawless Execution Sustains Growth

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April | 2025

Backup