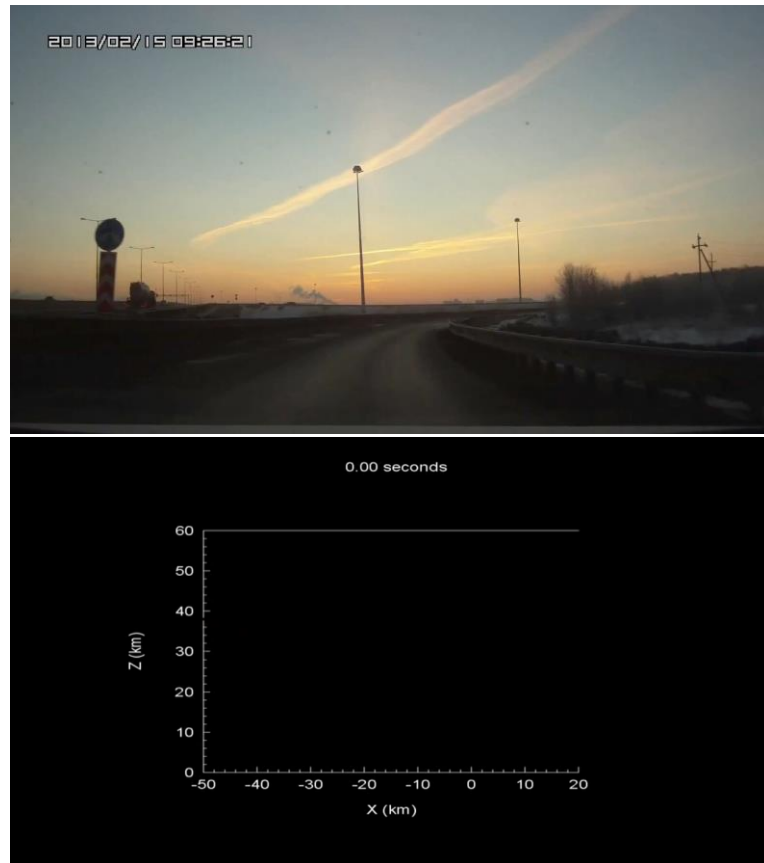


Hera mission status

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Hera is required to:

- fully validate the kinetic impactor technique
- enable its applicability to other targets
- provide unique science bonuses
- inspire the public, engagement in planetary defense



Hera: a mission of "firsts"



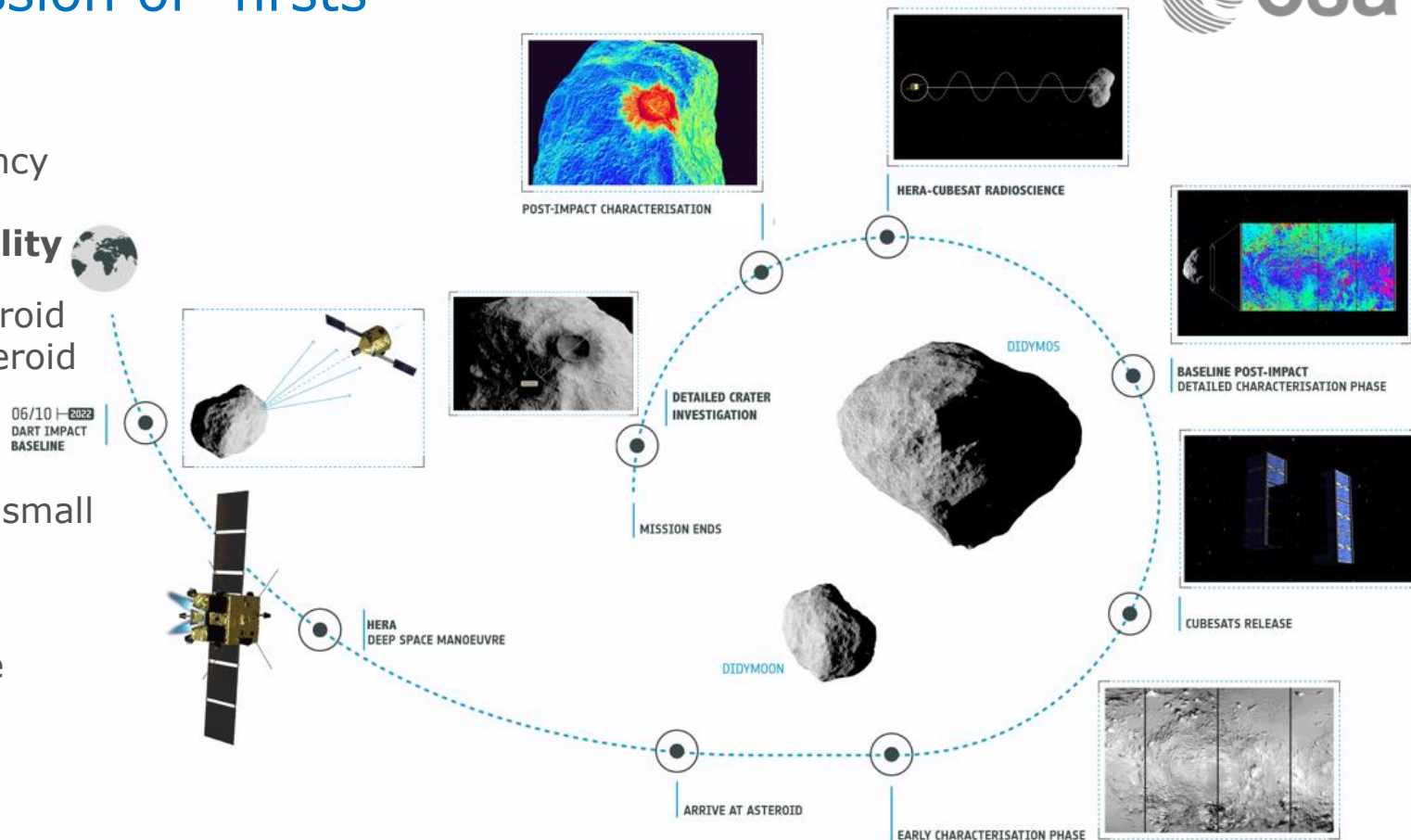
- **First** precise measurement of deflection efficiency and **Planetary Defence capability**



- **First** binary asteroid and smallest asteroid ever visited

- **First** detailed measurement of small body cratering physics

- **First** deep-space CubeSat for very close asteroid inspection

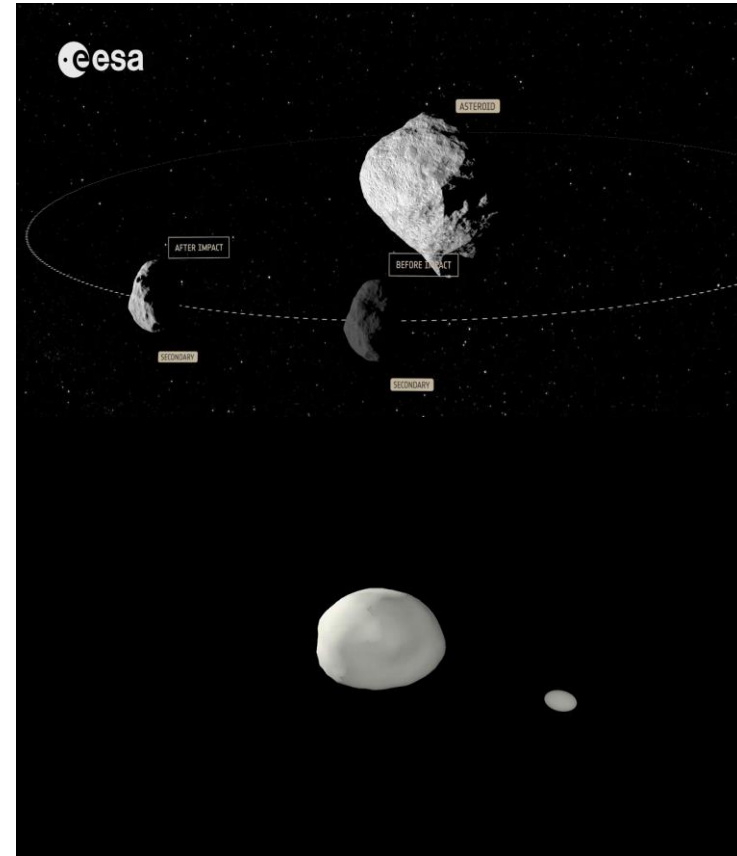




What will DART provide?

What will DART provide?

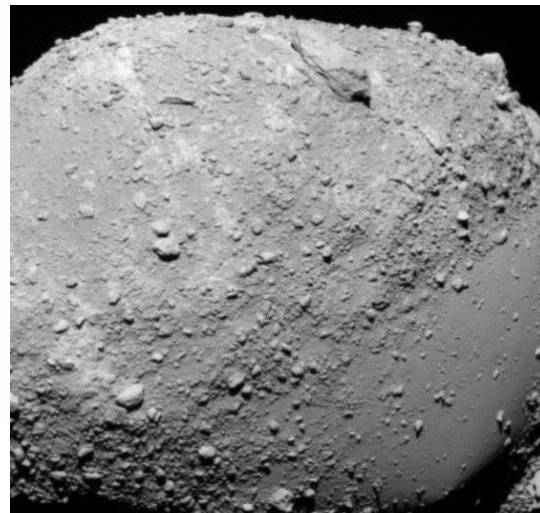
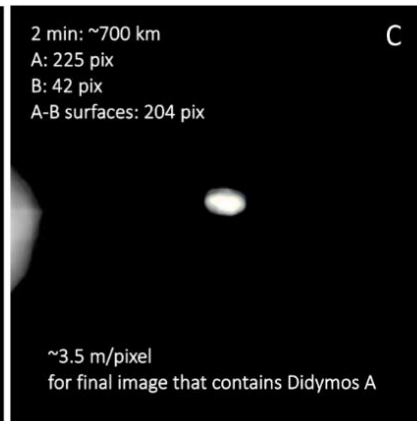
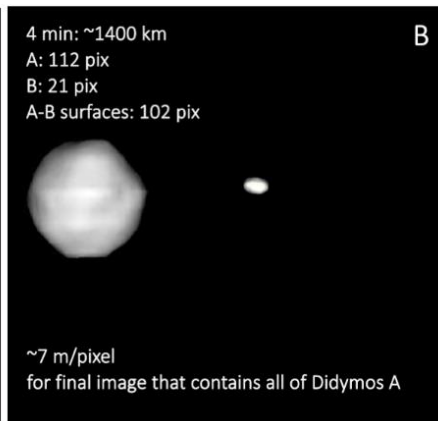
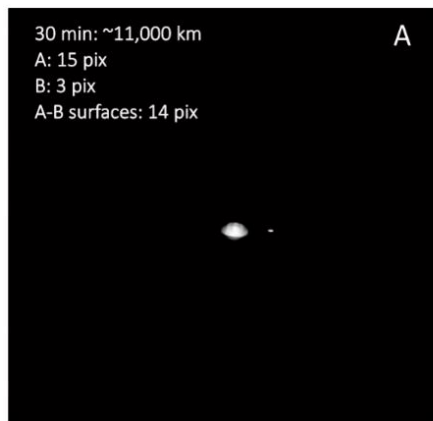
1. First **demonstration of KI technique** to deflect an asteroid
2. Test **autonomous GNC** for hypervelocity impact on 150m target (good size / type)
3. Measure deflection: Didymoon's **orbital period change** (ground observations)



What will DART provide?

DART imaging (GNC plus science)

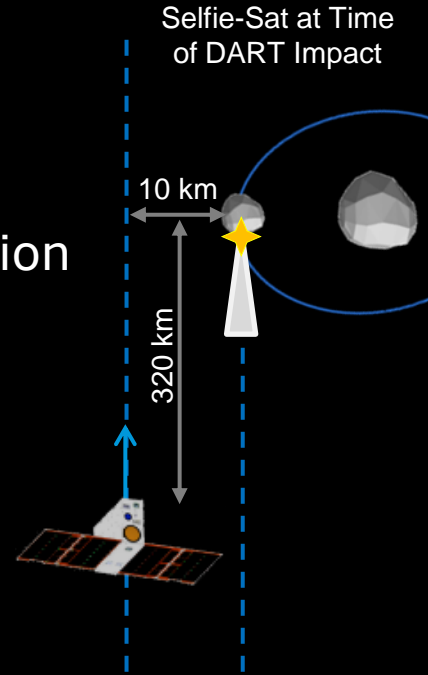
Far range → sizes, global shape, Didymoon volume ($\sim 30\%$)



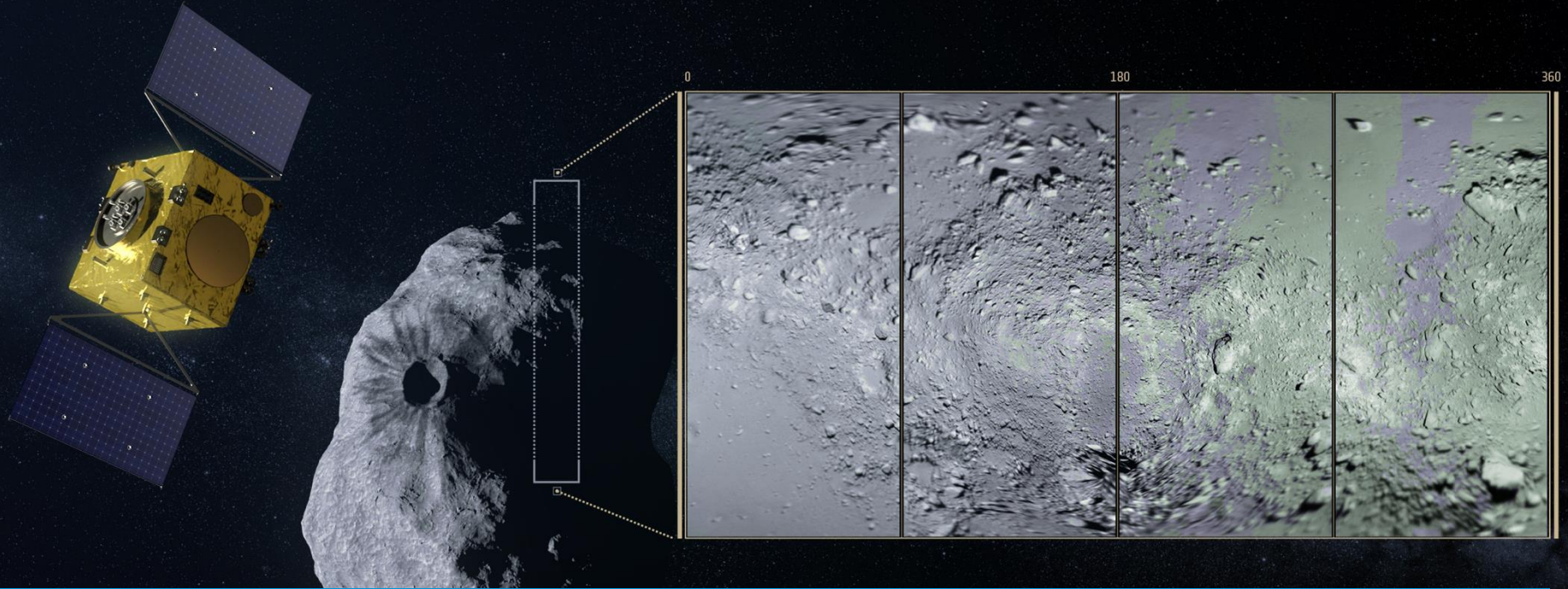
Close range → impact site location on Didymoon,
local slope ($\pm 10^\circ$) surface geomorphology (~ 50 cm)

SelfieSat to perform ~5-6 min Didymoon fly-by

- confirm impact
- image ejecta plume
- assist shape determination



Phase-C kicked-off on 15 May 2018



What is missing?

Hera's measurements!

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What is missing (momentum transfer)

Momentum transfer factor, β :

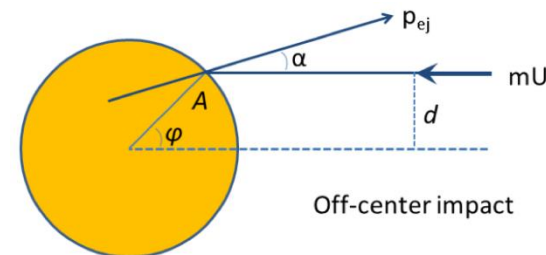
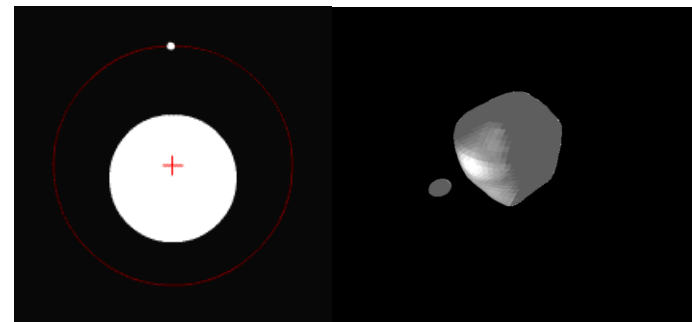
→ Need to know target's **mass** (<10% accuracy)

Hera

→ Need to **disentangle orbit, rotation, shape effects**

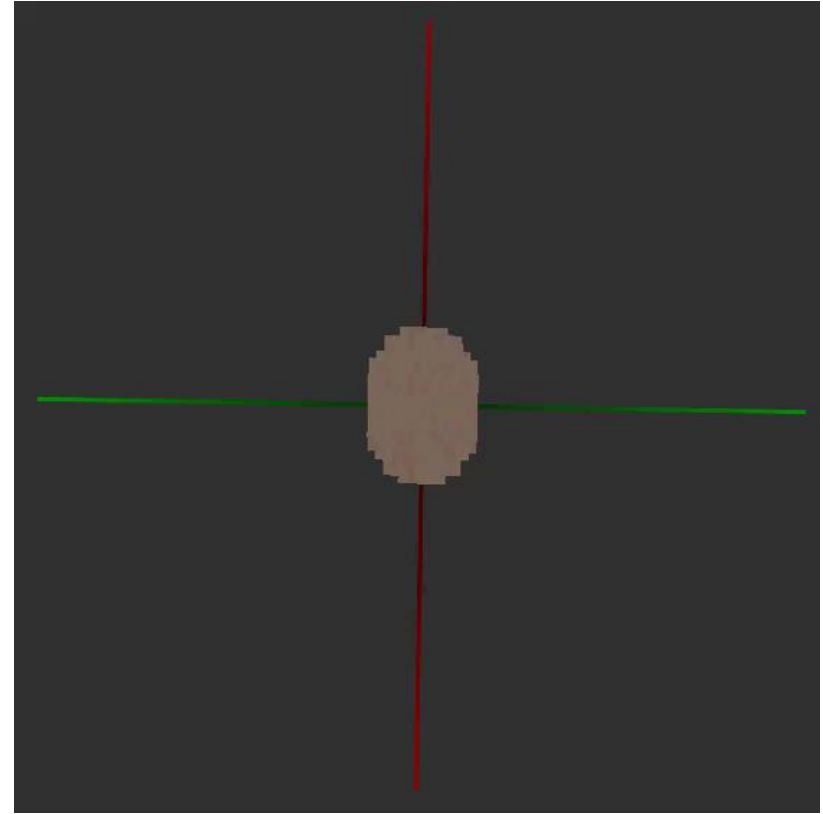
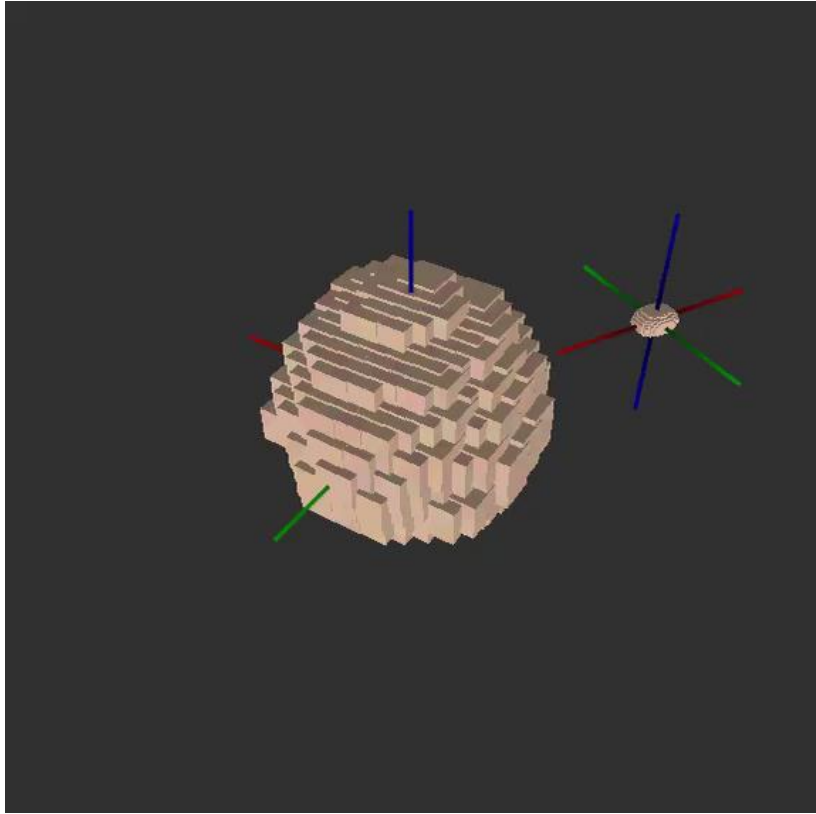
Hera

orbital parameters (→ total mass <10%), shape, volume (densities <20%), spin/orbit pole (1-5%), libration



An anchor point of the impact deflection effect

What is missing (libration)



What is missing

Hera is needed to transform a kinetic impactor experiment into a Planetary Defense mission

- **Impact parameters**

Impact velocity **DART**

Impactor density, mass

- **Crater properties**

Diameter, depth, volume

Shape

Hera

Target properties

- Porosity
- strength

Hera

β

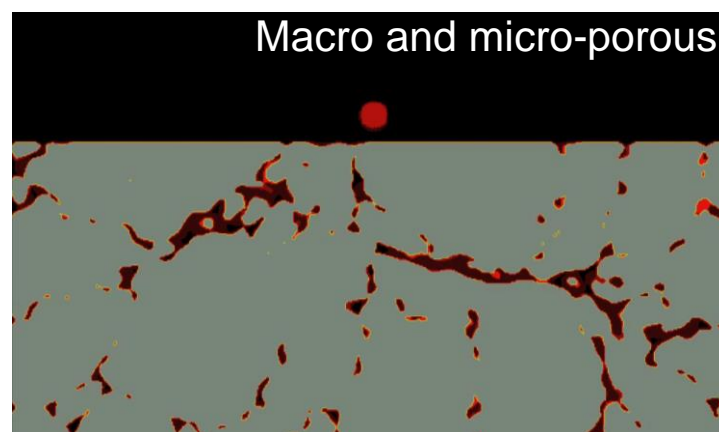
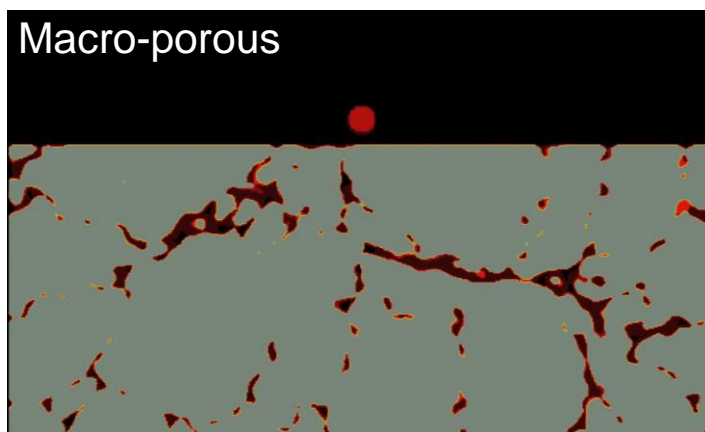
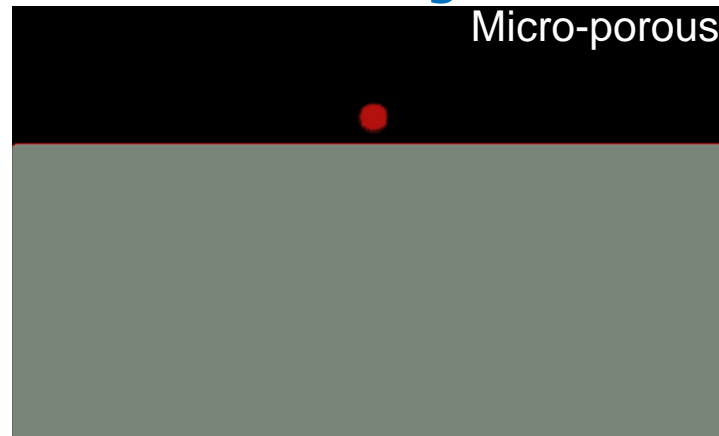
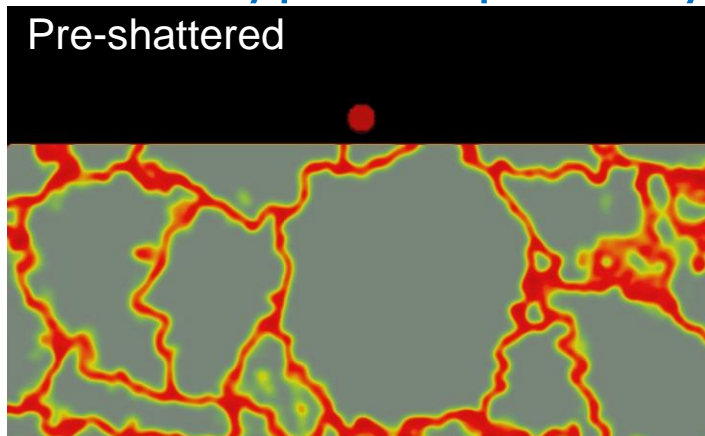
Critical parameter to

- evaluate outcome of DART
- validate models
- make accurate predictions

**Understand how to do it if needed and...
even for larger asteroids**

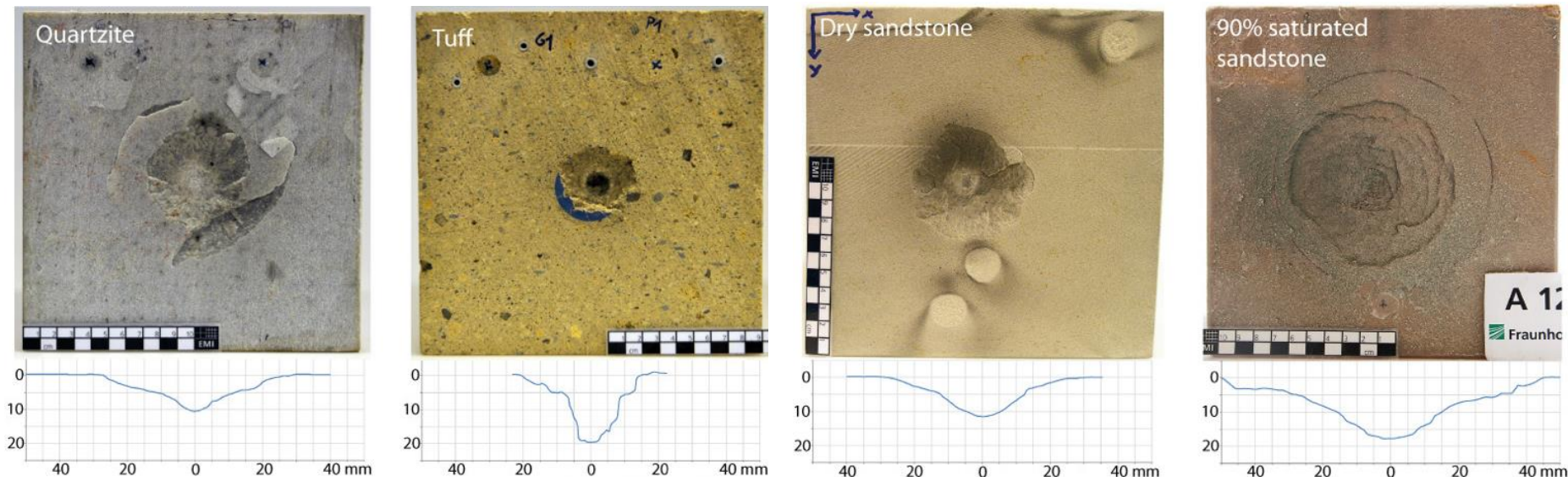


Different types of porosity affect cratering



Validation
possible only
at lab scale

Effect of target properties on crater size $\rightarrow \beta$



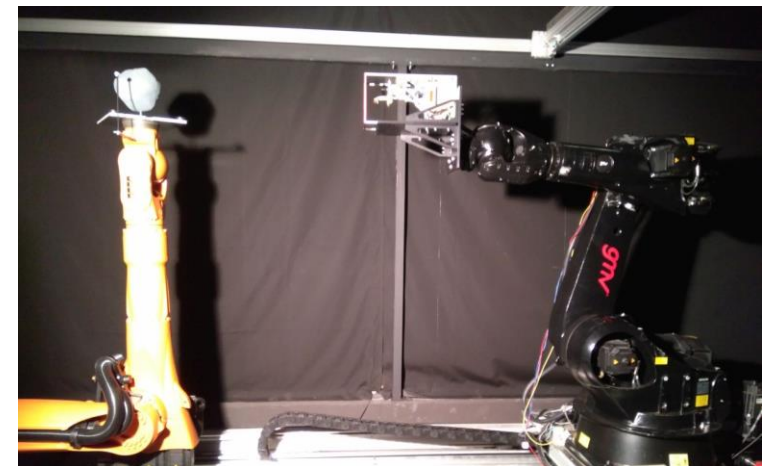
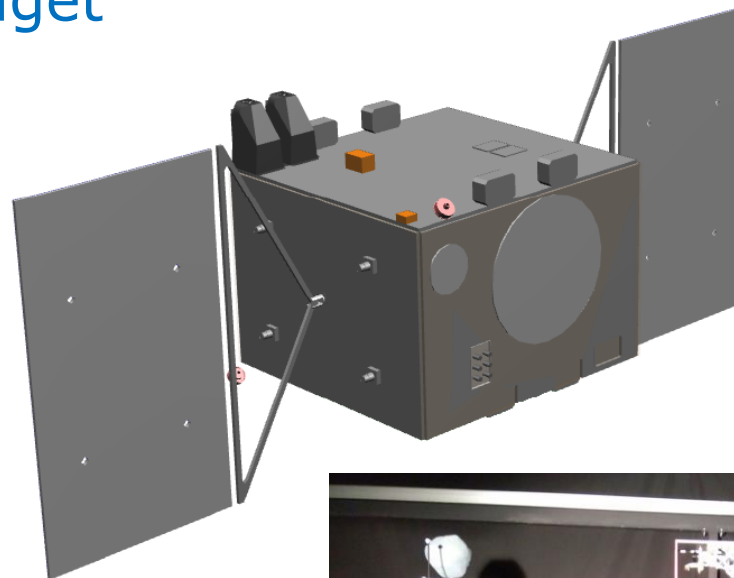
Poelchau et al. 2014

Hera will provide unique data on crater size
essential for reliable predictions from numerical modelling

AIM_D² spacecraft mass budget



| Subsystem | Nominal | Margin | Total |
|--|--------------|------------|--------------|
| | [kg] | [%] | [kg] |
| EPS | 34.9 | 10% | 38.4 |
| OBDH | 26.4 | 10% | 29.0 |
| TT&C | 22.0 | 8% | 23.8 |
| AOCS/GNC | 12.2 | 5% | 12.8 |
| CPS | 50.6 | 6% | 53.8 |
| TCS | 11.9 | 16% | 13.8 |
| Harness | 24.7 | 30% | 32.1 |
| Structure | 84.8 | 20% | 101.7 |
| Platform total | 267.4 | 14% | 305.5 |
| Payload | 19.0 | 0% | 19.0 |
| Payload total | 19.0 | 0% | 19.0 |
| Spacecraft dry mass | 286.4 | 13% | 324.5 |
| System margin | | 20% | 64.9 |
| Spacecraft dry mass + Margin | | | 389.4 |
| Propellant mass | | | 249.0 |
| Pressurant | | | 1.0 |
| Spacecraft launch mass | | | 639.4 |
| Launcher performance (w.o. adapter) | | | 770.0 |
| Launcher Margin | | | 130.6 |



Hera baseline payload

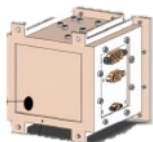


11.6 kg
17-34 W



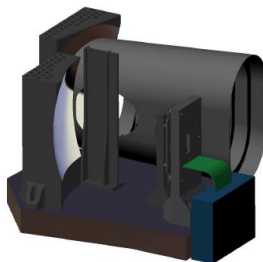
NAVCAM
(In storage)

1.4 kg
9 W

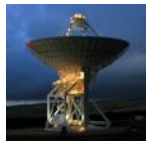


μLidar

475nm- 900nm

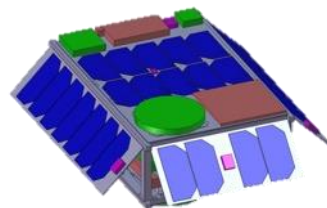


CHIEM



RADIOSCIENCE

14.9 kg (6U)



- 2 x 1U payloads among:
- Hyperspectral imaging
 - Volatiles
 - Relative Radioscience
 - Seismometry
 - Minearology
 - Dust environment
 - Gravimetry

Additional payload mass available, to be finalized during phase B1

Additional interests expressed to ESA (to be discussed bilaterally for consolidation, rejection or further assessment):

Gravimetre

Monostatic radar

Multispectral camera

μlander

Cameras

Thermal imager

Bifocal metrology

in Space



Space Safety

from Space



Maritime



Food



Disaster Management

Safety and Security Applications

A graphic showing a bright orange and red sun-like sphere on the left, with several curved, wavy lines in shades of purple, blue, and yellow extending from it towards the right, representing solar wind or magnetic field lines.

Space Weather


A graphic showing a blue and green Earth with a yellow, ringed planet (like Saturn) in the background. A small, dark, irregularly shaped object, possibly an asteroid or comet, is shown in the upper right corner against a dark blue starry space background.

**Planetary
Defence**

Cornerstones of Space Safety

A photograph of a satellite in orbit above Earth's cloud-covered surface. The satellite is gold-colored with various instruments and a large black circular dish antenna. It has solar panels and other equipment attached to its structure.

**Debris and Clean
Space -
Prevention**



**Space Weather
(L5)**

An illustration showing a bright orange sun on the left with solar wind represented by white lines flowing towards the right. On the right, a blue and purple planet with white orbital lines is shown.



**Asteroid
deflection
(Hera)**

An illustration of the Earth in blue and green, with a yellow asteroid approaching from the top right. The background is a dark blue space filled with white stars.

Cornerstone Missions



Debris removal

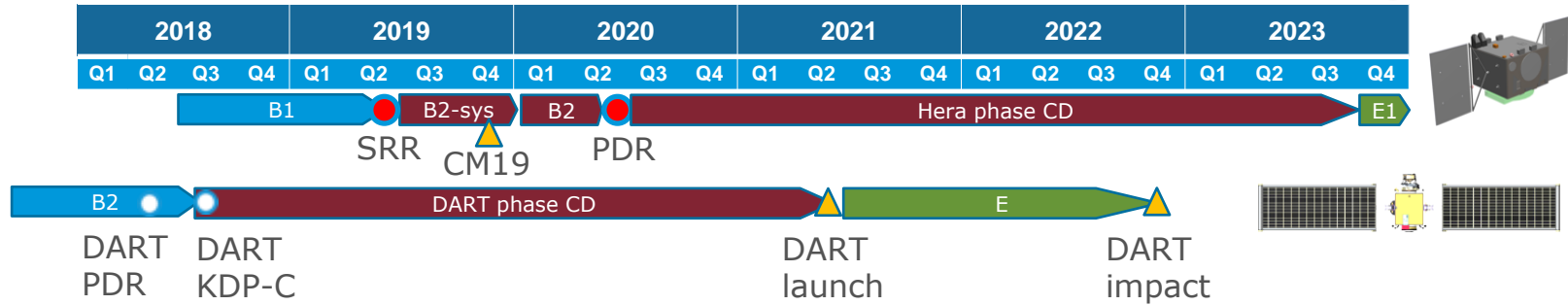
An illustration of a yellow and black spacecraft in space, with a large black cylindrical object attached to its side. The Earth's blue and white surface is visible in the background.



**Spacecraft
Collision
Avoidance Sys.**

An illustration of a dense field of white dots representing space debris against a dark background.

Hera phase B1

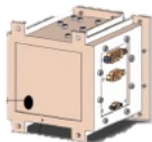


- **ITT released** (DE, BE, RO, LU, SE, PT, ES, CZ, AU, FI, PL, CH) including breadboarding activities:
 - Onboard computer E(Q)M
 - GNC and FDIR software validation with hardware in the loop in robotic lab
 - Onboard Software prototype implementation and validation for autonomy
- 4 thematic **workshops** with industrial team + ESA teams:
 - T_0+2 "Cubesat", T_0+3 "TEC", $T_0+3.5$ "OPS", T_0+4 "GNC"... $T_0+11.5$ "SRR"

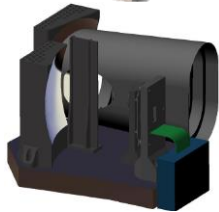
Payload and technology activities



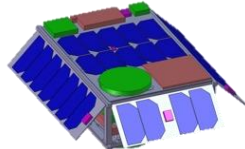
AFC (Asteroid Framing Camera) QM will be provided to contractor in phase B1 for GNC testing (2 flight models in storage)



PALT (planetary altimeter) RFQ in preparation (PT, RO), expected KO to be in parallel to spacecraft phase B1



CHiEM (hyperspectral camera) RFQ in preparation (BE), expected KO to be in parallel to spacecraft phase B1



Cubesats ITT for two parallel studies to be released mid-June, KO in September (DE, BE, RO, FI, SE, CZ, DK)



Inter-Satellite Link (ISL) RFQ to be issued mid-June (PT), expected KO to be in parallel to spacecraft phase B1

Hera community (working groups)



- **Hera investigation workshop** @ ESAC (payload) in November
- **AIDA international workshop** @ Europe in Q2 2019

Impacts simulation

Chairs: Kai Wunnemann
Martin Jutzi



Close-proximity operations

Chairs: Ozgur Karatekin
Naomi Murdoch
Jens Biele



ESA project scientist:

Michael Küppers



PI: Patrick Michel



Data Analysis Exploitation Interpretation

Chairs: Alain Hérique
Jean-Baptiste Vincent
Paolo Tortora
Simon Green



Dynamics

Chairs: Menios Tsiganis
Adriano Campo Bagatin
Sébastien Charnoz



Ground-based observations

Chairs: Petr Pravec
Julia de Leon
Benoît Carry
Alan Fitzsimmons

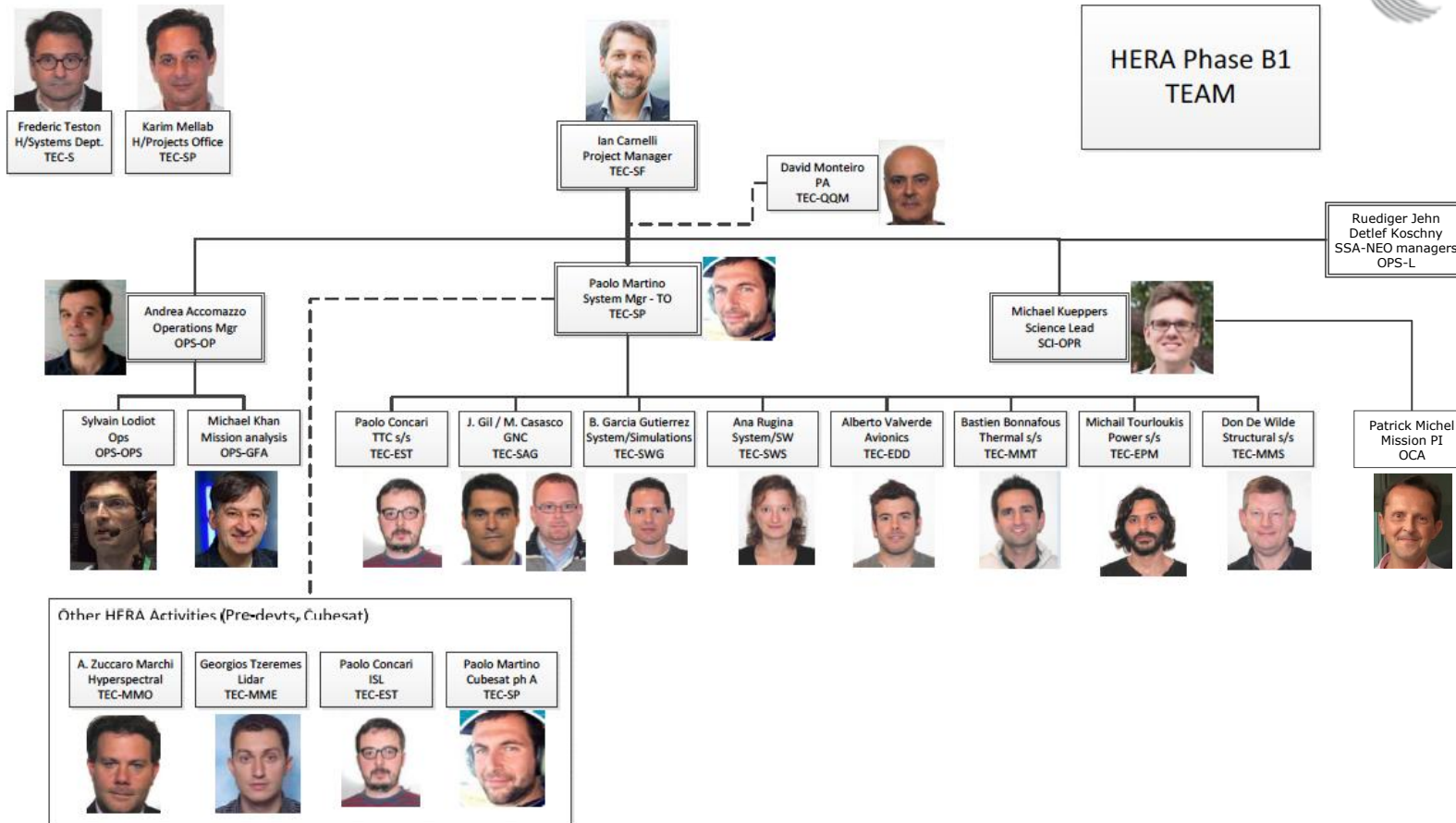


A detailed illustration of a space mission. A yellow satellite with two large solar panel arrays is positioned on the left, observing two large, grey, irregularly shaped asteroids in the center and right. The background is a deep blue space filled with numerous small white stars. A bright yellow sun is visible on the right side, creating a lens flare effect. Several small, blue and white striped rectangular objects are scattered in the background.

Ian Carnelli
General Studies Programme manager
Advanced Concepts & Studies Office (TEC-SF)
ian.carnelli@esa.int

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Hera team at ESA



| Parameter | Required accuracy | Associated payload |
|---|--|---|
| Size, mass, shape, density | <ul style="list-style-type: none"> Mass: 10% Density: 20% Shape accuracy of 6% or few meters | <p>Mass from binary orbit, spacecraft tracking (camera, cubesat, radioscience)</p> <p>Shape model (camera), Lidar</p> |
| Dynamical state (period, orbital pole, spin rate, spin axis) | <ul style="list-style-type: none"> Period already known to better than 0.1% Orbital pole: 5° Spin rate: 1% Spin axis: 1° | camera |
| Geophysical surface properties, topology, DART crater's properties | <ul style="list-style-type: none"> Global surface resolution: 1m Local surface resolution (10% of the surface): 10cm | <p>Camera (surface features)</p> <p>Cubesat (sub-meter resolution)</p> |
| Chemical and mineral composition of Didymoon and Didymos | Spectral resolution: 45nm or better | Camera, cubesat |
| Impact ejecta | No accuracy required | Camera, cubesat |