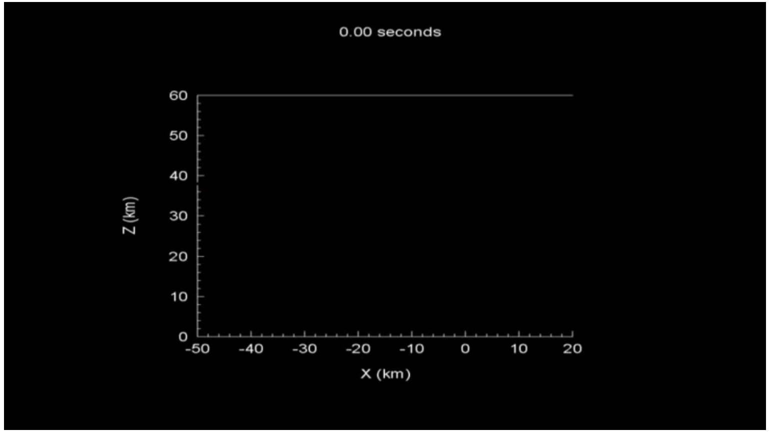
Hera mission status

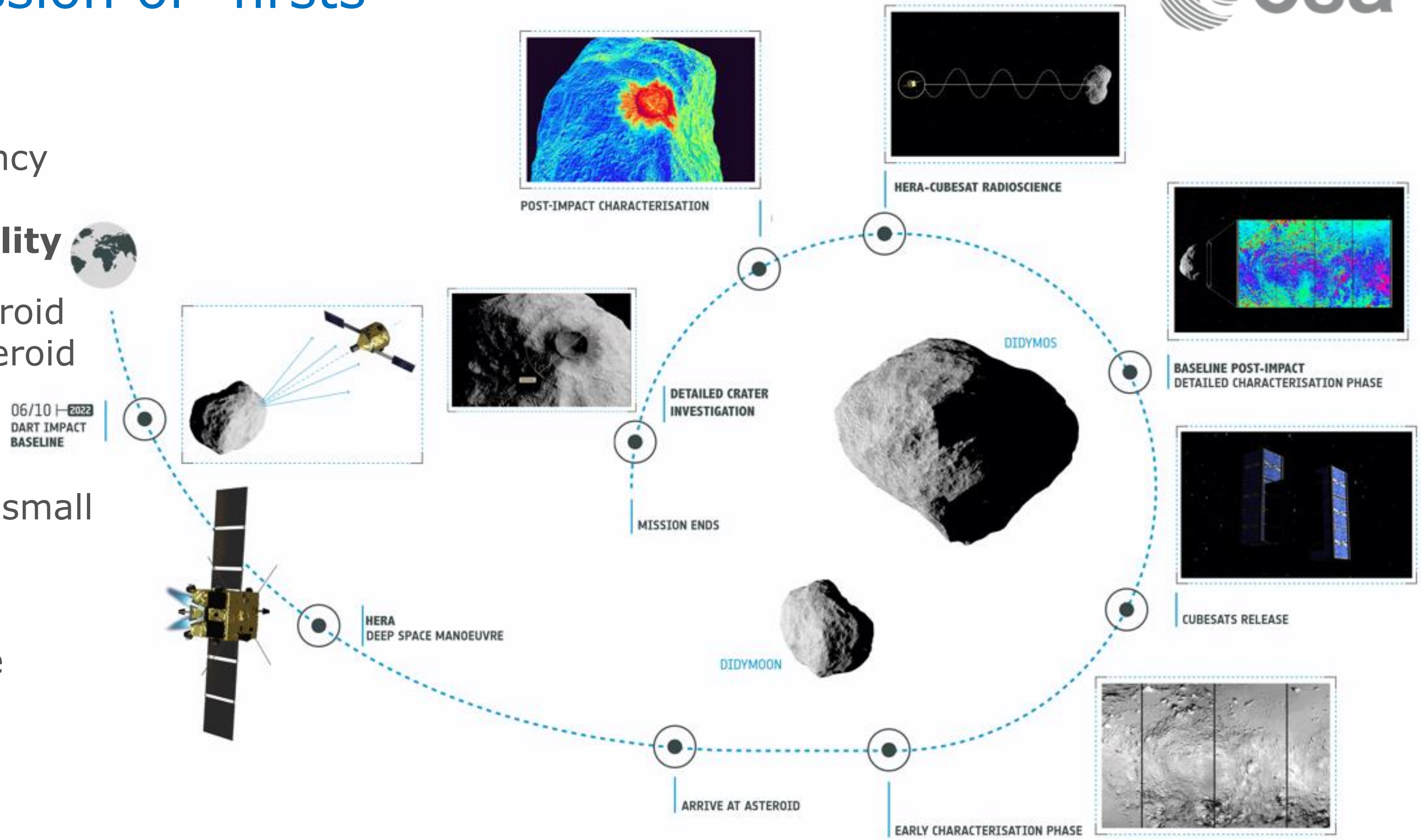
Hera is required to:

- 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



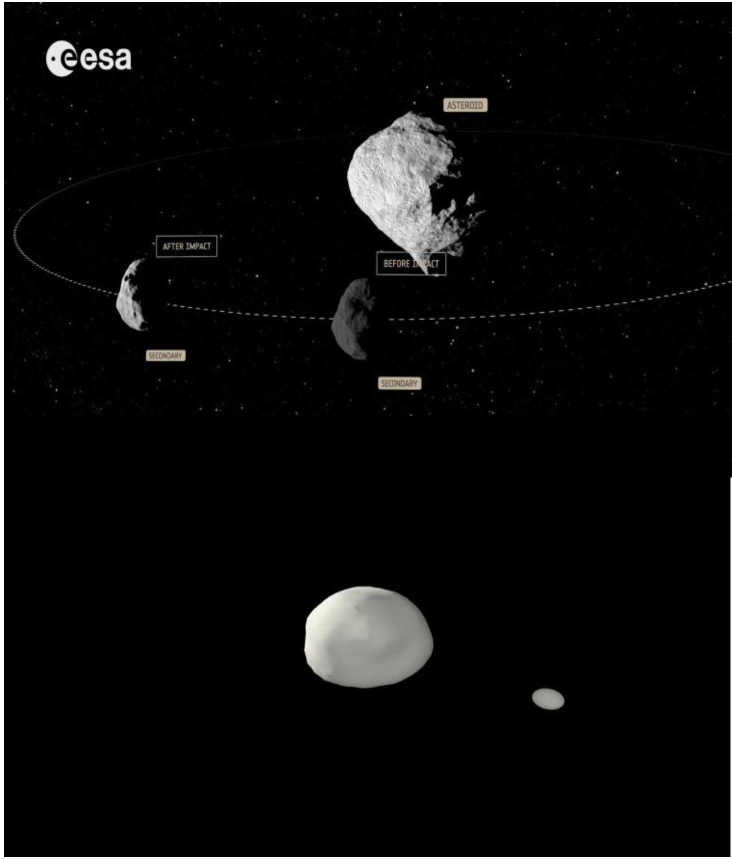
What will DART provide?

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)

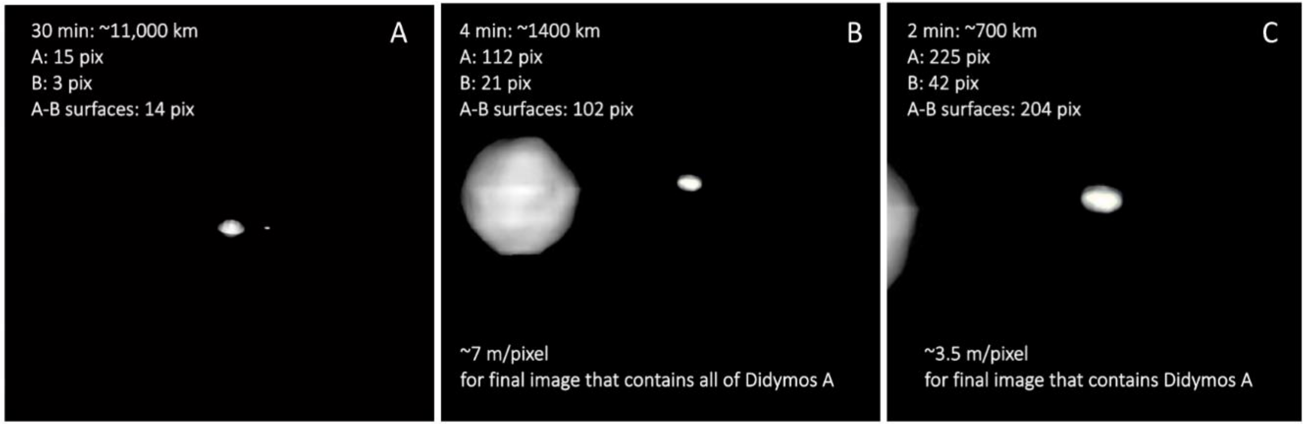
3. Measure deflection: Didymoon’s **orbital period change** (ground observations)

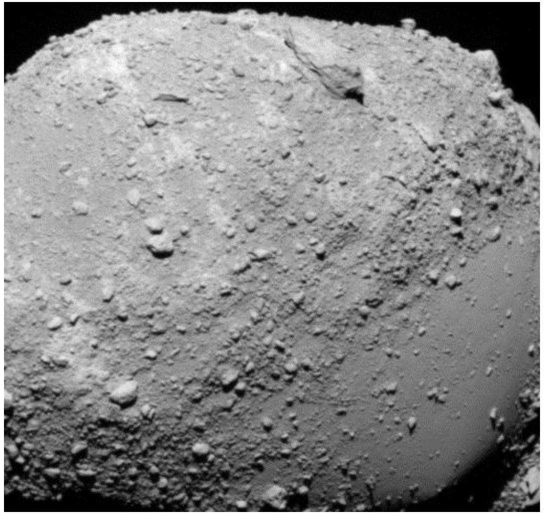


What will DART provide?

DART imaging (GNC plus science)

Far range → sizes, global shape, Didymoon volume (~30%)



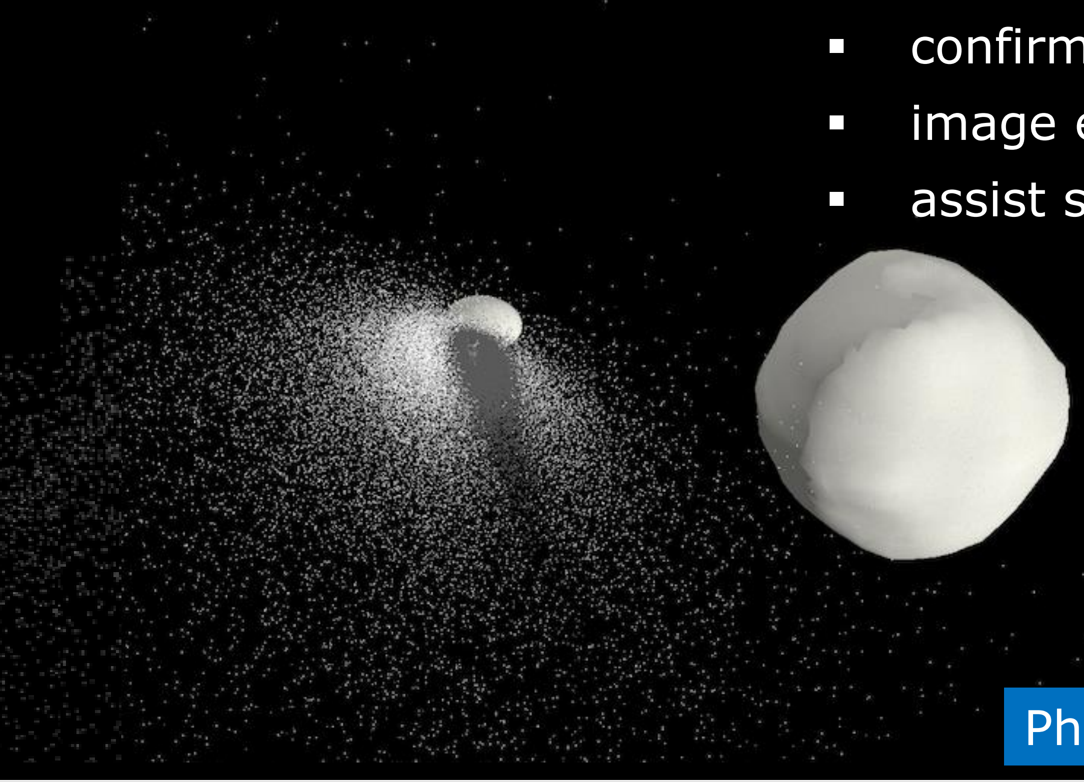


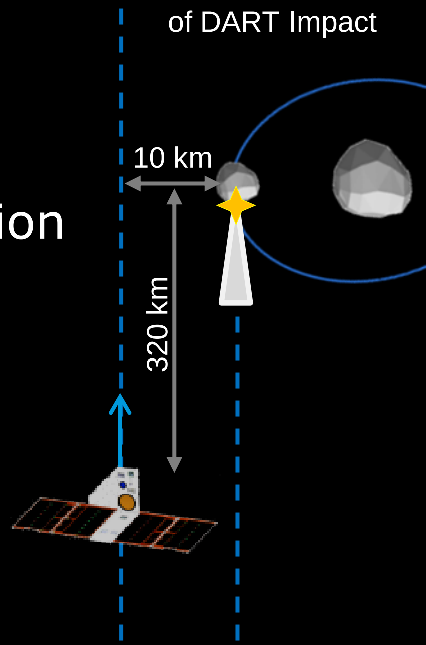
Close range → impact site location on Didymoon,
local slope (+/-10deg) surface geomorphology (~50cm)

What will DART provide?

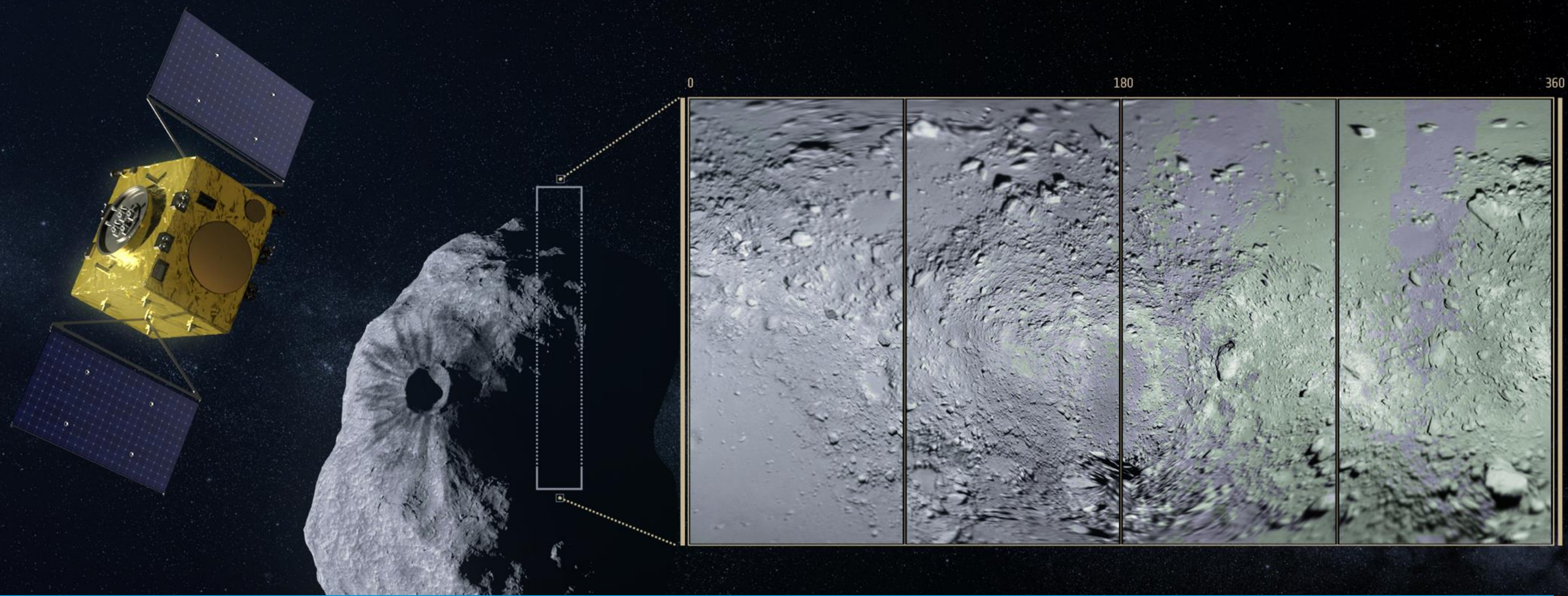
SelfieSat to perform ~5-6 min Didymoon fly-by

- confirm impact
- image ejecta plume
- assist shape determination





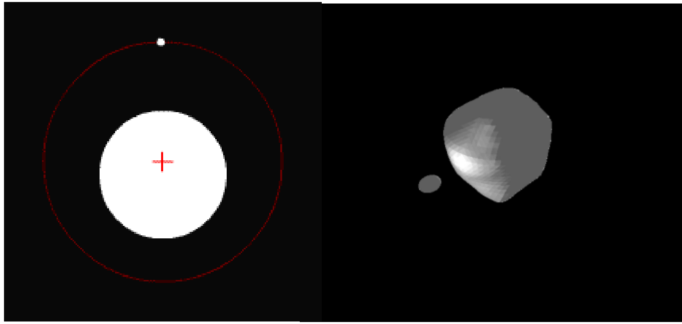
Phase-C kicked-off on 15 May 2018



What is missing? Hera’s measurements!

What is missing (momentum transfer)

Momentum transfer factor, $\boldsymbol{\beta}$:



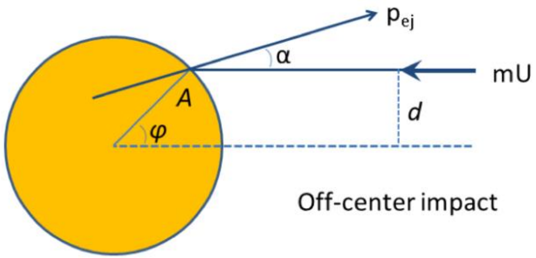
→ Need to know target's **mass** (<10% accuracy)

Hera

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

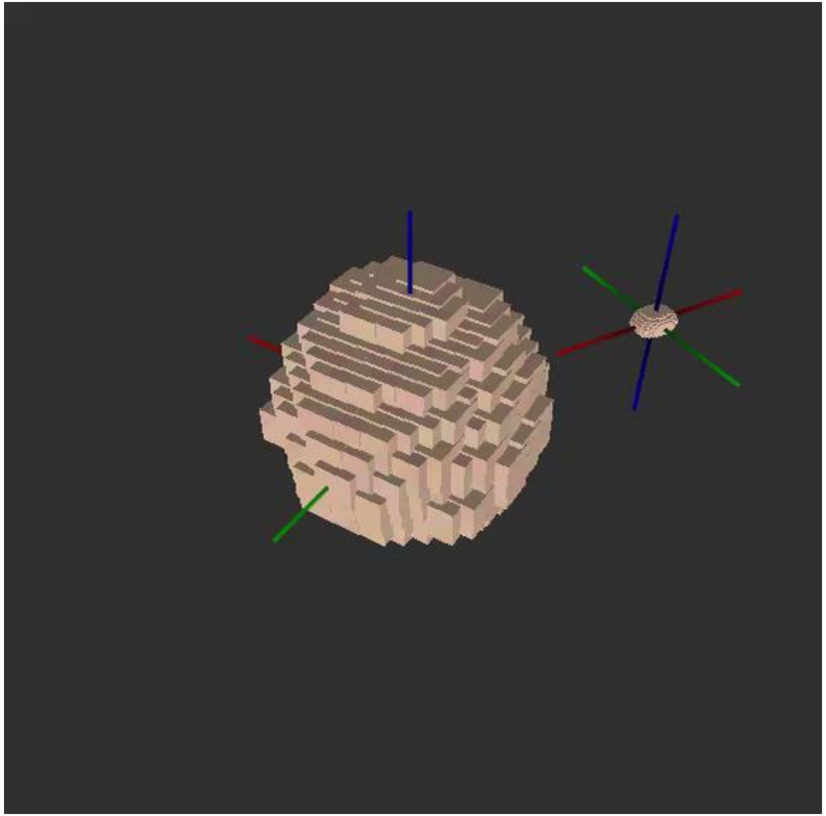
Hera

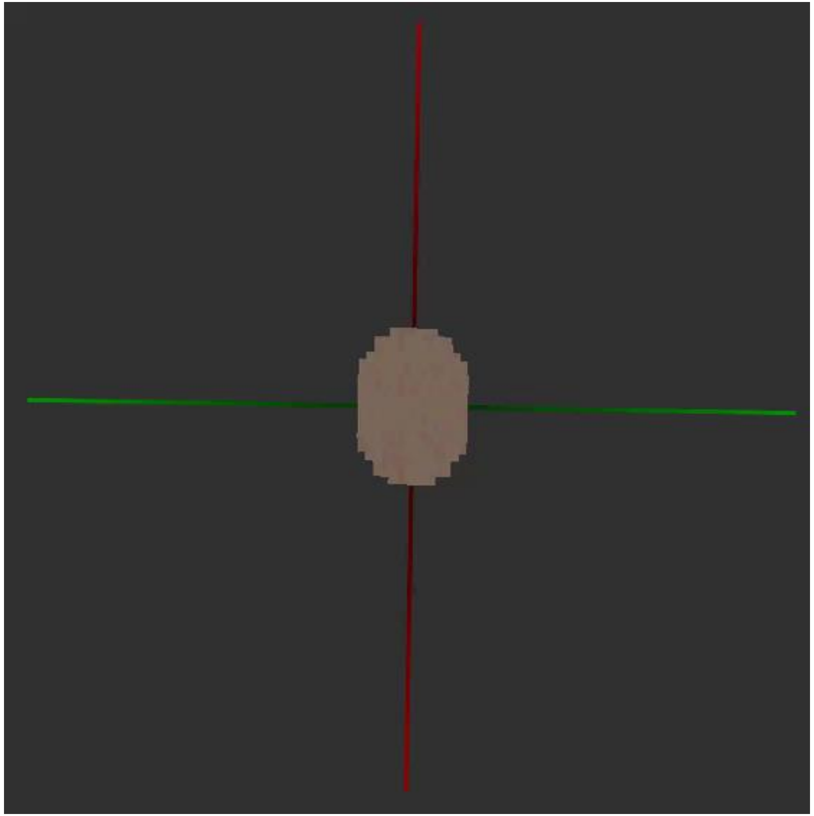
orbital parameters (→ total mass <10%), shape, volume (densities <20%), spin/orbit pole (1-5%), libration



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

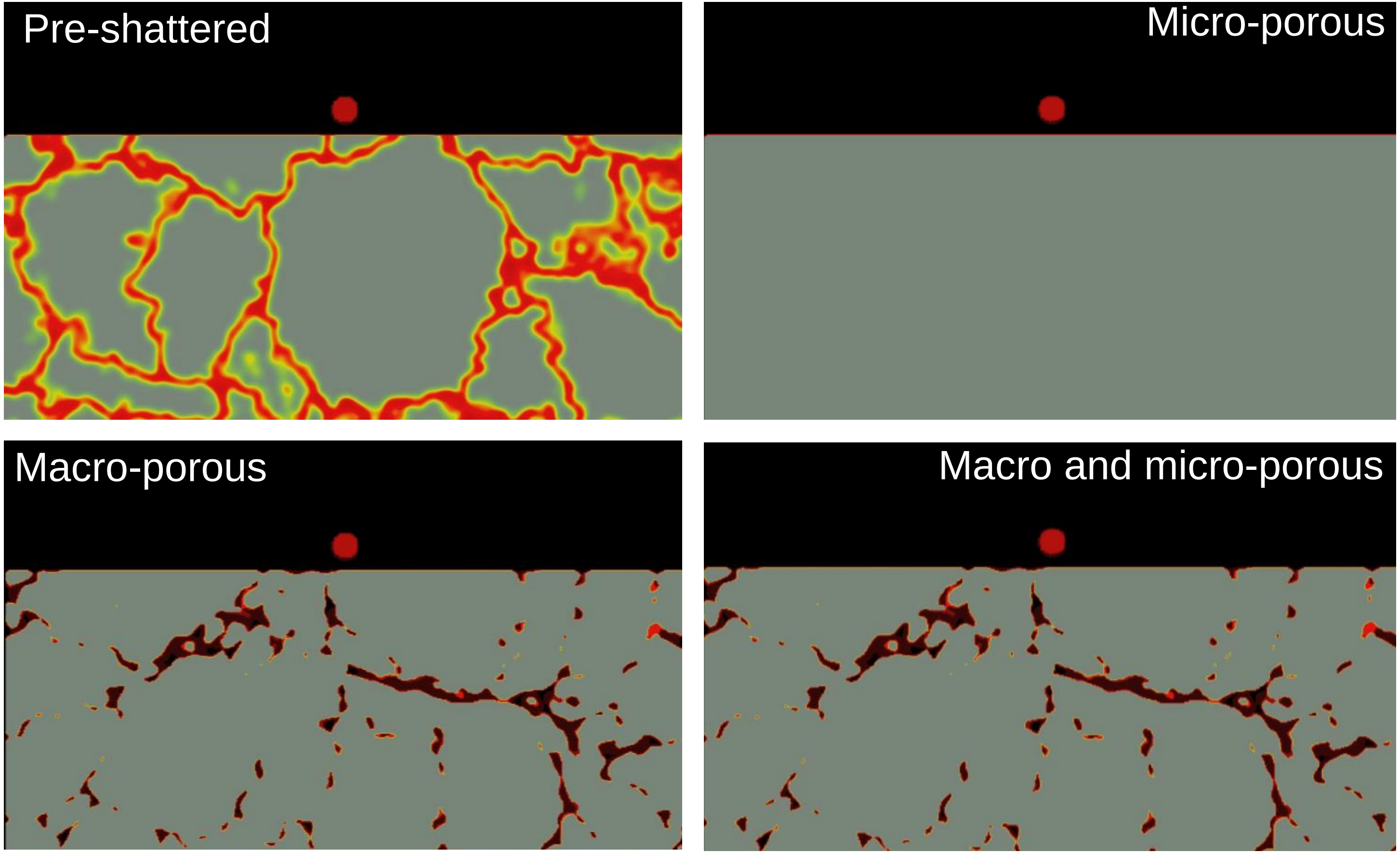
Hera

β

Critical parameter to
- evaluate outcome of DART
- validate models
- make accurate predictions

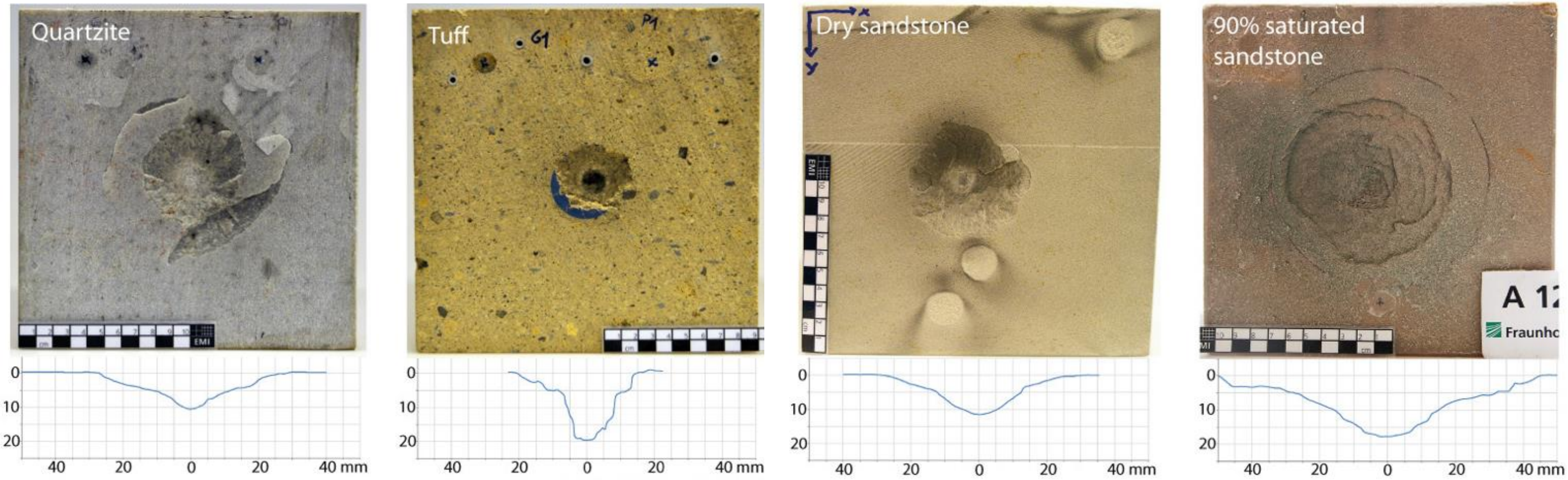
Understand how to do it if needed and… even for larger asteroids

Different types of porosity affect cratering



Validation possible only at lab scale

Effect of target properties on crater size → β

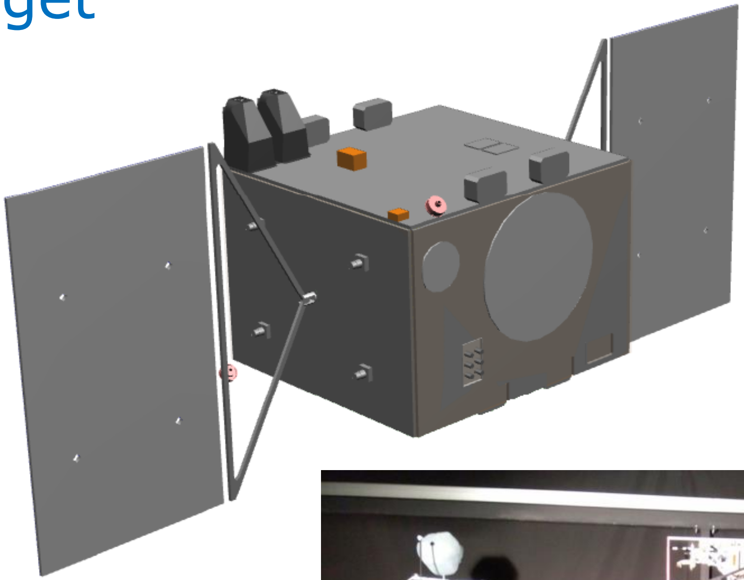


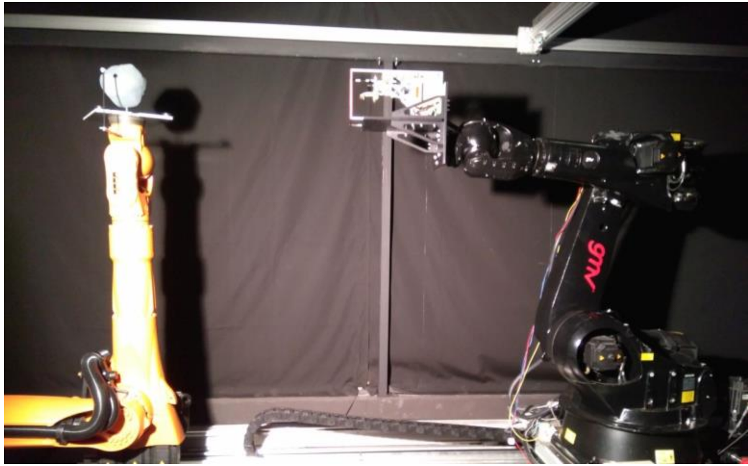
Poelchau et al. 2014

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

AIM$_{D^2}$ spacecraft mass budget

Subsystem	Nominal [kg]	Margin [%]	Total [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**



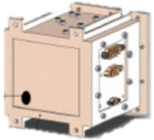


Hera baseline payload

11.6 kg
17-34 W

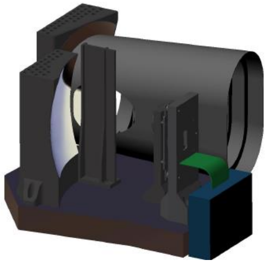
NAVCAM
(In storage)

1.4 kg
9 W



μLidar

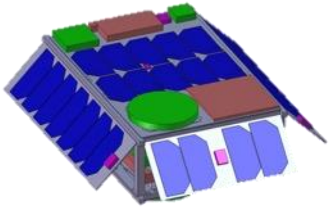
475nm- 900nm



CHIEM

RADIOSCIENCE

14.9 kg (6U)



2 x 1U payloads among:

- Hyperspectral imaging
- Volatiles
- Relative Radioscience
- Seismometry
- Minearology
- Dust environment
- Gravimetry

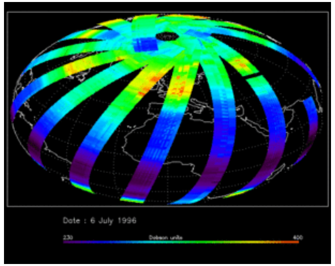
Additional payload mass available, to be finalized during phase B1

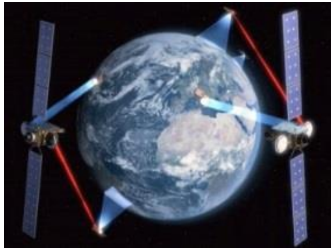
Additional interests expressed to ESA (to be discussed bilaterally for consolidation, rejection or further assessment):

Gravimetre		Monostatic radar	Multispectral camera
μlander	Cameras	Thermal imager	Bifocal metrology

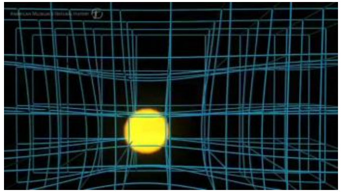
Main Programmatic Categories for CM19

Applications



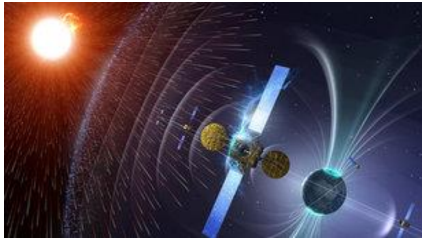


Science and Exploration



Enabling and Support (transp., tech, & ops)

Safety and Security



Safety and Security

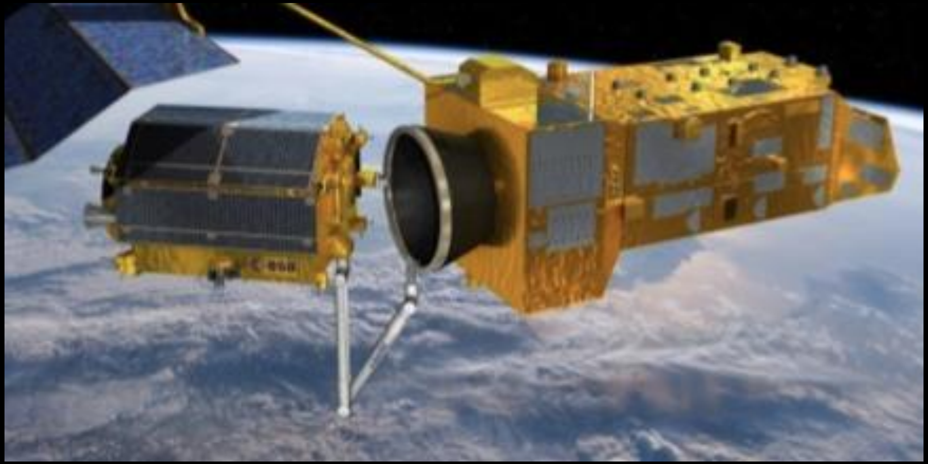
in Space

Space Safety

from Space

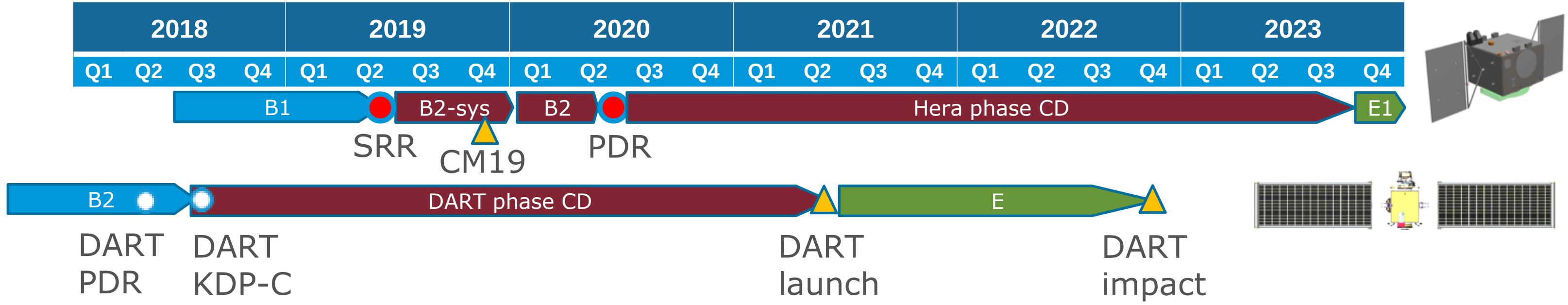
Safety and Security Applications

Cornerstones of Space Safety



Cornerstone Missions

Hera phase B1

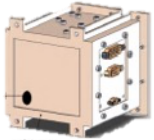


- **ITT released** (DE, BE, RO, LU, SE, PT, ES, CZ, AU, FI, PL, CH) including breadboarding activities:
  - Onboard computer E(Q)M
  - GNC and FDIR software validation with hardware in the loop in robotic lab
  - Onboard Software prototype implementation and validation for autonomy

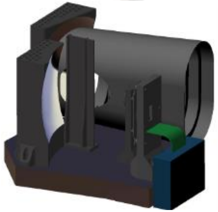
- 4 thematic **workshops** with industrial team + ESA teams:
  - T_0+2 “Cubesat”, T_0+3 “TEC”, T_0+3.5 “OPS”, T_0+4 “GNC”… T_0+11.5 “SRR”

Payload and technology activities

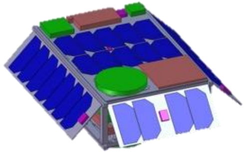
AFC (Asteroid Framing Camera) QM will be provided to contractor in phase B1 for GNC testing (2 flight models in storage)



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 Spetember (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

ESA project scientist:
Michael Küppers

PI: Patrick Michel

Impacts simulation

Chairs: Kai Wunnemann
Martin Jutzi

Close-proximity operations

Chairs: Ozgur Karatekin
Naomi Murdoch
Jens Biele

Data Analysis Exploitation Interpretation

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

Dynamics

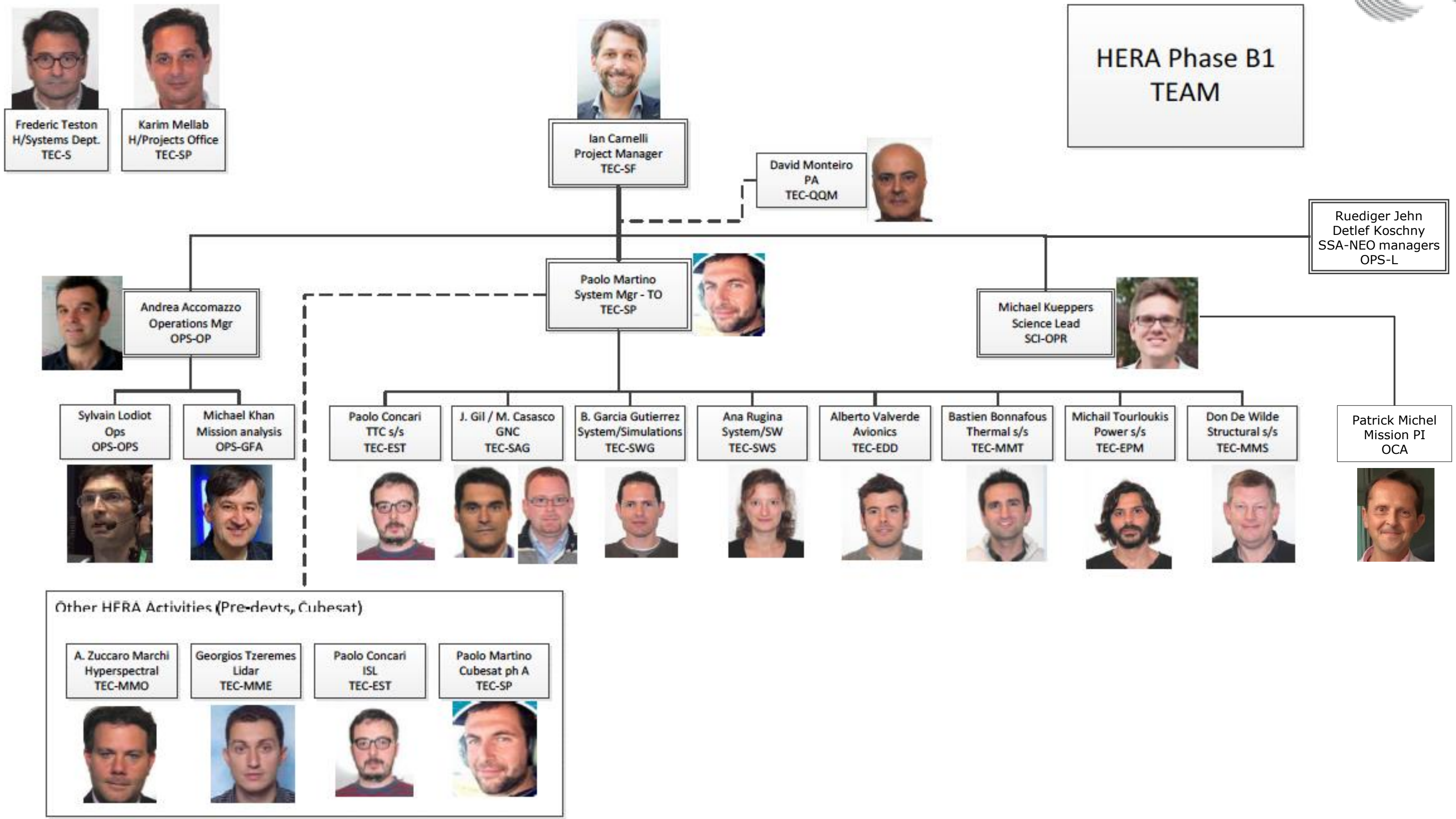
Chairs: Menios Tsiganis
Adriano Campo Bagatin
Sébastien Charnoz

Ground-based observations

Chairs: Petr Pravec
Julia de Leon
Benoît Carry
Alan Fitzsimmons

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

Hera team at ESA



Mission measurements

Parameter	Required accuracy	Associated payload
Size, mass, shape, density	▪ Mass: 10% ▪ Density: 20% ▪ Shape accuracy of 6% or few meters	Mass from binary orbit, spacecraft tracking (camera, cubesat, radioscience) Shape model (camera), Lidar
Dynamical state (period, orbital pole, spin rate, spin axis)	▪ 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	▪ Global surface resolution: 1m ▪ Local surface resolution (10% of the surface): 10cm	Camera (surface features) Cubesat (sub-meter resolution)
Chemical and mineral composition of Didymoon and Didymos	Spectral resolution: 45nm or better	Camera, cubesat
Impact ejecta	No accuracy required	Camera, cubesat