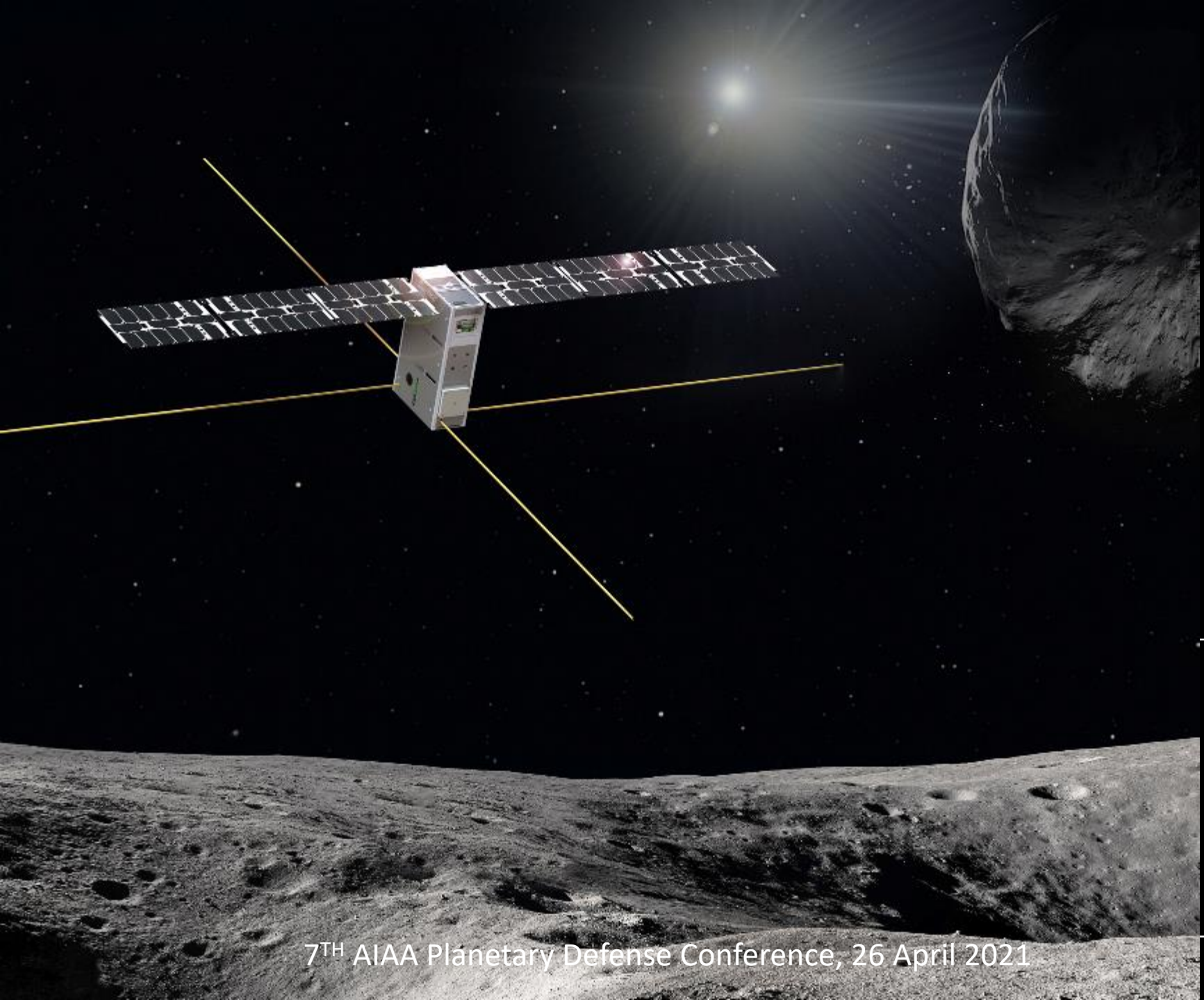


JUVENTAS CUBESAT

Ozgur Karatekin[1]

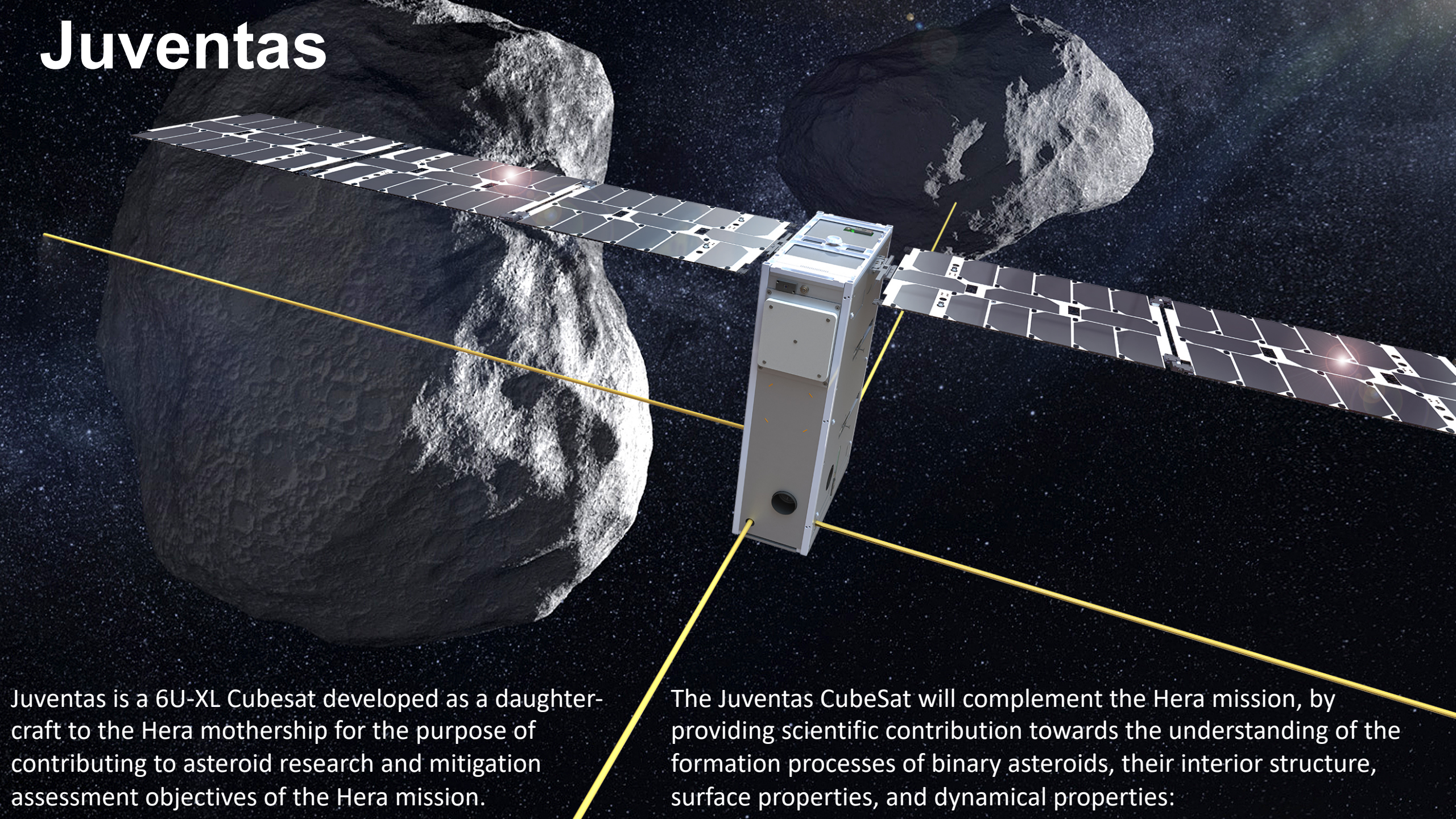
& Juventas team

Stefaan Van wal[(2)], Mehdi Scoubeau[(2)], Etienne le Bras[(2)], Victor Manuel Moreno[(3)], Alain Herique[(4)], Paolo Tortora [(5)], Birgit Ritter[(1)],, Michael Kueppers[(6)], Patrick Michel[(7)], Ian Carnelli[(6)], and Juventas team.

[(1)] *Royal Observatory of Belgium,* [(2)]*GomSpace,* [(3)]GMV [(4)]*IPAG,* [(5)]*Università Di Bologna*, [(6)]ESA, [(7)]Observatoire de la Côte d'Azur

7TH AIAA Planetary Defense Conference, 26 April 2021

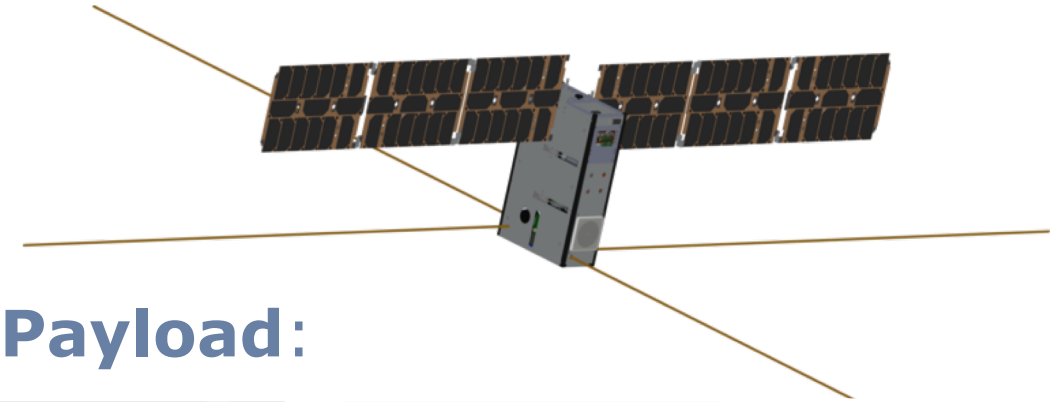
Juventas



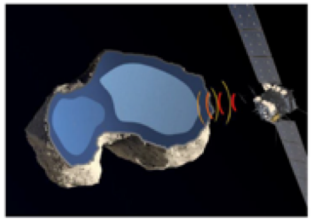
Juventas is a 6U-XL Cubesat developed as a daughter-craft to the Hera mothership for the purpose of contributing to asteroid research and mitigation assessment objectives of the Hera mission.

The Juventas CubeSat will complement the Hera mission, by providing scientific contribution towards the understanding of the formation processes of binary asteroids, their interior structure, surface properties, and dynamical properties:

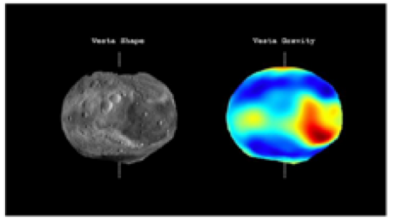
Juventas



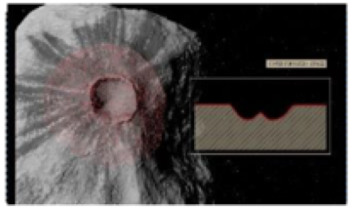
Payload:



Interior Structure

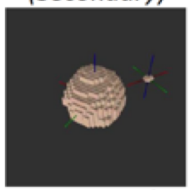


Gravity Field

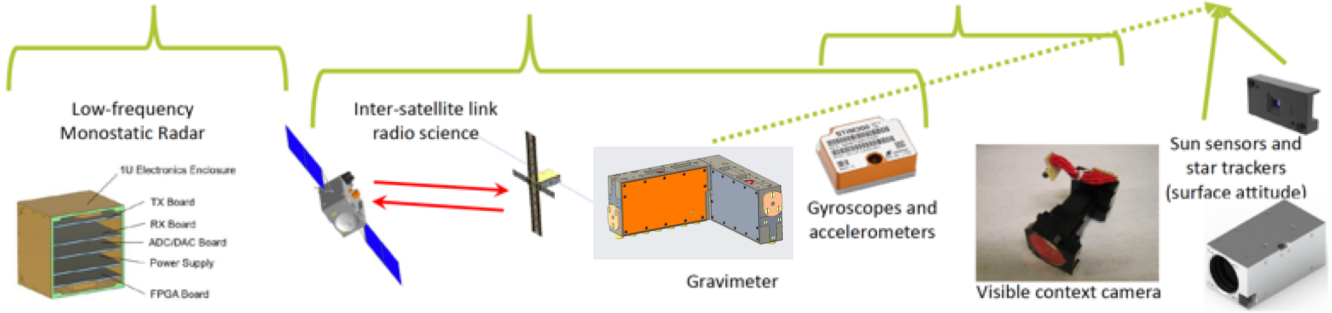


Surface Properties

(Secondary)



Dynamical Properties



Country	Company	Role
BE	Royal Observatory of Belgium	PI, landing science / gravimeter
BE	Spacebel	Operations partner (TBD)
CZ	Filip Zaplata	LFR digital
DK	GomSpace	Spacecraft platform subsystems
FR	Univ. Grenoble / IPAG	LFR design lead (Co-I), Rx chain
FR	CNES	Operations partner
DE	TU-Dresden	LFR Tx chain and antenna simulation
IT	U. Bologna	Radio Science (Co-I)
LU	GomSpace Luxembourg	Mission and system lead, ISL lead to OHB
LU	EmTroniX	LFR electronics
NL	ISIS	Deployer interface (procurement)
PL	Astronika	LFR antenna
RO	gmv	GNC subsystem
ES	Emxys	Gravimeter payload

See PDC presentations:

Alain Herique JuRa: the Juventas Radar on Hera to fathom Didymoon. *Wednesday, 1:15 pm*

Paolo Tortora Hera Radio Science Experiments through Ground-Based and Satellite-to-Satellite Doppler Tracking. *Wednesday, 1:15 pm.*

Birgit Ritter Surface Gravimetry on Dimorphos with GRASS on Juventas. *Friday, 7:30 pm.*

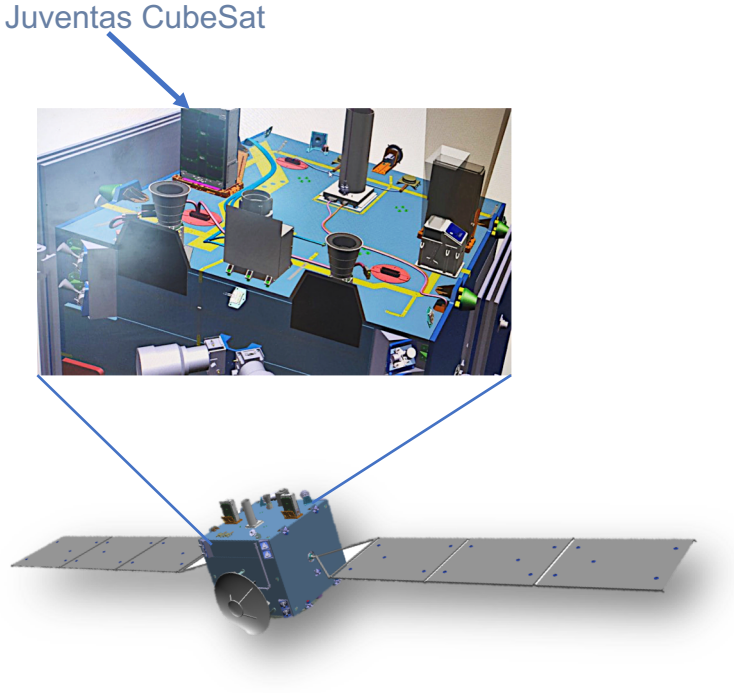
Juventas Science Matrix

Science Objective	Investigation	Measurements	Instruments	Mission Phase
SO#1: Gravity field of Dimorphos	Gravity field characterisation outside Brillouin sphere at least up to degree & order 2	Deflection during orbit measured with ranging, LoS to HERA (second CubeSat)	ISL radio link	Proximity operations
	Surface gravity	Surface acceleration	Gravimeter	Surface operations
	CubeSat descent / touchdown/bouncing	Dynamic recording of each event	GNC	Landing / Bouncing
SO#2: Internal structure of Dimorphos	Reconstruction of material density & largest monolithic object	Properties of (back-)reflection of transmitted signal	Low frequency radar	Proximity operations
SO#3: Surface properties of Dimorphos	Visible imaging	Inspection of Didymoon surface features and impact crater	Visible camera	Proximity operations, Surface operations
	Surface strength measurement	Rebounds from the surface	IMU	Landing / Bouncing
SO#4 (secondary) Dynamical properties of Dimorphos	Orbital analysis	Orbital analysis by ranging LoS to HERA (second CubeSat)	ISL radio link	Proximity operations
	Variable surface acceleration	Surface acceleration measurements over >1 orbit	Gravimeter	Surface operations
	Attitude and Time dependent surface illumination	Attitude and time dependent surface illumination	Star tracker, sun sensors	Surface operations
SO#5 (secondary) Surface/sub-Surface properties of Didymos	Reconstruction of material density & largest monolithic object	Properties of (back-)reflection of transmitted signal	Low frequency radar	Proximity operations

Juventas Mission Profile

Launch and Cruise

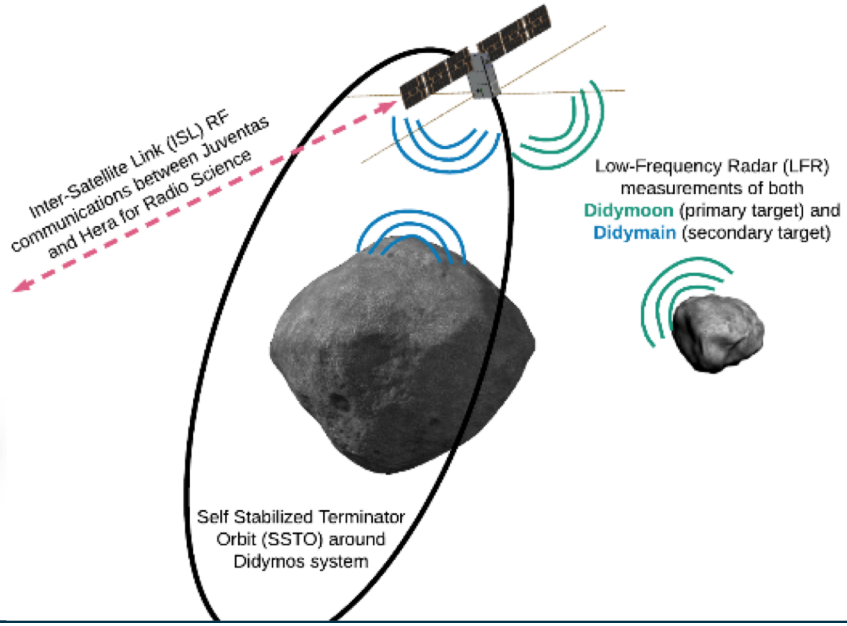
Juventas is transported to Didymos by Hera, stowed within a deployment canister. It is released at Didymos and undergoes a short commissioning period



Proximity Operations

Radar & Radio Science Observations

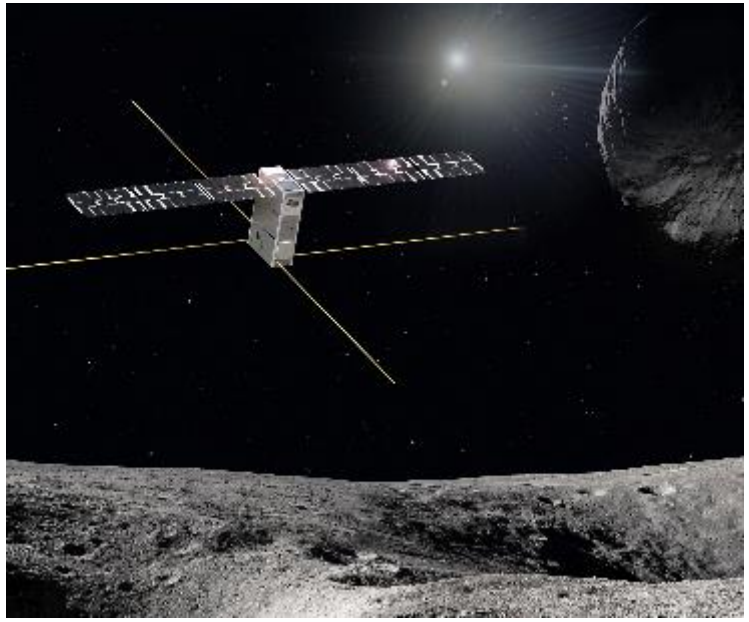
Juventas performs the main scientific observations with its low frequency radar payload to look inside the asteroid interior, and operate radio science experiments through the ISL link



Surface Operations

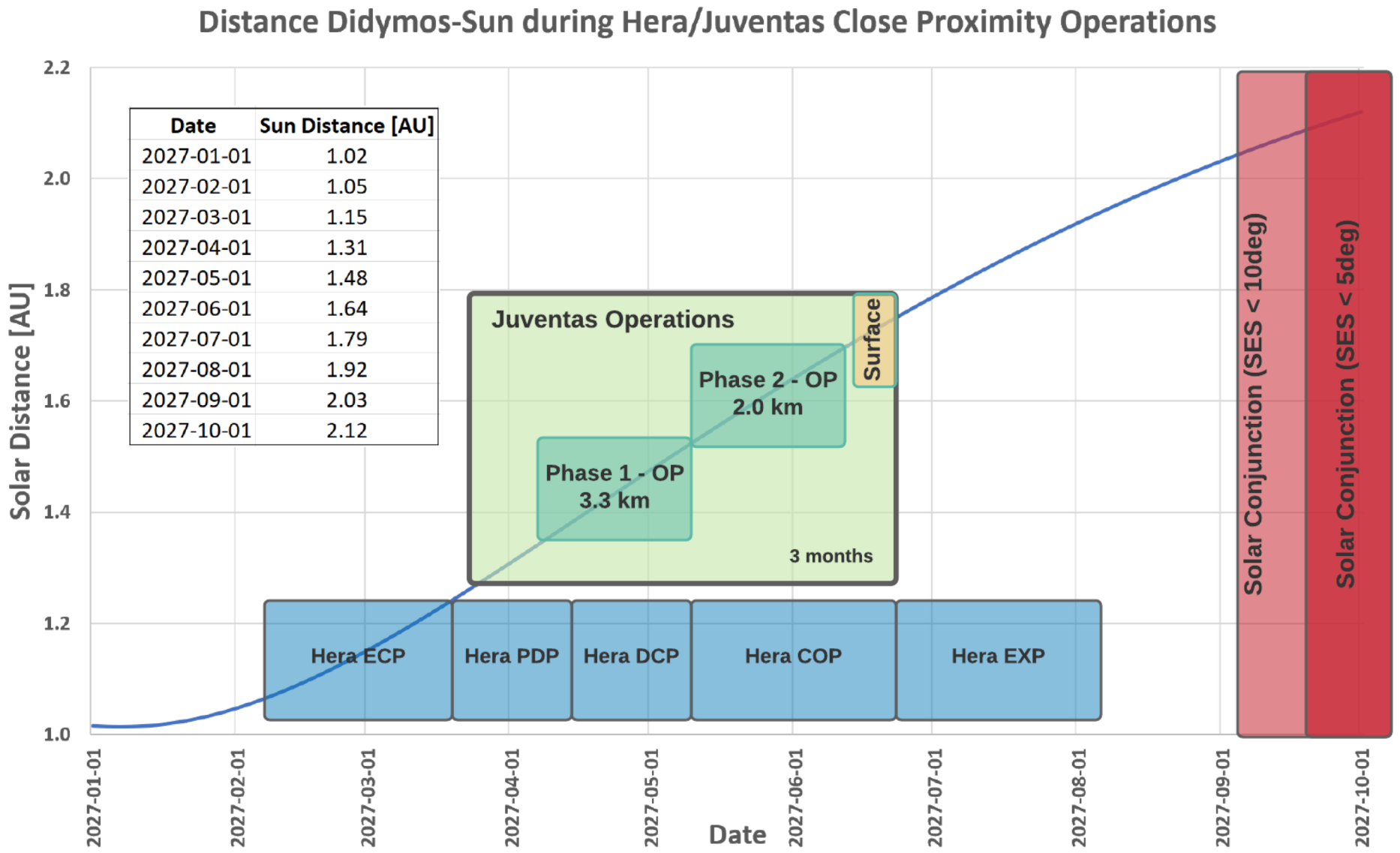
Surface Mechanical Properties & Gravity

Juventas attempts to land on the surface of Didymoon, making measurements of the impact and bouncing events and then operating its gravimeter payload from the surface to understand dynamical properties of the asteroid system



Mission Timeline

Scenario	LPO	LPC	Arrival	Cruise Duration
Baseline 2024	Oct 8, 2024	Oct 25, 2024	Dec 28, 2026	2.17 – 2.22 years



Date	Sun Distance [AU]
2027-01-01	1.02
2027-02-01	1.05
2027-03-01	1.15
2027-04-01	1.31
2027-05-01	1.48
2027-06-01	1.64
2027-07-01	1.79
2027-08-01	1.92
2027-09-01	2.03
2027-10-01	2.12

Proximity Operations

Self Stabilized Terminator Orbits

- Equilibrium elliptical orbits perpendicular to sun direction due to high SRP perturbation

Two phases:

- SSTO at 3.3 km
- SSTO at 2.0 km

Attitude strategy:

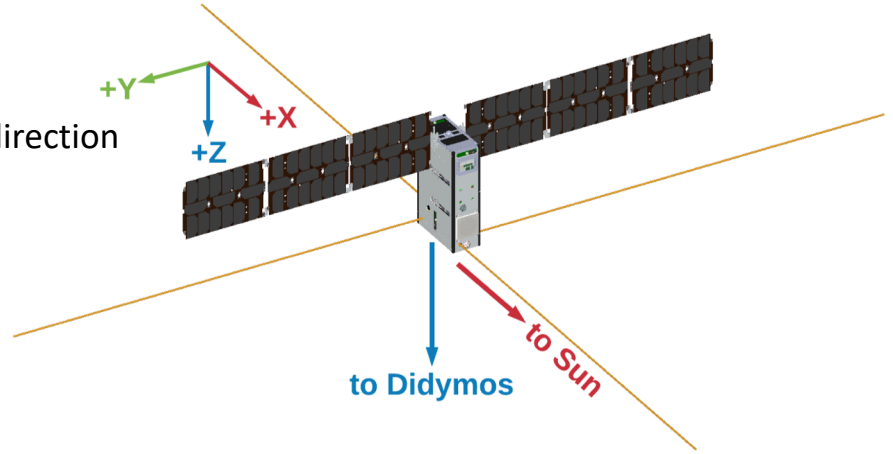
- Camera + Altimeter pointing to Didymos
- Solar panels rotated to maximize solar exposure 90º
- ISL -X mainly facing HERA

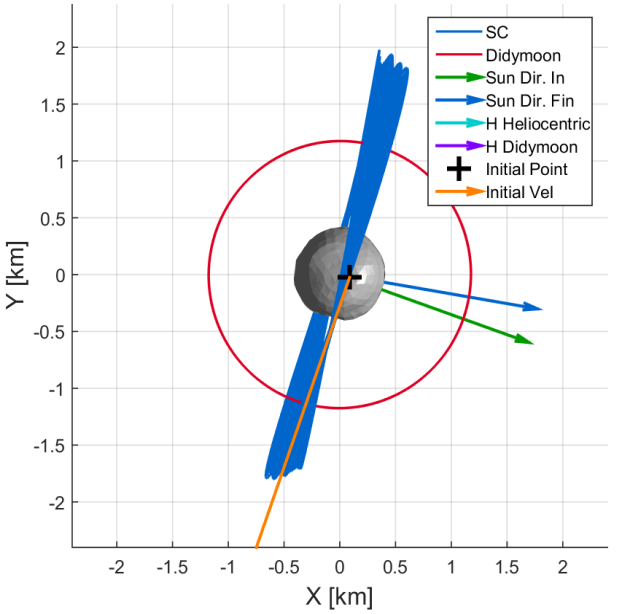
Science Observations

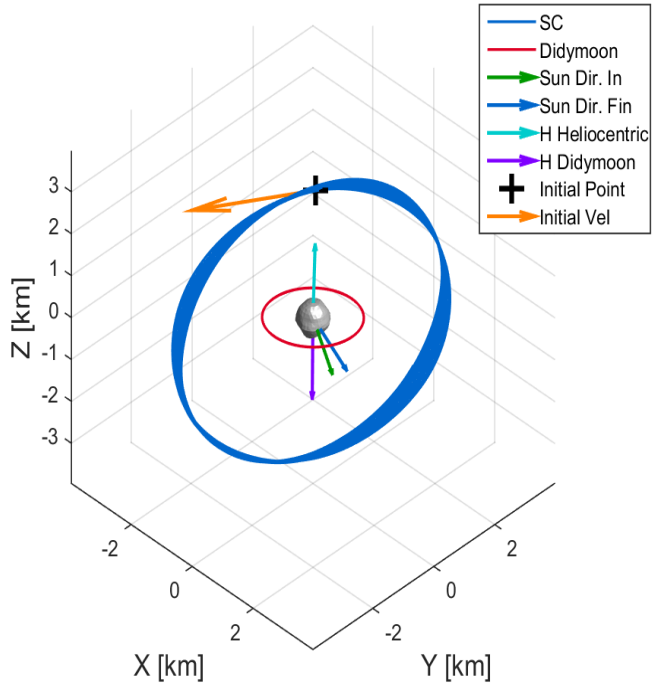
- Radar observations
- Radio science

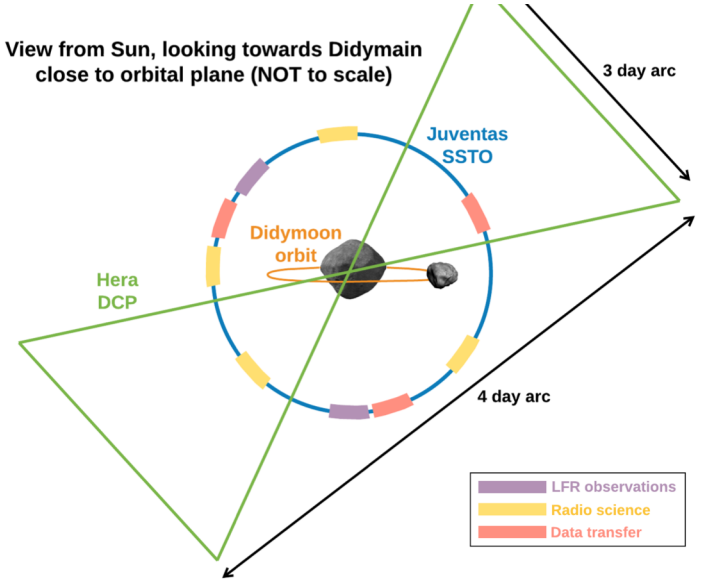
ISL communications

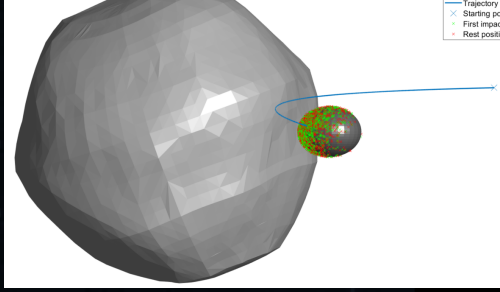
- Near-continuous link
- Scheduled data transfer with higher bit rate when favorable geometry

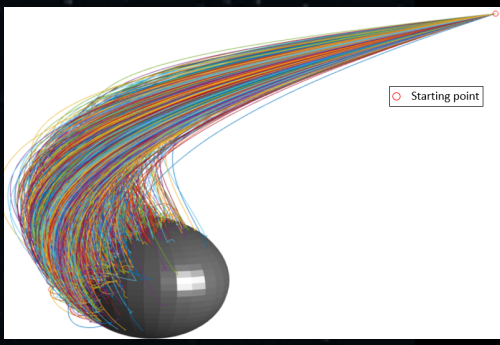


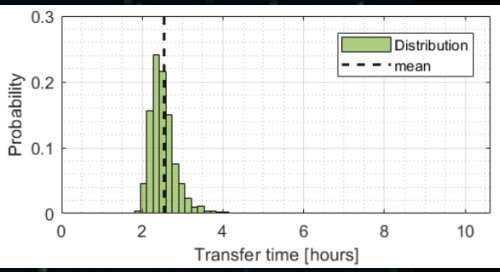




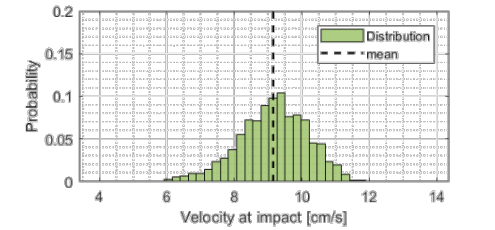




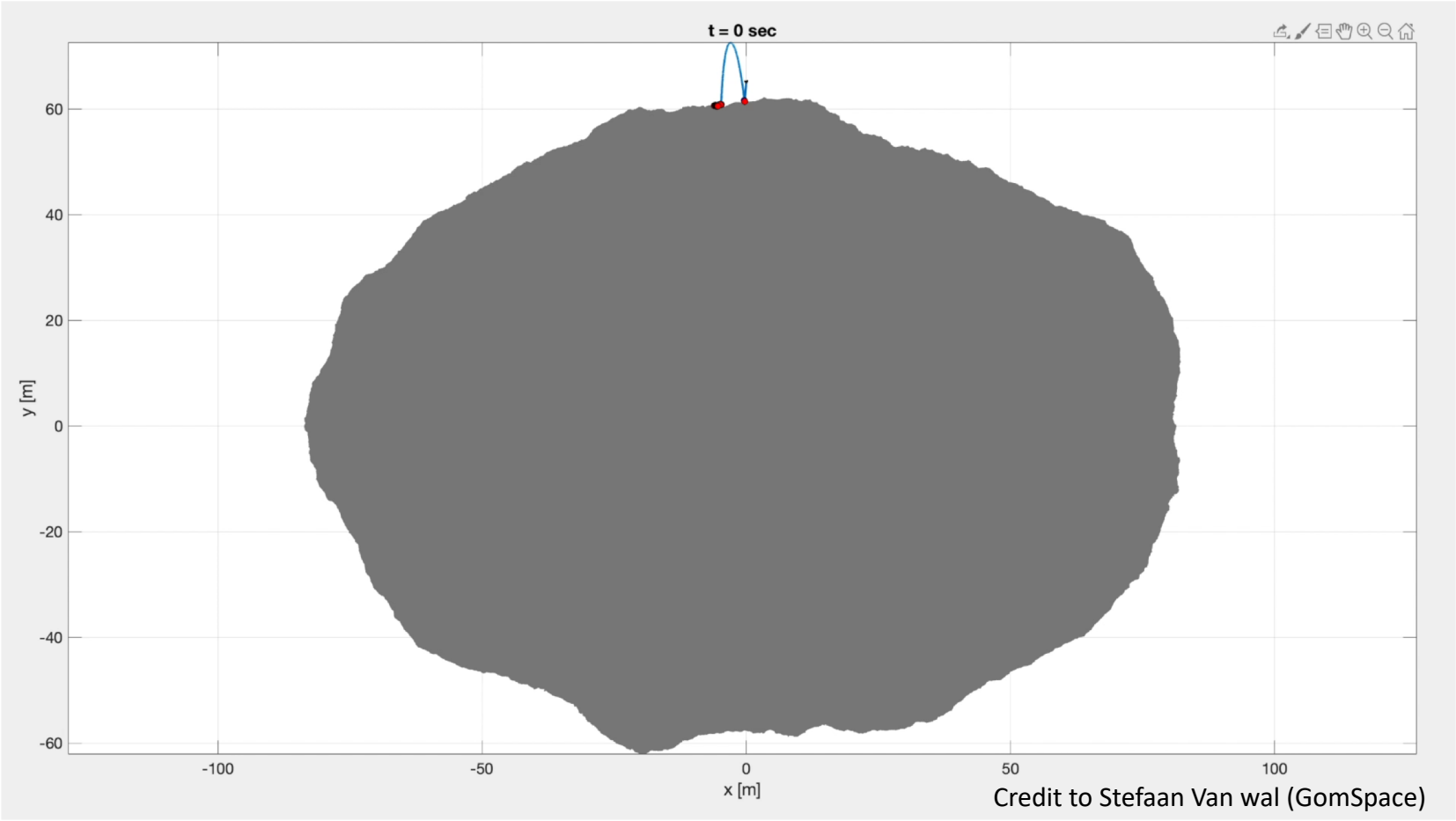




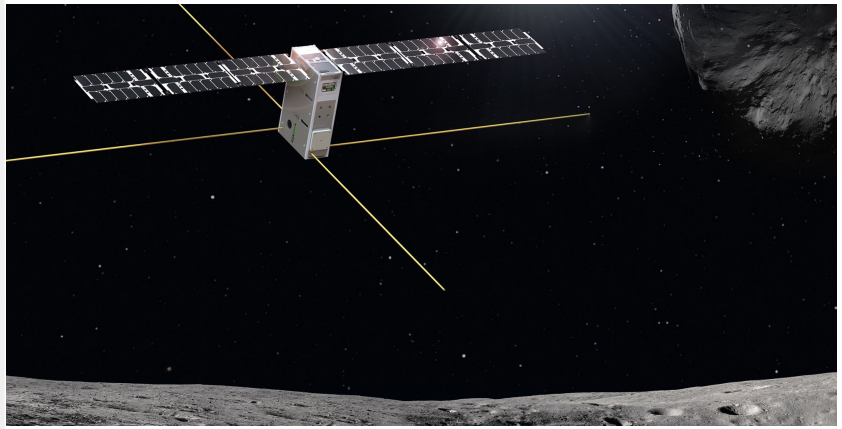
VELOCITY AT IMPACT

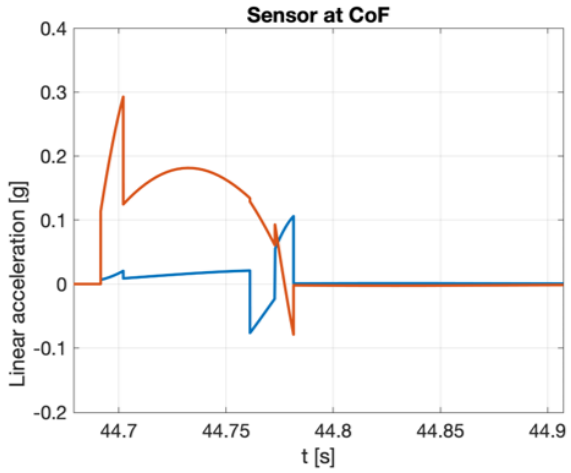


Surface touchdown & bounces



Credit to Stefaan Van wal (GomSpace)

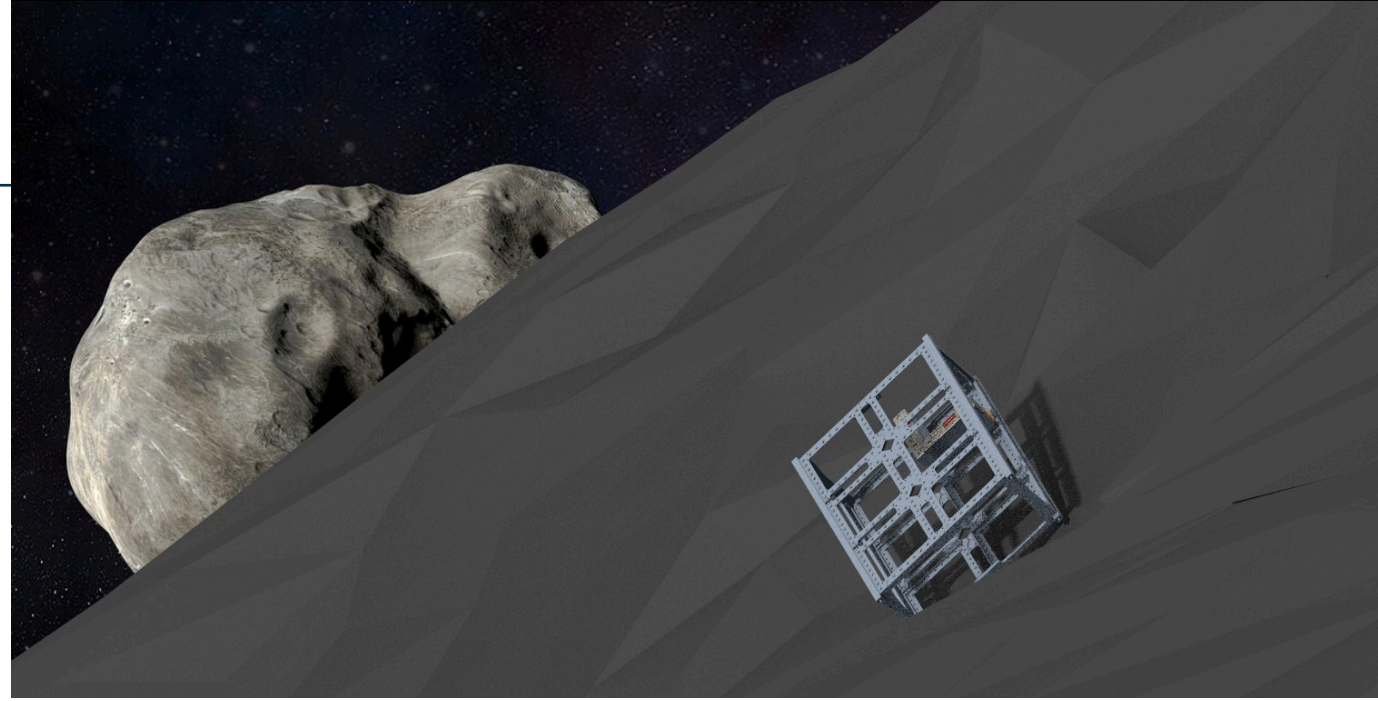


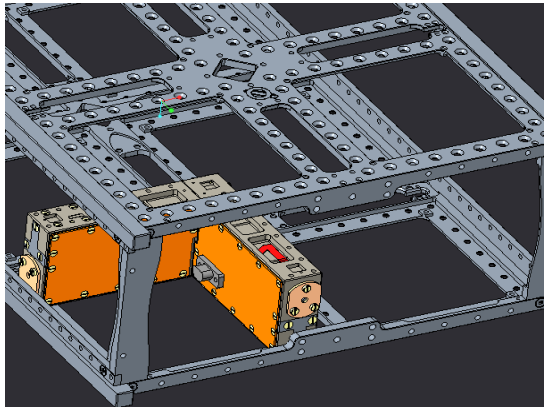


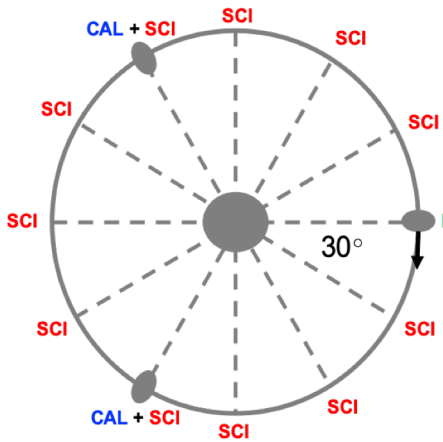
Science Objective	Investigation	Measurements	Instruments	Mission Phase
Surface Mechanical Properties	Surface strength measurement	Rebounds from the surface	IMU, ISL	Bouncing
Local (High degree) Gravity	CubeSat descent / touchdown/bouncing	Trajectory (Radio tracking, LR), dynamic recording of events	GNC, ISL	Descent / Bouncing

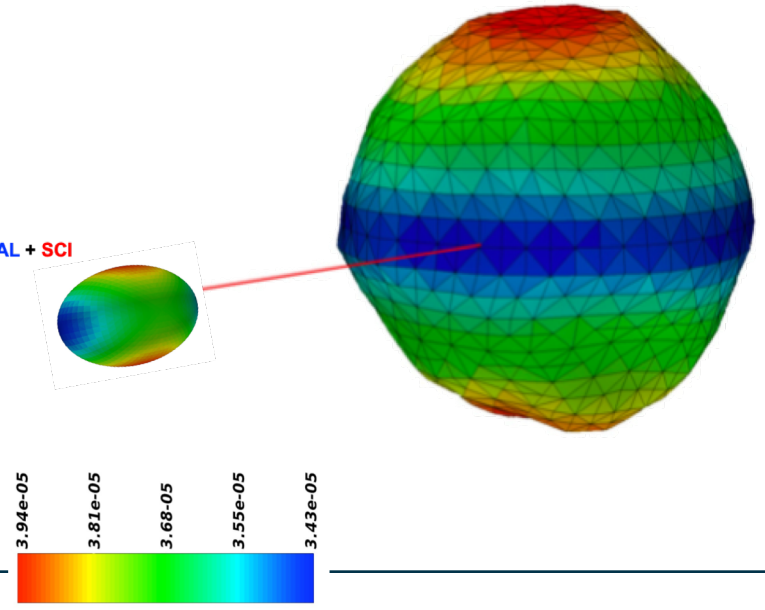
Surface Operations

- Gravimeter starts to operate after soft-landing of Juventas on the surface
- Gravimeter measurements at equally spaced measurements over a Didymoon orbit (every 30 degrees) to get dynamic variations
- Goal: survivability of 1 day = approx. 2 Didymoon orbits
- ISL link
- Surface attitude sensors
  - Star trackers, sun sensors
  - Navigation and context camera images from surface (TBC)



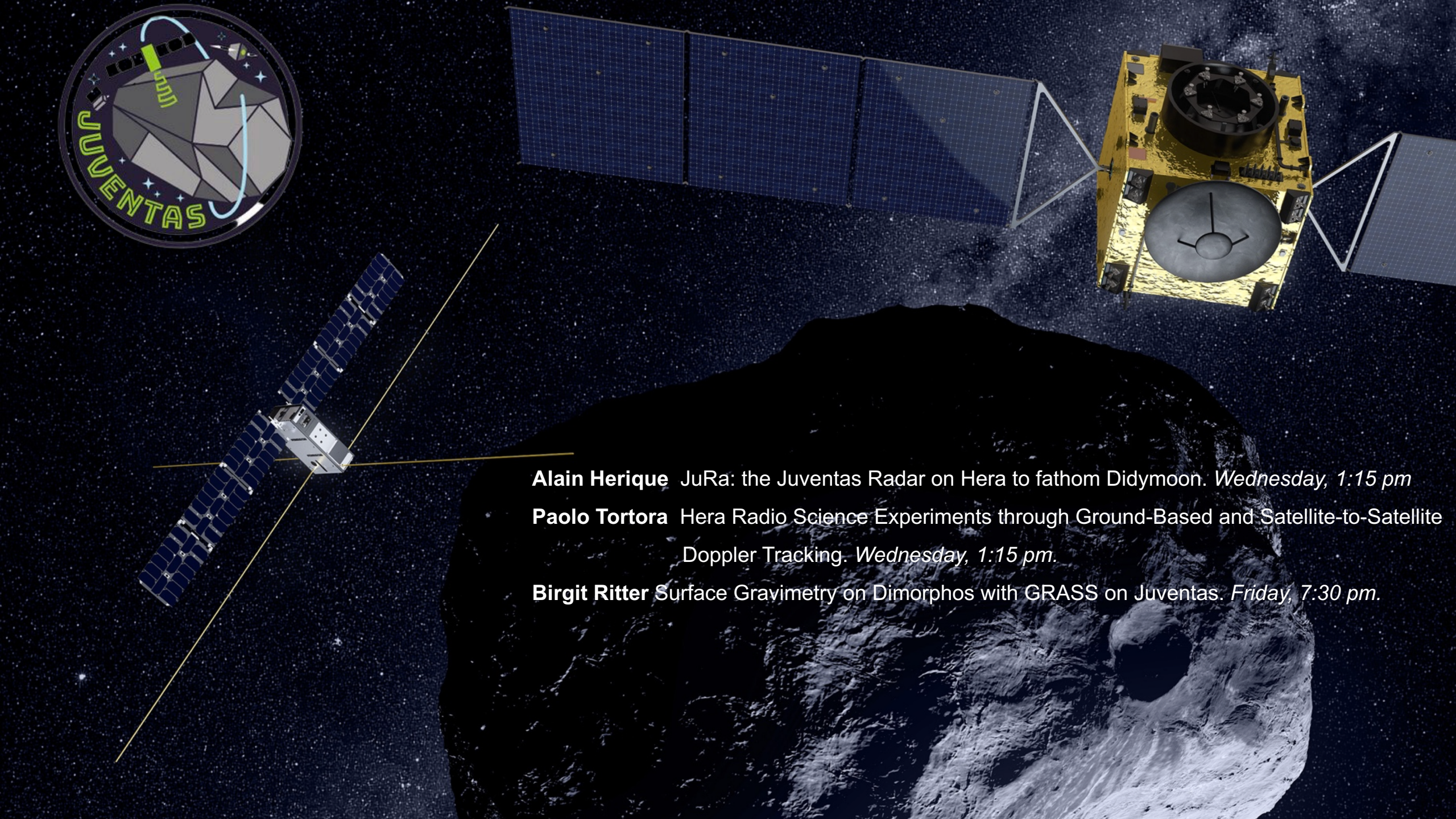






OBJECTIVES MAPPED TO HERA REQUIREMENTS

Hera ID	Hera Mission Requirement Description	Juventas Objective	Juventas Instrument/Measurement
Core Requirements for Planetary Deflection			
D1	Determine the mass of Dimorphos	SO1	ISL radio science Gravimeter
D2	Global properties of Dimorphos (size, global shape, volume, density, porosity)	SO1, SO2	LFR radar: density/porosity Accelerometers: porosity Gravimeter: surface gravity/density ISL radio science: gravity
D3	Size distribution of surface material	SO3	LFR radar Visible imaging (with navcam)
D4	Dynamical properties of the Didymos system	SO4	Gravimeter: Surface accelerations over a Didymoon orbit Attitude: landed attitude over Didymoon orbit using star trackers or sun sensors ISL radio science (via orbital analysis, TBC)
If DART is successful:			
D5	Shape and volume of the DART impact crater	SO3	Visible imaging (with navcam)
D6	Size distribution of excavated material	N/A	LFR radar (TBC)
Opportunity for Planetary Defence			
D7	Surface strength	SO3	Accelerometers: Surface strength from impact
D8	Interior structure of Dimorphos	SO2	LFR radar
D9	Composition of Dimorphos	SO3	LFR radar Accelerometers: Surface strength from impact
If DART is successful:			
D10	Transport of impact ejecta from Dimorphos to Didymos	N/A	



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