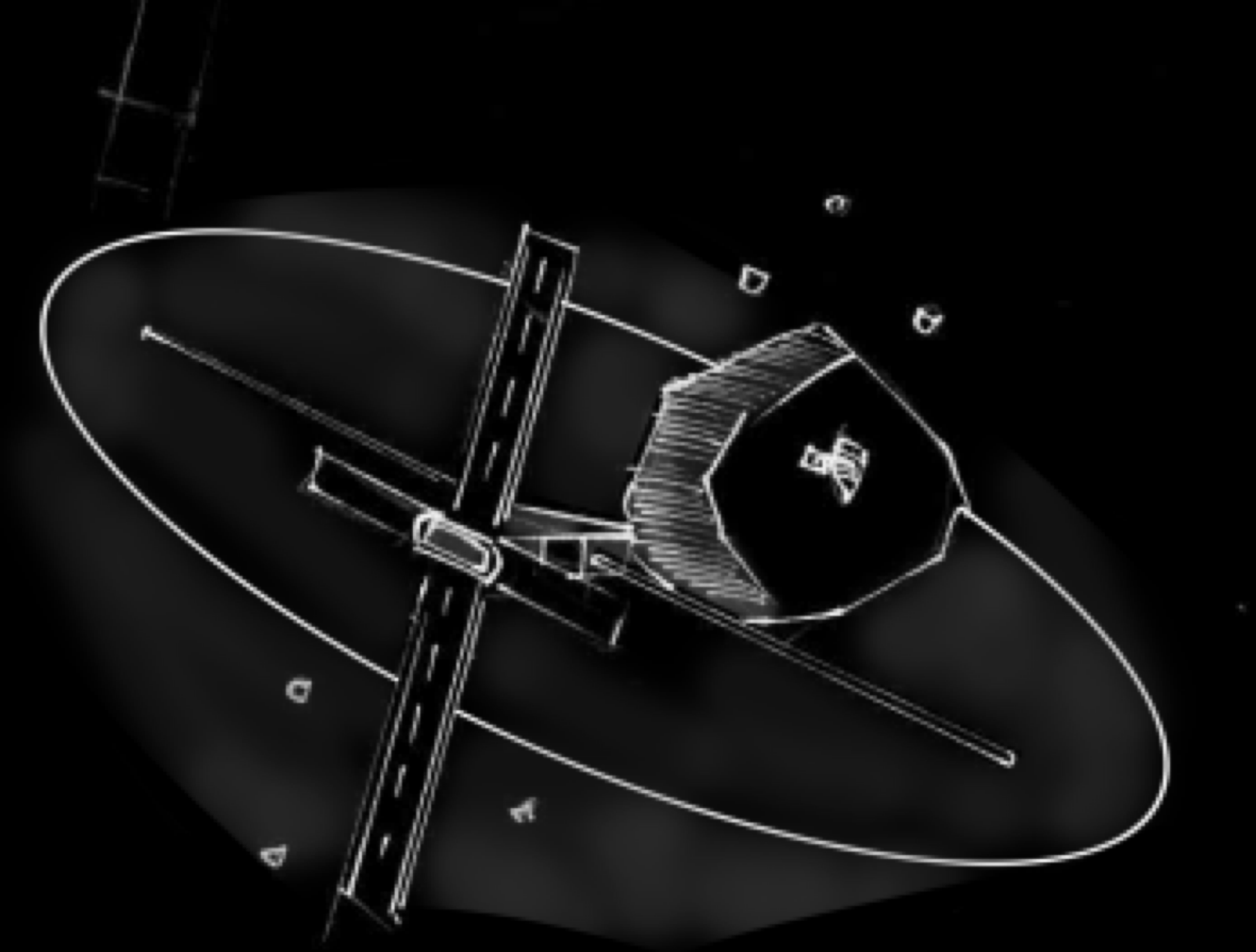


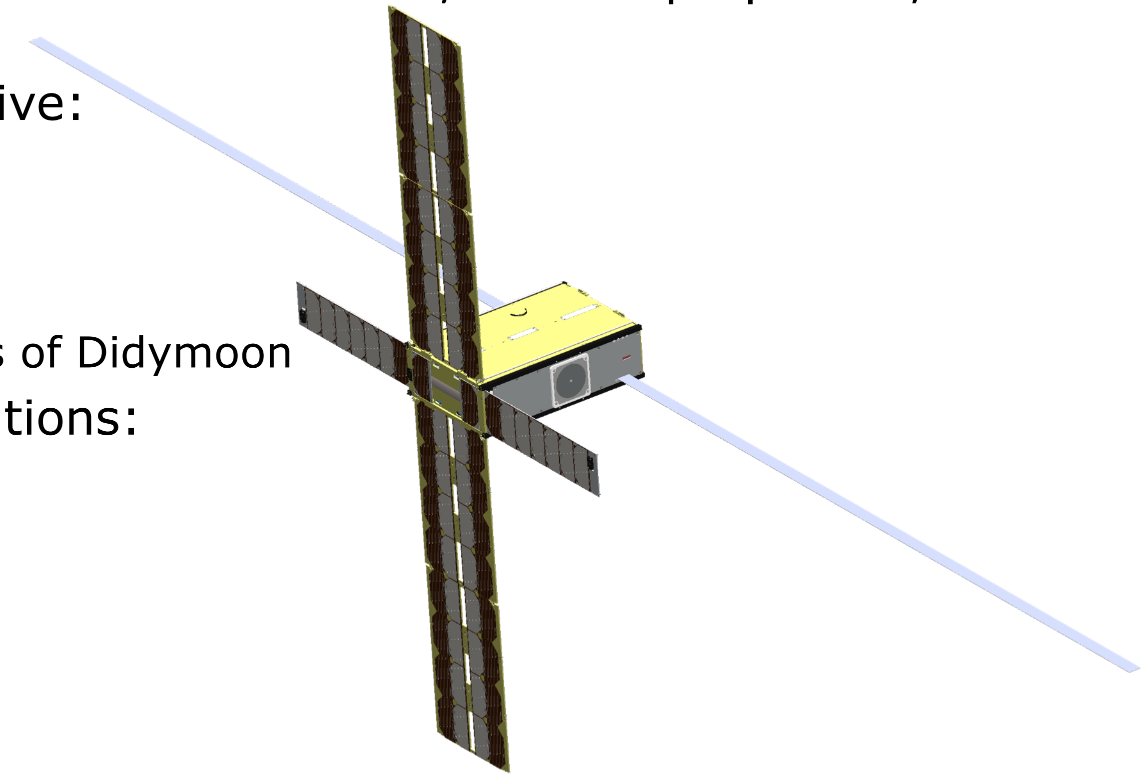
JUVENTAS CUBESAT

HERA WORKSHOP NOV. 15, 2018

Ö. KARATEKIN, H. GOLDBERG

JUVENTAS 6U CUBESAT FOR THE HERA MISSION

- Juventas is a 6U Cubesat developed as a daughtercraft to the Hera mothership for the purpose of contributing to asteroid research and mitigation assessment objectives of the Hera mission. The Juventas Cubesat will provide scientific contribution towards the understanding of the formation processes of binary asteroids, their interior structure, surface properties, and dynamical properties
- Three primary objectives and one secondary objective:
  - SO#1: Characterise the gravity field of Didymoon
  - SO#2: Characterise the internal structure of Didymoon
  - SO#3: Determine the surface properties of Didymoon
  - (Secondary) SO#4: Determine the dynamical properties of Didymoon
- Payloads are centered around geophysical investigations:
  - Low frequency Radar (SO#2)
  - 3-axis Gravimeter (SO#1,4)
  - ISL radio link (SO#1,4)
  - Visible camera for context (SO#3)
  - Accelerometers and gyros (SO#1,3,4)



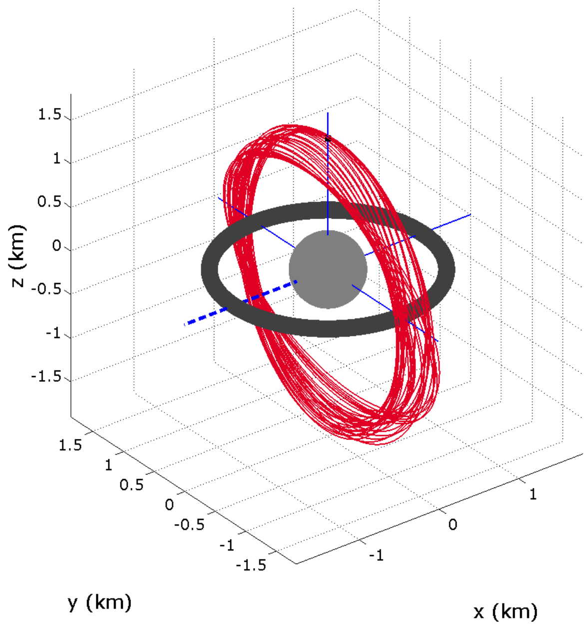
JUVENTAS CONOPS

1. Pre-release checkout, <1 day
2. Release, detumbling, and commissioning, 4 days
3. Global observations, 10 days

   Self-Stabilizing Terminator Orbits (SSTO), shown at right with perturbations
4. Proximity operations, 10 days
5. Descent and Didymoon landing attempt, 1 day
6. Didymoon surface operations, 4 days

Ref. NASA, NEAR artists concept

Evolution of the SC in 28 days in the Synodic Ref. Frame



RADAR SCIENCE (SO#2)

- Spaced coverage measurements to determine internal structure – heterogeneity from submetric to global scale
- Reconstruction of material density and largest monolithic object

Radar:

- Monostatic low frequency radar for ground penetrating measurements
- Measurement of (back)reflection of transmitted signal (propagation delay, received power, spatial variation)

RADIO SCIENCE (SO#1,SO#4)

- Use of line-of-sight ISL radio link between Hera mothercraft and Juventas Cubesat for radio science

- Mission design of flyby trajectories assist in determination of shape and gravity field for higher degree and order harmonics, allow for identification of density anomalies
  - Degree 2 gravity field can be retrieved with uncertainty <15%

- Measurement derived from phase-coherent Doppler shift due to relative line-of-slight velocity differences between Hera and Juventas Cubesat
  - Cubesat-to-Cubesat link may also be utilized if desired

- Dynamical properties of Didymoon can be determined from landing position through orbital analysis augmented with attitude and illumincatino information from sun sensors and star trackers

ACCELEROMETER SCIENCE (SO#1,SO#3)

- Mechanical surface properties (porosity and grain properties) give insight into asteroid evolution
- Dynamic recording of landing our bouncing impact events at high sample rates
- Accelerometer measures ratio of incoming to outgoing velocity during landing or bouncing events to determine energetic Coefficient of Restitution (CoR), as done by Philae on 67P/Churyumov-Gerasimenko
  - Gyros also used for rotational dynamics from landing or bouncing events

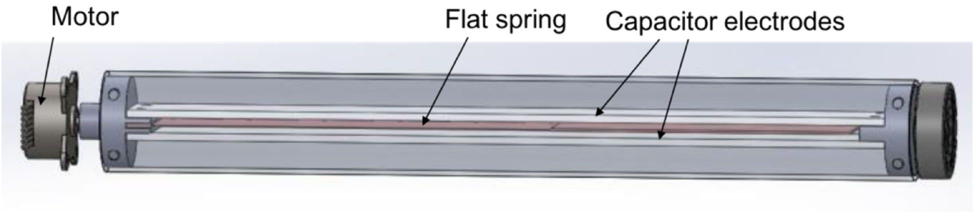
- Accelerometer details:
  - Measurement Range: ±10g
  - Resolution: 1.9 µg
  - Sampling rate: up to 2kS/s
  - Mass: 55 g
  - Power: up to 1.5 W

GRAVIMETER SCIENCE (SO#1,SO#4)

- Local measurement of surface accelerations at Didymoon landing location
  - Measurements over >1 orbit, evenly spaced temporally for tide measurements
- Determine surface geopotential, contributes to the understanding of subsurface structure & heterogeneity

- Electrostatic measurement from deflection of flat spring by gravity

- Gravimeter details:
  - Measurement range: 1000mGal
  - Sensitivity: 0.001 mGal
  - Mass: 300 g
  - Power: 0.3 W



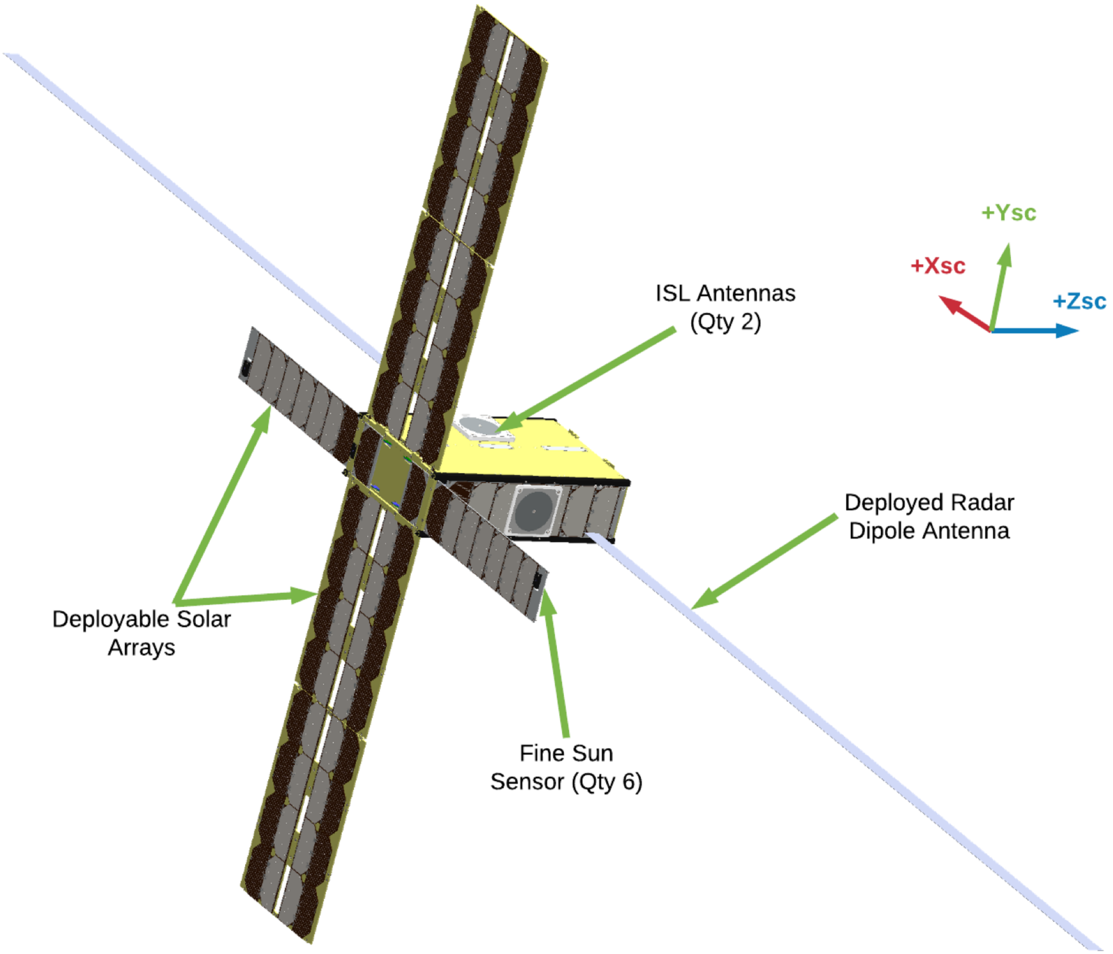
Royal Observatory of Belgium

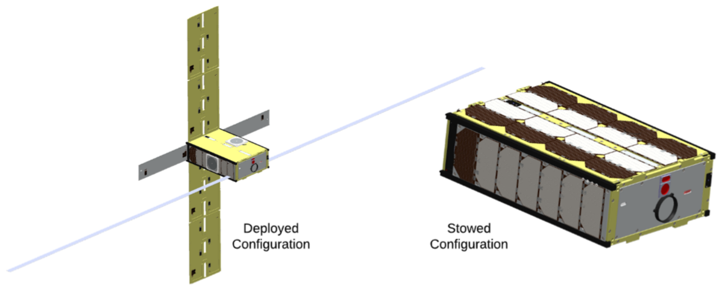
VISIBLE CAMERA (SO#3)

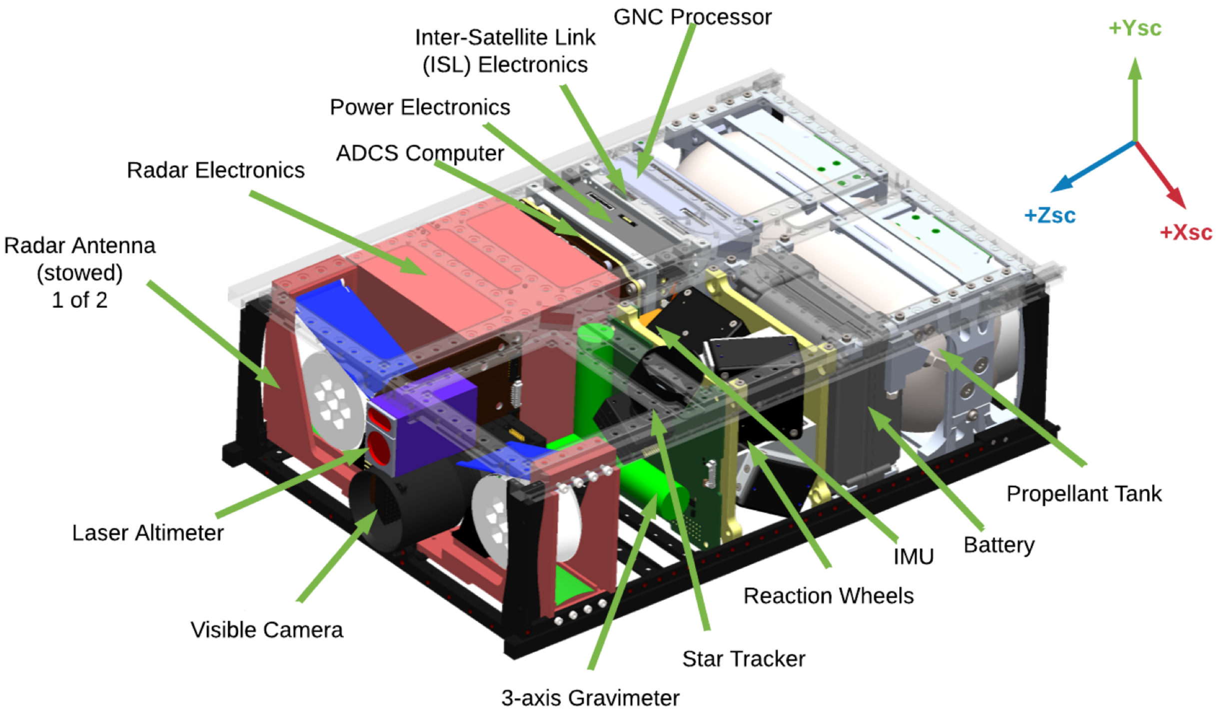
- Context of local target body surface
- Used to feed GN&C and science teams
- 5cm pixel resolution at imaging altitude of 250m for imaging DART impact site

- Camera details:
  - Hyperion IM200, 2048x1944 pixels
  - Lens: 16mm F/1.2 (23 deg FoV)
  - Mass: 60 g
  - Power: 0.7 W

JUVENTAS CUBESAT CONFIGURATION







JUVENTAS SPACECRAFT DESCRIPTION

- Nanosatellite designed as daughtercraft for deep space mission
- Spacecraft bus features
  - “6U” CubeSat form-factor (3U x 2U x 1U), to be deployed from Hera mothership
  - Max 10 kg wet mass, 9.4 kg dry mass, up to 540g liquid butane propellant
  - Autonomous operations with fault protection
  - 3-axis stabilized inertial-reference pointing platform
  - 6 DoF Butane propulsion system with 14 m/s delta-V (incl. ECSS margins)
  - Deployable solar panels – maximum power input of 27W (at 1.8AU) and >80W-hr battery
  - Nominal operation between 1.3 – 1.8 AU (capable up to 2.3AU)
  - Dual S-band antenna for inter-satellite link to Hera mothership, also including protocols for range/navigation information, up to 460 kbps based on link with 2W RF transmit power
  - Ultrastable oscillator for GN&C and payload usage
  - Designed to maximize scientific payload operations for radar and gravity science investigations
    - Nominal total average power for science operations is 24W

SUMMARY AND CONCLUSION

- Cubesat provides beneficial adjunct science to Hera.
  - Allows for adjusting risk posture on more “disposable” asset to attempt surface landing.

- Next steps:
  - Ongoing development to mature Cubesat and payload design for deep space environment
  - Discussion of accommodation and interfaces with Hera team
  - Refinement of mission design for science return based on payload drivers

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"WE HELP TEAMS ACROSS THE
GLOBE ACHIEVE THEIR GOALS IN SPACE"

GomSpace A/S | Alfred Nobels Vej 21A [1.] | DK-9220 Aalborg East | Denmark
T: +45 9635 6111 | F: +45 9635 4599 | info@gomspace.com