Imaging Simulations of HERA Didymos Approach

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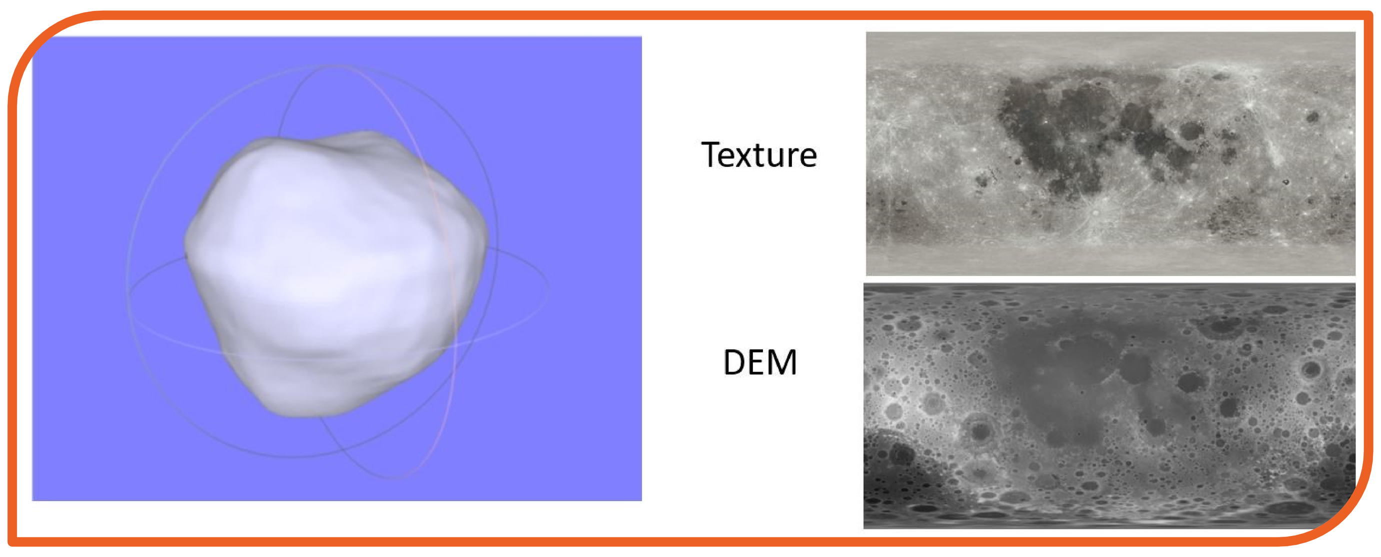
Scope

The **AIDA** (Asteroid Impact Deflection Assessment) collaboration between ESA and NASA involves **DART** (Double Asteroid Redirection Test) and the **HERA** spacecraft. DART is led by NASA and will impact the smaller body of the **binary asteroid Didymos** (Dimorphos). The European HERA Mission [1] will rendezvous Dimorphos in 2026 following up the impact produced in 2022 by DART.

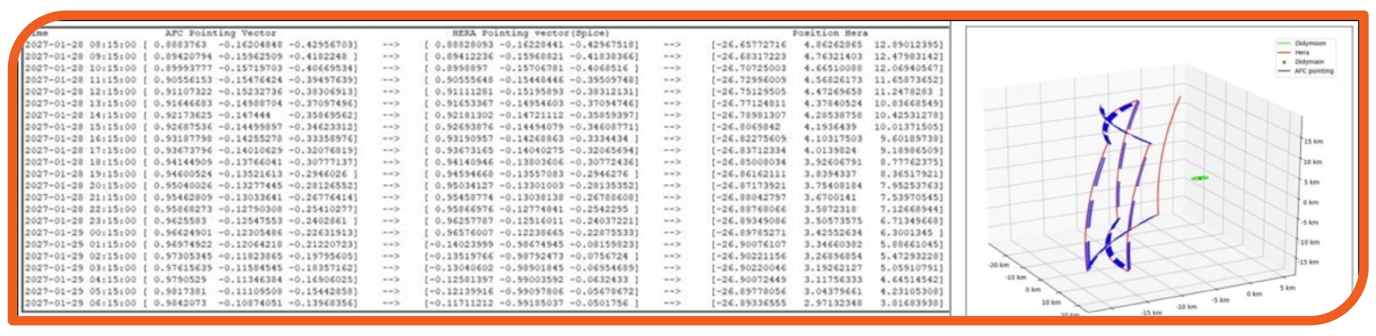
The **Austrian contribution** to Phase B2 Part 1 of the HERA mission was carried out by **JR**, **VRVis** and science collaborators of the **University of Vienna** under GMV contract. Tools to define virtual images of Didymos for tactical and strategic aims as well as to test the vision-based determination of the asteroids' shape were designed and implemented. Simulations of the expected crater impact produced by DART were started to estimate and visualize the expected crater shape for the interpretation of the internal structure of Dimorphos.

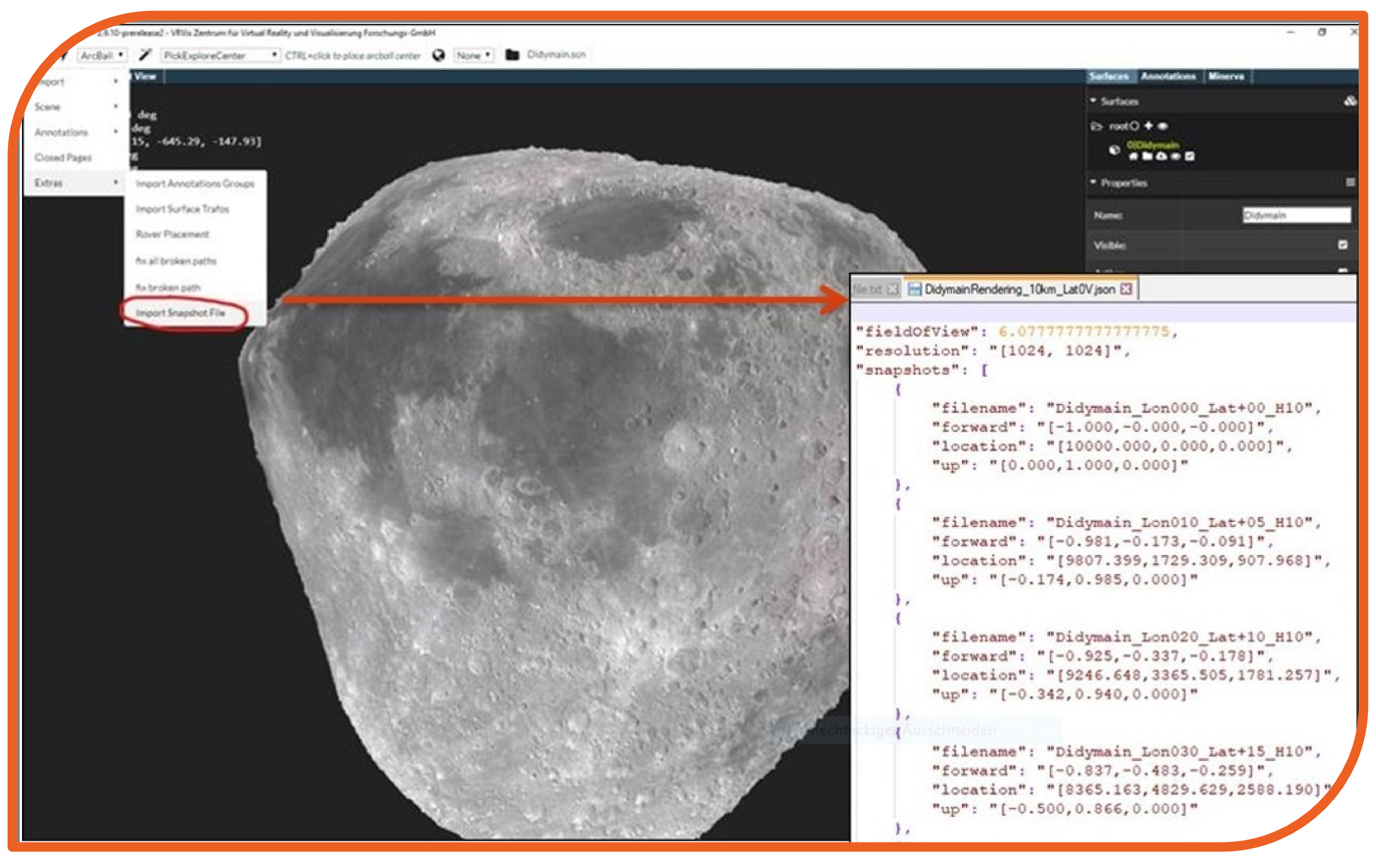


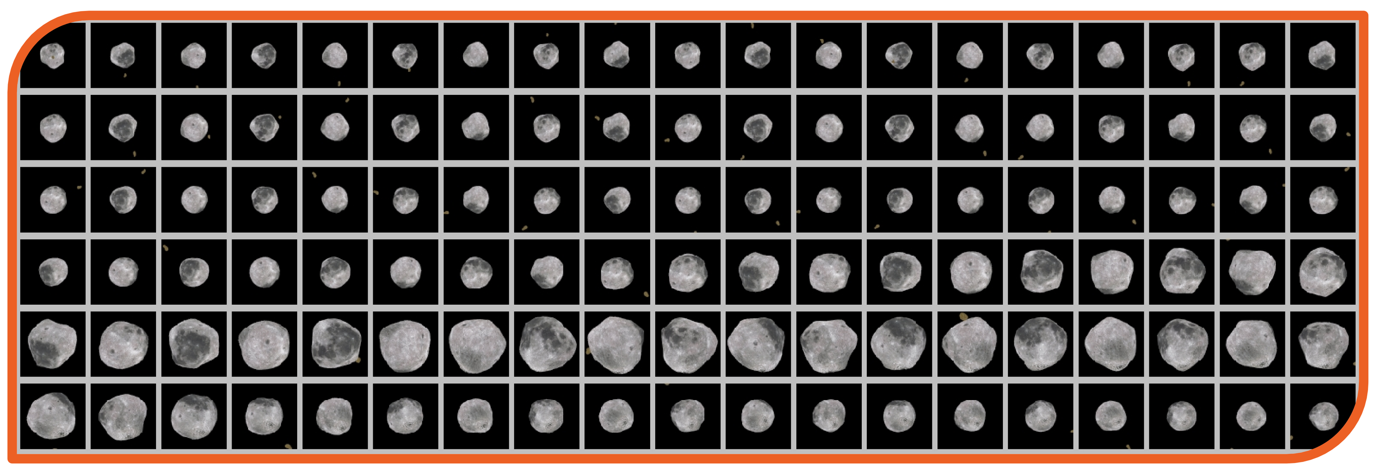
Left: Didymain 3D model. Right: DEM and texture of the Moon used to enhance Didymain model.

Didymos Image Rendering

The shape and dimensions of Didymos were provided as *.txt files by GMV. Further additional data required to generate synthetic images in the most representative and faithful way with the **PRo3D** Viewer [2] were namely: the spacecraft´s camera geometry, its planned positions and orientations along the available trajectories, Didymos' positions and orientations and the solar illumination direction. For the calculation of the camera´s and Didymos' positions and orientations the HERA SPICE Kernels were used.



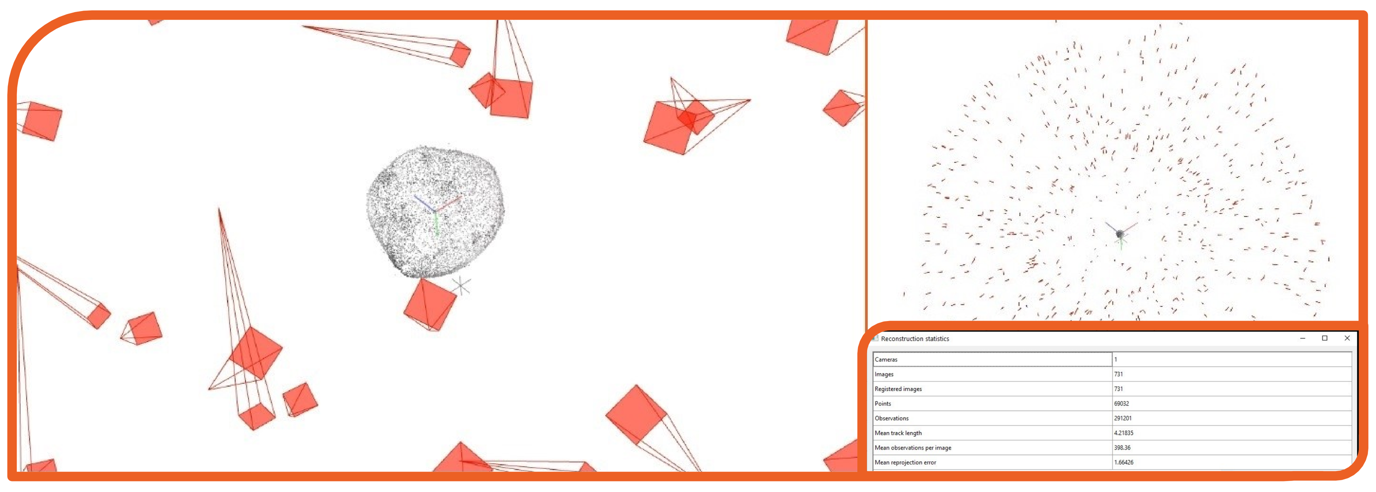


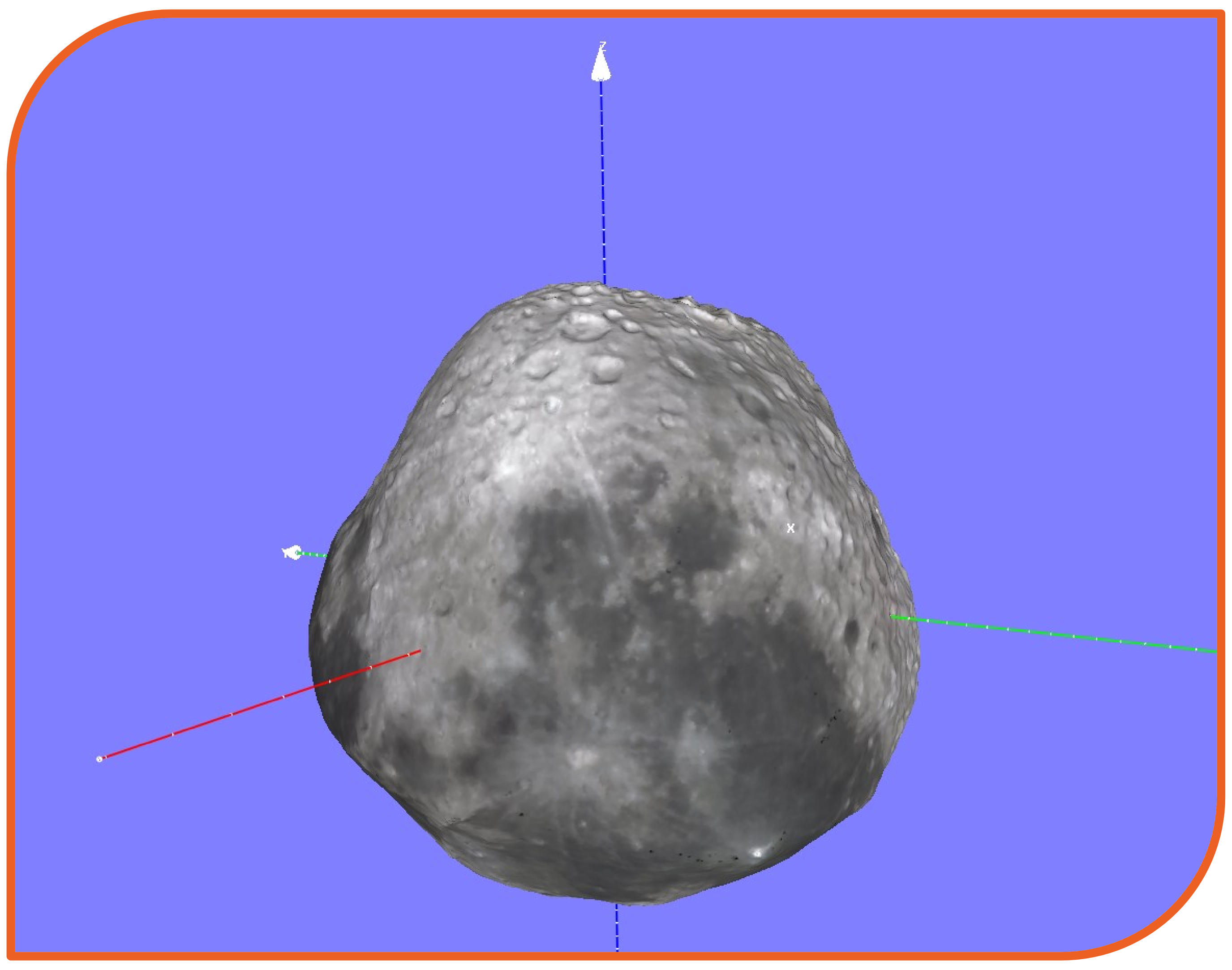


Top: HERA trajectory using SPICE kernels. Centre: Rendering with PRo3D. Bottom: Set of rendered images.

Shape Reconstruction

To simulate the vision-based Asteroids' shape reconstruction, the images rendered with **PRo3D** were supplied to the **ColMap** [3] framework for 3D reconstruction by means of Structure from Motion (SfM), taking into account the relative motion between camera and Asteroid. In order to establish correct SfM conditions, all camera poses and orientations calculated with the SPICE Kernels were transformed with the inverse rotations of Didymain.





Top: ColMap calculation results. Bottom: Didymain 3D reconstruction with ColMap.

DART Impact Simulation

To simulate the kinetic impact of DART on Dimorphos, a Smooth Particle Hydrodynamics (SPH) hypervelocity impact code [4,5] that combines elasto-plastic continuum mechanics with a fragmentation model for fracture and brittle failure [6] was developed. The presented scenarios use the p−α porosity model [7]. The simulations assumed Dimorphos to consist of basaltic rock with varying porosity and material parameters as in [8]. DART was modelled as a single aluminium SPH particle. Each individual impact scenario was resolved in approximately one million SPH particles, and dynamically visualized.

Conclusion

The simulation approaches performed by the Austrian team in Phase B2 Part 1 of the HERA project demonstrated the vision-based 3D-reconstruction of small bodies (asteroids) and their surface after impact under the expected nominal mission conditions to enhance and broaden the knowledge about their structure and material composition.

References:
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