



DART Mission Space- and Ground-Based Archived Data Products

Raymond Espiritu¹, C. Dany Waller¹, Calley Tinsman¹, Hari Nair¹, Carolyn Ernst¹, R. Terik Daly¹, Olivier Barnouin¹, Angelo Zinzi^{2,3}, Nicholas Moskovitz⁴, David Osip⁵, Tim Lister⁶, Eileen Ryan^{7,8}, William Ryan^{7,8}

1. Johns Hopkins University Applied Physics Laboratory, Laurel, MD, USA
2. Agenzia Spaziale Italiana, Roma, Italy
3. Space Science Data Center, Roma Italy
4. Lowell Observatory, Flagstaff, AZ, USA

5. Las Campanas Observatory, La Serena, Chile
6. Las Cumbres Observatory Global Telescope Network, Goleta, CA
7. New Mexico Institute of Mining and Technology, Socorro, NM, USA,
8. Magdalena Ridge Observatory, Socorro, NM, USA

Overview

On Sept 26, 2022 the DART spacecraft impacted with Dimorphos, the secondary asteroid in the Didymos binary asteroid system. Data products generated from cameras mounted onboard the DART and LICIACube spacecraft, as well as from ground observatories, were used to determine the effectiveness of using a kinetic impactor for planetary defense [1–4].

NASA's Planetary Data System (PDS) is used as the long-term archive for the data products created from this mission. The products include images from instruments onboard the DART and LICIACube spacecraft, as well as images taken from ground-based observatories such as Lowell, Magdalena Ridge, Las Cumbres, and Las Campanas. Derived data products from these image sets are also archived, as well as ancillary information such as the Spacecraft, Planetary, Instrument, C-kernel and Ephemeris (SPICE) kernels, and radio science products.

DART/DRACO

All images taken by the Didymos Reconnaissance and Asteroid Camera for OpNav (DRACO) imager on the DART spacecraft are archived. Calibration files used to transform raw images into calibrated images are also sent to the PDS.

In total over 259,000 raw and 246,600 calibrated images were generated during flight. The complete set of raw and calibrated DRACO images is now available from the PDS.

Below is the calibrated image of the last full frame taken by DRACO before impact. North is to the lower left.



LICIACube/LUKE/LEIA

LICIACube is a 6U CubeSat carried by the DART spacecraft and was deployed 15 days before DART impacted Dimorphos. Its purpose was to witness the impact and acquire images for about 10 minutes around the time of impact. LICIACube hosts two cameras: LEIA and LUKE. LEIA is designed to acquire long-range images while LUKE is able to take color images using a Bayer-filter.

The LICIACube data is expected to be available in the PDS in September 2023.

Below is a LUKE image taken a few minutes after the DART impact.



Ground Observatories

The datasets from the four ground based observatories each contain raw and calibrated images as well as ASCII tables of photometric light curves. While the details of image calibration and generation of photometric light curves varied from observatory to observatory, the organization of data into raw, calibrated, and light curve derived data remained the same. This was done to standardize the datasets from each telescope as much as possible and minimize the amount of customization required to archive the datasets with PDS.

Observations made by Lowell Observatory during 2020-2021 are currently available from PDS while observations from all observatories during the 2022-2023 observation period should be available from PDS by September 2023.

Radio Science

Signals emitted from the High Gain Antenna (HGA) onboard the DART spacecraft were received by the Deep Space Network (DSN) and converted into spacecraft tracking data. Together with the Ionosphere Calibration Files and Maneuver Acceleration File, these constitute the DART Radio Science (RS) dataset archived with the PDS.

DART RS data is currently available from the PDS while LICIACube RS data is expected to be available in September 2023.

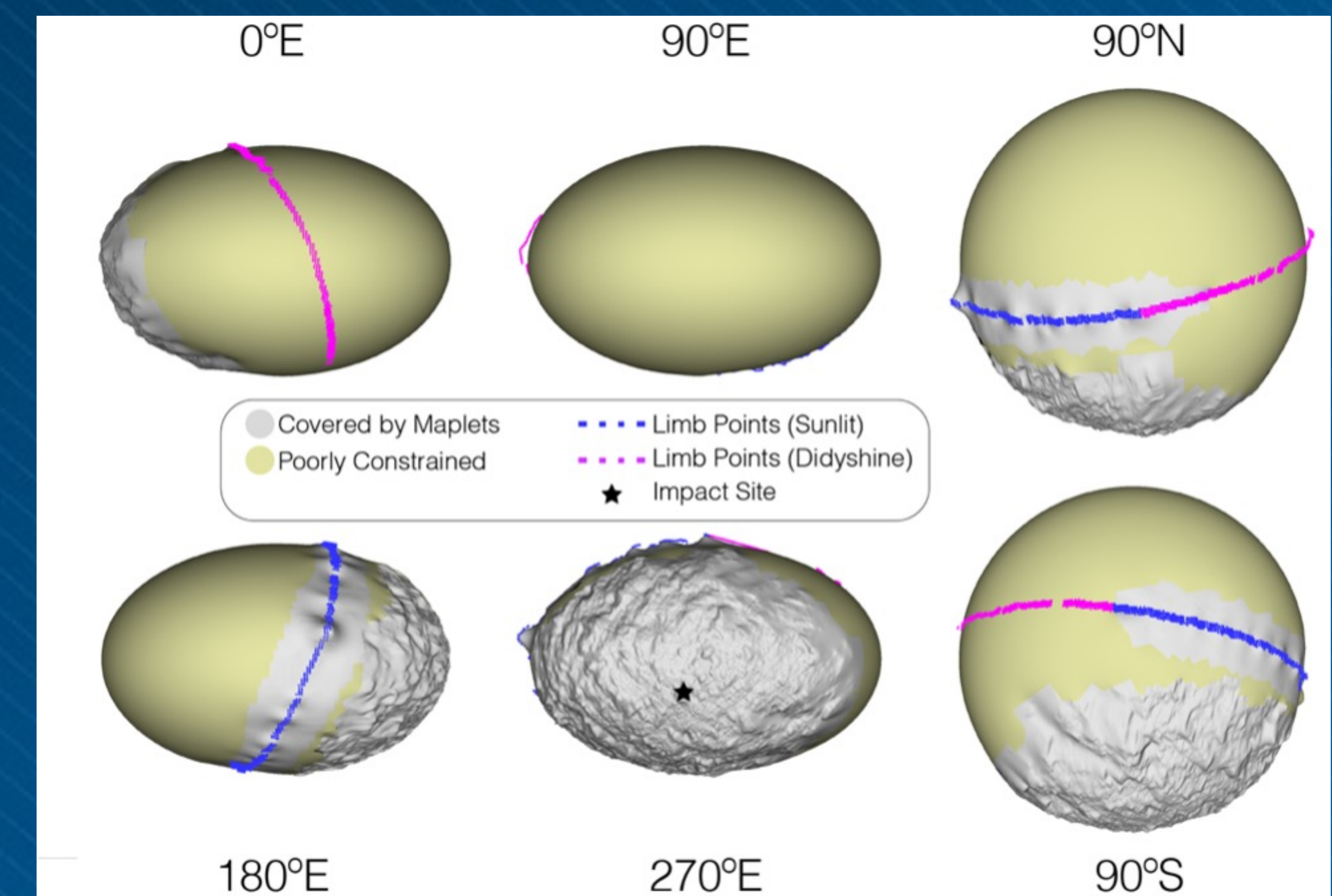
Shape Models

Global Digital Terrain Models (DTMs), as well as an impact site DTMs and tilt maps, are generated using stereophotoclinometry (SPC).

Some of the other data products generated for this dataset include the Asteroid Center of Figure, coordinate system, pole location and rotation period. In addition, adjusted spacecraft pointing and trajectory data (SPICE CK and SPK kernels) are created using a best-fit solution determined during SPC processing.

The shape model data is expected to be available in the PDS in September 2023.

Below is the preliminary Dimorphos global DTM as viewed along its principal axes [1], including the areas constrained by DRACO data.



References:

- [1] Daly, R.T. et al. (2023) *Nature*, doi:10.1038/s41586-023-05810-5
- [2] Thomas, C.A. et al. (2023) *Nature*, doi:10.1038/s41586-023-05805-2
- [3] Li, J.-Y. et al. (2023), *Nature* doi: 10.1038/s41586-023-05811-4
- [4] Cheng, A.F. et al. (2023) *Nature*, doi: 10.1038/s41586-023-05878-z

DART data available from the PDS Small Bodies Node (PDS-SBN): https://pds-smallbodies.astro.umd.edu/data_sb/missions/dart/index.shtml

DART SPICE kernels available from the PDS NAIF Node: https://naif.jpl.nasa.gov/pub/naif/pds/pds4/dart/dart_spice/