UPDATES TO THE SMALL BODY MAPPING TOOL (SBMT) FOR THE DOUBLE ASTEROID REDIRECTION TEST (DART). R. J. Steele[1], C. M. Ernst[1], R. T. Daly[1], J. M. Peachey[1], N. R. Lopez[1], O. S. Barnouin[1], and A. C. Martin[1], [1]The Johns Hopkins University Applied Physics Laboratory, 11101 Johns Hopkins Road, Laurel, MD, 20723, USA (sbmt@jhuapl.edu)

Introduction: Spacecraft missions return massive amounts of valuable data, but those data can be hard to access, visualize, and analyze. Most asteroids, comets, Kuiper belt objects, and small moons present additional challenges because two-dimensional map projections severely distort features on irregularly shaped bodies. The Small Body Mapping Tool (SBMT) developed at the Johns Hopkins University Applied Physics Laboratory addresses these challenges [1,2].

The SBMT allows users to find, access, and analyze spacecraft data in a contextual way for small bodies. It lets users search for spacecraft data and project it onto small body shape models to help them do their science in three dimensions without worrying about map projection issues or sorting through Planetary Data System (PDS) archives. Alternatively, users can use the SBMT as a starting point to pinpoint the data they need and then download the raw data from the PDS. The Tool includes a diverse suite of bodies and data types (images, spectra, altimetry data) and supports co-registration of these data products.

The Small Body Mapping Tool is publicly available as a free download at sbmt.jhuapl.edu. It works on Mac, Linux, and Windows operating systems and has a user-friendly graphical interface that has been improved over the last year. The SBMT is written in Java and uses the Visualization Toolkit (VTK), an open-source, freely available software system for 3D computer graphics, rendering, and visualization [3]. Anyone can access datasets for 12 asteroids, 5 comets, and 19 satellites. Datasets and added features for active missions (e.g., DART) are currently restricted to team members, but will be made public once all data products in the SBMT have been archived with the PDS.

Challenges from the DART Mission: The DART mission provided some challenges for SBMT development.

Multiple Bodies: Before DART, the SBMT could only support viewing one body model and its associated data in the 3D renderer. This was true even for some images in the Tool which contained multiple supported bodies (e.g., some Cassini images containing multiple saturnian moons). However, most DART images, from both the DRACO camera on the main spacecraft and the LUKE camera on LICIACube, contain both bodies of the Didymos system.

Multiple Spacecraft: Most bodies in the SBMT contain data from a single spacecraft (e.g. NEAR at Eros). However, the SBMT does include bodies (e.g. Phobos) that contain data from multiple spacecraft. DART is novel in that multiple spacecraft are collecting data for multiple objects simultaneously, and provides an opportunity to improve how the SBMT handles the import and display of that data.

DART-Focused Improvements: For the DART encounter and initial Planetary Data System (PDS) delivery, and to address the challenges above, the SBMT now has:

Support for multiple bodies. For DART, the SBMT can display Didymos and Dimorphos as single bodies in the renderer, as well as the combined Didymos system. Configurations for Didymos- and Dimorphos-centric systems are available. This feature is important for DART as the images closer to impact are centered on Dimorphos.

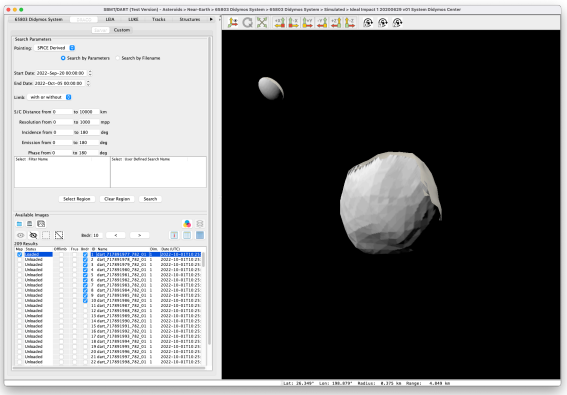

Figure 1. The simulated (pre-encounter) Didymos System in the SBMT. A simulated DRACO image appears over both bodies.

Deeper SPICE integration. The *Observing Conditions* pane has long used pointing knowledge, most recently from SPICE kernels, to display spacecraft position and pointing. To support rendering multiple bodies, SPICE support in the SBMT has been expanded to multiple body systems so secondary bodies (e.g. Dimorphos) can be placed in the proper location and orientation relative to the primary (e.g. Didymos). This feature is required so that images are properly projected on the rendered bodies, as in Figure 1.

Improved Support for Color Images. Recent improvements to SBMT from a NASA PDART introduced the GDAL library to improve the handling of different image types. This integration includes the handling of color images, like those taken by the LUKE instrument on LICIACube, or MSI Images from the NEAR mission to Eros. It is now easier to ingest multispectral images, view the various layers on the body, and view RGB or false color images.

Improvements to the Images Tab. The SBMT DART version is the first to receive improved images tab functionality. Improvements include image loading and rendering performance, improvements in contrast stretching, and image auto-masking detection. The latter was vital for displaying the subframes of DRACO images, as seen in Figure 2.

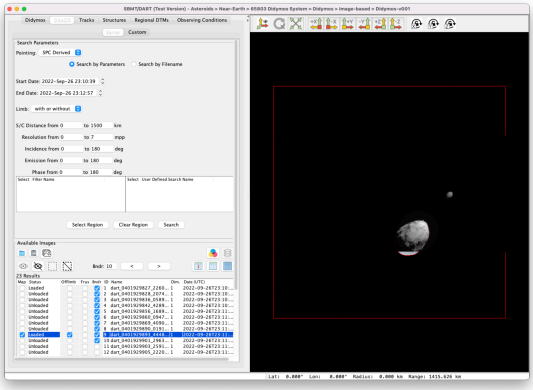

Figure 2(a). An auto-masked DRACO image is shown on Didymos.

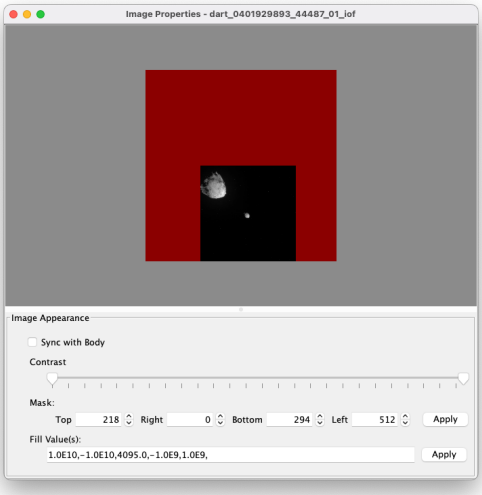

Figure 2(b). The full image is shown in the properties pane. The red regions are automatically masked out by reading header values in the FITS file.

Upcoming Improvements: The SBMT currently has the ability to show trajectories for a spacecraft, as well as camera fields of view, in the *Observing Conditions* tab. However, the ability to simultaneously visualize multiple spacecraft trajectories and fields of view, for example the main DART spacecraft and the LICIACube Cubesat and their respective imagers, is not currently supported. This functionality will be added in a future release of the Tool.

Newly Available Data: In December of 2022, the complete DART image dataset was delivered to the PDS [4]. This delivery included raw and calibrated images for DRACO. In early 2023, the publicly available version of SBMT will be updated to include shape models for both Didymos and Dimorphos, as well as coregistered DRACO images from DART. Once LUKE images from LICIACube have been released through the PDS, they will be included, too.

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References: [1] Kahn et al., 2011, *LPS 42*, abs. 1618. [2] Ernst et al., 2018, *LPS 49*, abs. 1043. [3] Schroeder et al., 2006, *The Visualization Toolkit: An object-oriented approach to 3D graphics*, Kitware, Inc. [4] DART Science Team. (2022). DART DRACO Calibrated Data Archive. PDS Planetary Node. https://doi.org/10.26007/m6y3-mg52.