THE USGS ASTROGEOLOGY DATA PRODUCTS PORTFOLIO: SUPPPORTING PLANETARY SPATIAL DATA INFRASTRUCTURE.

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Introduction: The USGS Astrogeology Science Center (ASC) is funded through both traditional NASA Research and Analysis (R&A) programs and an USGS-NASA Interagency Agreement (IAA) to create data products that improve planetary spatial data infrastructure (PSDI) and thereby enable high-quality planetary science and exploration. Here we briefly describe both recently completed data products, and data product that are currently in development. Each project either provides one of the three foundational PSDI datasets (geodetic control, topography, well-controlled orthoimages) [1], or is considered a framework product that will enable new science.

Recently Completed Data Products: The USGS has recently completed and made publicly available a number of data products. Here we highlight three "global" products that are foundational PSDI elements for their respective planetary bodies.

Mars THEMIS global mosaic and pointing and spacecraft kernels. We have released daytime and nighttime Thermal Emission Imaging System (THEMIS) controlled mosaics at 100 m/pixel and covering ±65º latitude. The mosaics and final updated pointing kernels are available online at (https://astrogeology.usgs.gov/maps/mars-themis-controlled-mosaics-and-final-smithed-kernels). The mosaics have well-characterized accuracy [2] and provide a foundational controlled imaging dataset for Mars.

Enceladus global basemap and pointing kernels. We have photogrammetrically controlled 621 Cassini Imaging Science Subsystem (ISS) images (all with resolution better than 500 m/pixel) and created a new basemap to support geologic mapping [3]. A high-pass filtered mosaic (emphasizing surface morphology over surface brightness variations) and updated pointing kernels are available online at (https://astrogeology.usgs.gov/search/map/Enceladus/Cassini/Enceladus_Cassini_ISS_Global_Mosaic_100m_HPF.) The mosaic provides a controlled (relative) global imaging dataset for Enceladus.

Mercury MESSENGER visible and topographic map. The USGS has recently published a Scientific Investigations Map of Mercury's surface (imaging) and topography [4] (https://pubs.er.usgs.gov/publication/sim3404). The topography is derived from a combination of Mercury Dual Image System (MDIS) [5] and Mercury Laser Altimeter (MLA) data, the latter of which provides coverage of the poorly illuminated north pole. The map provides a foundational global topographic dataset for Mercury.

Data Products in Development: The ASC is currently working on a large number of global and regional data products that will become available in the next few years. Below we briefly describe each, including the funding source, project lead(s), and expected delivery date for public dissemination.

Lunar digital terrain model (DTM) improvements via rigorous lidar registration (PDART & IAA funded: B. Archinal). To improve the quality and absolute accuracy of SOCET SET® lunar digital terrain models (DTMs) we are developing capability within ISIS's photogrammetric bundle solution (*jigsaw* [6]) to simultaneously control image and lidar data. To demonstrate this capability we are creating DTMs of three sites in the South Pole Aitken basin. We expect that these DTMs will be publicly available by October of 2020.

Lunar Apollo 15 mosaics from the Kaguya Terrain Camera (PDART funded: L. Gaddis). Kaguya Terrain Camera (TC) images from its extended mission have high spatial resolution but poor image geometry due to the loss of reaction wheels, and limited radio tracking. Recent orbital reconstruction [7, 8] results in new extended mission orbits with a precision at the level of several tens of meters or better, and these now permit construction of an improved 10º x 10º test mosaic of the Hadley Rille region [9]. Doing so requires the development of an ISIS camera model (a Community Sensor Model – CSM – is also in development), which will also enable the planetary community to more-easily access and use these data. The camera model will be available by the Spring of 2020, and the mosaic is expected by Fall of 2020.

Lunar Kaguya Spectral Profiler Data Availability (PDART funded: J. Laura). Kaguya Spectral Profiler collected a rich, hyperspectral spectral data set of the lunar surface. In FY18 we prototyped methods necessary to store and efficiently query this high dimensionality data set. In FY20, we will be making the data set available to the public for download and analysis at the individual spectrum level thereby reducing the data access burden. Additionally, we will expose spectral search capabilities where an individual spectrum can be used as a pseudo-keywords to find similar spectra.

Mars controlled CTX mosaic (IAA funded: J. Laura). The Mars Reconnaissance Orbiter Context Camera (CTX) has provided near-global image coverage at 6 m/pixel. Photogrammetrically and geodetically controlling such a large dataset is technically and logistically challenging. In FY19 we are developing the methodologies necessary to complete a controlled CTX mosaic (e.g., automated point matching, data streaming, handling images across multiple tiles). In FY20 we may begin producing a controlled product for part of Mars' equatorial region and investigate approaches to handling the polar regions.

Mars CTX-based South Polar DTMs (IAA funded: D. Mayer). There is no systematic topographic model available for Mars poleward of 87º S. To address this deficiency [10], we are constructing DTMs of the south polar region using CTX stereopairs and the Ames Stereo Pipeline (ASP [11]) software package. The large number of required stereopairs (>3000 candidates have been identified) demands an automated approach. We expect delivery of a south polar DTM mosaic tied to Mars Orbiter Laser Altimeter (MOLA) by October of 2019.

Europa updated pointing kernels and basemap (IAA funded: M. Bland/R. Fergason). We are constructing a new control network that includes all usable Voyager and Galileo images of Europa. Our immediate goal is to provide the community with updated image pointing kernels for the dataset, which improves data usability and enables creation of a new basemap and regional high-resolution mosaics. Expected delivery of these products will be in October of 2020.

Europa DTM Assessment (PDART funded: M. Bland). The relatively low spatial-resolution and variable illumination of Galileo images, and the lack of "ground" control makes characterizing Europa's surface challenging. Over the past several years we have been comparing DTMs generated by different technique (e.g., SOCET SET®, ASP) to evaluate how well we can actually know Europa's topography. We find that, for stereo-only techniques, the variability between different methods can be larger than the formal vertical precision of the methods [12]. All of the DTMs produced during this work will be delivered in the spring of 2020.

Enceladus global shape model (IAA funded: M. Bland). Building on earlier work [3], we have developed a new shape model for Enceladus by photogrammetrically solving for latitude, longitude, and radius across a dense network of image tie points (more than 30 million image measures, see [5] for details). The model has spatially variable horizontal "resolution" and vertical accuracy, but can resolve Enceladus' triaxial shape, large-scale region topography, and, in some areas, local-scale topography (e.g., craters) [13]. Expected delivery of the shape model will be in October of 2019.

Titan controlled global mosaic (IAA funded: B. Archinal). Titan is the largest solid-surface body in the Solar System without a global geodetic/photogrammetric control network. Recently, Cassini ISS images of Titan have been improved (better SNR) and used to create a high-quality uncontrolled mosaic [14]. We are currently working to extend our previous work [15] and use this improved dataset to develop a photogrammetrically controlled mosaic that combines the improved image quality of [14] with improved and well-characterized geometric accuracy. Expected delivery of these products will be October of 2020.

Triton updated pointing kernels and image quality improvements (PDART funded: M. Bland). To support preparation of a new USGS geologic map of Triton [16] we have processed 41 Voyager 2 images (i.e., all images with scale less than 2 km/pixel) to a calibrated and "clean" state (removed reseaux, line-drops, etc.) and we have photogrammetrically improved image locations. Image relative misalignment, originally as large as 300 km, is now just 1-2 km (generally a few pixels) [17]. Both the clean, relatively controlled images themselves and the updated pointing kernels are expected to be delivered in the fall of 2019.

Acknowledgements: References to commercial products are for identification purposes and do not imply an endorsement by the U.S. Government.

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