THE NASA PLANETARY DATA SYSTEM'S CARTOGRAPHY AND IMAGING SCIENCES NODE AND THE PLANETARY SPATIAL DATA INFRASTRUCTURE (PSDI) INITIATIVE. L.R. Gaddis, J. Laura, T. Hare, and J. Hagerty. U.S. Geological Survey, Astrogeology Science Center, Flagstaff, AZ (lgaddis@usgs.gov).

Introduction: An effort currently underway within the NASA-funded planetary research community is the Mapping and Planetary Spatial Infrastructure Team (MAPSIT, [1]). MAPSIT is a community assessment group organized to address a critical lack of community-based strategic spatial data planning for space science and exploration (http://www.lpi.usra.edu/mapsit/). MAPSIT is managed for NASA through the U.S. Geological Survey's (USGS) Astrogeology Science Center (ASC) and the Inter-Agency Agreement for Planetary Spatial Data Infrastructure (PSDI) research (NASA-USGS-PSDI-IAA, [2]). A new initiative of NASA and USGS is the development of a PSDI that builds on extensive knowledge from the terrestrial research community [3, 4]. PSDI is a framework designed to enable the efficient discovery, access, and exploitation of planetary spatial data to facilitate data analysis, knowledge synthesis, and scientific decision-making. ***Here we address the role of this PSDI in the context of ongoing work to archive and deliver planetary data by NASA's Planetary Data System, and in particular the PDS Cartography and Imaging Sciences Discipline Node (aka "Imaging" or IMG).***

IMG Background: The PDS Imaging Node is a curator of NASA's larger digital image collections from past, present, and future planetary missions. Current IMG data holdings total ~975 TB and they are projected to grow by ~200 TB each year [e.g., 5]. IMG provides to the NASA planetary science community the digital image archives, ancillary data, sophisticated data search and retrieval tools, and technical expertise necessary to develop and fully utilize the vast collection of digital planetary images of many terrestrial planetary bodies, including icy satellites. Science expertise at IMG includes orbital and landed camera instrument development, data processing, data engineering and informatics, planetary remote sensing at UV to RADAR wavelengths, and geospatial data analysis and product development. Managed primarily at the USGS ASC, IMG also leverages capabilities and ongoing NASA-funded projects in planetary nomenclature, software development (via the ISIS3 software [6]), spatial data analysis, and nomenclature at that institution.

IMG focuses primarily on archiving, distributing, and making available data from past and present NASA planetary space missions. Extended topics addressed by IMG include planetary geometric characterization and analysis, calibration, detailed geometric and physical camera and instrument modeling and characterization, geographic information systems, mosaicking and basemap generation for planetary surface and orbital exploration, metadata harvesting and analysis, etc. By leveraging institutional spatial data expertise and activities in ASC and working closely with data providers, IMG also provides access to data and software that geometrically characterize and transform planetary images. Through collaborations between IMG partners at USGS and the Jet Propulsion Laboratory (JPL), and within projects and mission operations at JPL, IMG provides software tools and capabilities in response to research and flight-project needs. Archival products of these activities are made available to users through PDS IMG online data services.

PSDI Background: The PSDI framework is intended to integrate people (developers and data users), regulatory mechanisms and policies, data access technologies, standards, and planetary spatial data. The PSDI addresses three issues often seen among spatial data users. First, because data collection can be prohibitively expensive, ***data reusability*** is a primary goal of the PSDI. Second, development and delivery of highly ***usable, derived data products*** and tools to support users directly without having individual users gain the specialized expertise necessary to produce them independently. Third, the ***use of standards*** and standardized methodologies in the development and sharing of tools and data will both benefit directly from a well-characterized framework and simplify integration of such products back into the PSDI.

The development and maintenance of three types of ***foundational data products*** [7] are critical to this PSDI: stand-alone data products, specialized products required for the derivation of other data products, and highly usable products providing high science return across the broadest possible user base. Because many of these elements have a

long lead-time, the MAPSIT community is currently engaged in developing a roadmap to ensure that the development of software, data products, and processing capability keeps pace with the planetary research and exploration needs of NASA.

Leveraging available data and the most recent technologies for data consolidation, delivery and accessibility, the ultimate goal of a PSDI is to provide seamless discovery, access, and exploitation of spatially enabled data for all data consumers without any predetermined requirement of spatial data expertise through the use of cutting edge technologies, standards, and transparent policy initiatives. ***Key aspects of the PSDI framework are its abilities to adapt and respond quickly to changing user needs by building on existing NASA capabilities in planetary data archiving and spatial data product development.***

The PDS Foundation for a PSDI Framework: As the primary archive for planetary digital data, the PDS plays a critical role in laying the foundation for the development of a PSDI, and also in the ultimate success of such a PSDI. In part this role is achieved by recognizing that the fundamental goals of the PDS and PSDI are complementary. PDS emphasizes the archival and long-term preservation of fundamental planetary data products, and these include raw and low-level data products as well as higher level products developed by missions and resulting from exploration, science, mapping and cartography research.

PDS IMG, along with other discipline nodes in the PDS, has developed a variety of specialized and sophisticated data delivery services to support users. For example, a user can conduct either a simple or complex data search using the Planetary Image Atlas (https://pds-imaging.jpl.nasa.gov) or the Planetary Image Locator Tool (PILOT, https://pilot.wr.usgs.gov/). The latter is integrated with the planetary image processing package ISIS3 and it allows users to select planetary image data, submit them for cloud processing (i.e., map-projection) using the Projection on the Web (POW) tool (https://astrocloud.wr.usgs.gov/) and export them in formats directly usable in common analytical and visualization tool such as ArcMap or QGIS geographic information systems. Thus the user need not understand the complex processing steps that ISIS3 performs to create such usable products from lower-level PDS data. For example, for such map-projected products to become truly *foundational*, the high-level images require additional processing to be properly adjusted as a collection (bundle-adjusted or controlled) to a foundational data set or to become foundational data themselves. This level of processing can be facilitated by PDS tools but is currently beyond the scope of what PDS can support. However, once created such foundational products can become part of the PDS archives through geospatial data delivery services such as the PDS IMG Annex (https://astrogeology.usgs.gov/pds/annex).

Summary: Although PDS, PDS IMG, and the PSDI have the common goals of making data accessible and usable for NASA mission planning and research, the implementations are distinct and complementary. Although the PDS focus is on long-term data availability and usability, the PSDI framework is a living structure that addresses user needs by leveraging the data within the PDS, using current technologies to transform those data to meet the standards and interoperability policies defined by the PSDI, and providing data access mechanisms that can evolve rapidly and readily as new technologies become available. The development of a strategic PSDI plan is foundational in realizing the ability to fully leverage NASA collected spatial data in the future. NASA plays a pivotal role in driving the development of a PSDI, identifying policy alignment with existing SDI mandates and filling policy gaps, and empowering partners to codify a user-centered plan for spatial data management. At present, the PSDI is in the planning stages, with current emphasis on gathering community input through MAPSIT on user needs, relevant standards for data delivery and software development, necessary foundational products and tools to develop them, and how the unique planetary science aspects of the people, standards, policies, data access networks and data will need to be integrated.

References: [1] Lawrence, S. J. et al. (2016), 47th LPSC, abs. #1710. [2] Keszthelyi, L. et al. (2017), this volume. [3] Laura, J. et al. (2017), Vision 2050, abs. #8110. [4] Laura, J. et al. (2017), this volume. [5] Gaddis, L. and T. Hare (2015), Eos, 96, doi:10.1029/2015EO041125. [6] Sides, S. et al. (2017) *LPS XLVIII*, 48th LPSC, abs. #2739. [7] Archinal, B.A. et al. (2017), 48th LPSC, abs. #2286.