

NASA PDS Imaging Node: Not Just A Data Archive. J. Padams¹, B. Deen¹, L. Gaddis², T. Hare², S. Lavoie¹, E. Sayfi¹, A. Stanboli¹, and K. Wagstaff¹, ¹Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, ²U.S. Geological Survey Astrogeology Science Center, Flagstaff, AZ. (jordan.h.padams@jpl.nasa.gov)

Introduction: The Imaging Node (IMG) of the NASA Planetary Data System (PDS) is the home to over 700 TB of digital image archives, making it one of the richest data repositories for planetary imagery in the world. Within these archives the data comes in many varieties, whether it's orbital versus landed missions, original raw experiment data versus derived products, differing coordinate systems, etc. Tools and services are needed to integrate these data so information can be correlated across missions, instruments, and data sets.

IMG has developed numerous tools and services to support both the wide variety of available data but also to meet the needs of its broad user community, from the scientist analyzing a particular crater on Mars to a member of the general public browsing the Internet for the coolest image of Jupiter. Leveraging partnerships with the Multimission Ground System and Service (MGSS) Office, Machine Learning and Instrument Autonomy Group (MLIA), Media Relations, and Multimission Image Processing Lab (MIPL) at the Jet Propulsion Laboratory (JPL) and the expertise in planetary science, cartography, geodesy, photogrammetry and science software development at USGS Astrogeology Science Center, IMG continues to push towards new tools and services that bring the data to the people and support significant scientific discovery. For example, data archived and supported by IMG have been used to discover water on the "bone dry" Moon (Moon Mineralogy Mapper data; [1]), recent geologic activity related to CO₂ frost in martian gullies (High Resolution Imaging Science Experiment data or HiRISE; [2]), recent impacts on the Moon and Mars (Lunar Reconnaissance Orbiter Cameras or LROC; [3]; HiRISE; [4]), and recent lunar volcanism (LROC; [5]).

Webification (w10n): Webification (W10N) (<http://pds-imaging.jpl.nasa.gov/w10n/>) is a specification that defines a common way to expose resources (composite files, databases, command-line applications, etc.) on the web. The core idea is to make the inner components of resources directly addressable and accessible via well-defined and semantically meaningful URLs. Webification provides access to applications (services) as well, through ReSTful URLs. This means that standalone applications can be transformed into web services through a component of Webification called Servicification (aka Serv10n API). This service is central to the server-side functionality for several

IMG services, including the Planetary Image Atlas, PDS Marsviewer, and Landmarks Web Services.

Atlas III: Upgraded to version 3 in Fall 2014, the Planetary Image Atlas (<http://pds-imaging.jpl.nasa.gov/search/>) provides access to the entire collection of IMG data through links to online holdings and data node catalogs [6]. The PDS Imaging Node Atlas III utilizes faceted navigation, an interactive style of browsing datasets that allows users to filter a set of items by progressively selecting from only valid values of a faceted classification system. In the Atlas III, facets are defined by the most commonly used search criteria for imaging datasets including but not limited to: mission name, instrument name, target, product type, lighting geometry meta-data (emission angle, incidence angle, phase angle), lat/lon meta-data, time constraints, etc. In addition to the faceted approach, the Atlas III builds on the features of the previous Atlas including a map interface for the Saturnian moons, Earth's moon and Mars. The Atlas III also incorporates the use of the MGSS webification backend that makes use of the image transformation software developed by MGSS (MIPL) through javascript widgets [7]. Nearly 15 TB of data are delivered to users across the globe by the Atlas each month.

Photojournal: The Photojournal provides access to the "best of" planetary image collection from recent and current missions and offers image highlights, press release images, derived products such as mosaics and perspective views, and other image products. (<http://photojournal.jpl.nasa.gov/index.html>). JPL media relations jointly funds this service, and it delivers more than 4 TB per month to users, with more than 75 images added per month [6].

PDS Marsviewer: The Mars Image Viewer (Marsviewer) is an image viewing tool tailored to Mars in-situ (landed) missions (<http://pds-imaging.jpl.nasa.gov/tools/marsviewer>) [8]. It makes it easy to view original images (EDRs) as well as all derived image products (RDRs), such as XYZ maps, slope, reachability, mosaics, etc. Originally designed as a QC tool for the MER image processing team, it sees wide use throughout the MER, MSL, and PHX ops and science teams (with InSight and Mars 2020 coming soon). Leveraging the Webification (w10n) protocol, Marsviewer is now available for remote use as well through IMG for use by the general public to access and view Mars in-situ images and derived data (<http://pds-imaging.jpl.nasa.gov/tools/marsviewer>).

UPC/PILOT: The Unified Planetary Coordinates (UPC) database [9] addresses the problem of the multiple and disparate coordinate systems in which PDS image data can be delivered by standardizing all coordinates to 0° to 360°, and positive east longitudes for select image data. The UPC database is available through the Planetary Image Locator Tool (PILOT, [10] <http://pilot.wr.usgs.gov/>). PILOT provides an interface to select planetary targets on which users can specify a geographic bounding box and execute searches resulting in rendered footprints, thumbnails, and browse images. Users can restrict searches based on instrument and observational and (or) positional constraints (for example, incidence angle, solar longitude, pixel resolution, and phase angle). Complete or partial sets of resulting images can be retrieved using an automated download script. A newly added feature in PILOT now allows users to locate overlapping images (stereo-pairs) suitable for deriving topographic surfaces [10].

Landmarks Web Services: The Landmarks Services include an overlapping image finder, landmark detector, landmark classifier, and change detection (<http://pds-imaging.jpl.nasa.gov/tools/landmarks>). Using the UPC Pilot Database to determine an image's location, the overlapping image finder provides the ability to find overlapping images for a surface location of interest. Landmarks are visually salient surface features, such as dust devil tracks or dark slope streaks on Mars, that are detected using an approach known as dynamic landmarking [11]. Change detection is done by comparing the landmarks found in overlapping images taken at different times. The instruments currently supported by these services include Mars Global Surveyor MOC, Mars Odyssey THEMIS, and Mars Reconnaissance Orbiter HiRISE.

POW: The Map Projection (on the) Web Service (POW) is a free online service that transforms raw Planetary Data System (PDS) images to science-ready, map-projected images. POW uses PDS Imaging Node tools (PILOT and UPC) to locate images and then allows the user to select and submit individual images to be map-projected [12].

Map-A-Planet 2 (MAP2): An update to the existing Map-A-Planet of the PDS, MAP2 is an on-line tool for extracting science-ready, map-projected images from global mosaics. The web service stores the mosaics in a searchable document management system or data portal called Astropedia (<http://astrogeology.usgs.gov>). Leveraging Astrogeology's ISIS3 (<http://isis.astrogeology.usgs.gov>), GDAL (<http://www.gdal.org>) and a local processing cluster [12], users can customize and download map-projected

image maps of Mars, Venus, Mercury, the Moon, four Galilean satellites (Callisto, Europa, Ganymede, Io), five moons of Saturn (Rhea, Dione, Tethys, Iapetus, Enceladus), and now the asteroid Vesta.

PDS Annex: Formerly Astropedia Annex, the PDS Imaging Node Annex is a data portal to allow the ingest and cataloging for derived geospatial products generated from PDS holdings for individual scientists. Examples of geospatial derived products are cartographic and thematic maps of moons and planets, local and regional geologic feature maps, topographic and perspective views of planetary landing sites, and tabular data containing unit information derived from planetary data. Many of these products have been developed as a result of NASA data analysis programs, often years after active missions (and their accumulating archives) have ended [13].

References: [1] Pieters, C.M. et al., 2009, *Science*, v. 326, #5952, pp. 568-572. [2] Dundas, C.M. et al., 2012, *Icarus* 220, pp. 124-143. [3] Robinson, M.S. et al., 2015, *Icarus* 252, pp. 229-235. [4] Dundas, C.M. et al., 2014, *JGR-P*, 119, 109-127. [5] Braden, S. et al., 2014, *Nature Geoscience*, v. 7, 787-791. [6] Gaddis, L., et al., 2014, USGS Open-File Report 2014-1056, p. 197-199. [7] Stanboli, A. et al., 2015, this volume. [8] Deen, B. et al., 2015, this volume. [9] Akin, S. et al., 2014, LPSC 45, abstract 2047. [10] Bailen, M.B. et al., 2015, LPSC 64, abstract 1074. [11] Wagstaff, K., et al., 2015, this volume. [12] Akins, S.W., et al., 2015, this volume. [13] Hare, T.M., et al., 2015, this volume.

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