ONLINE PLANETARY DATA AND SERVICES AT USGS ASTROGEOLOGY. T.M. Hare, L. Keszthelyi, L.R. Gaddis, and the Astrogeology Science Center, U. S. Geological Survey, Astrogeology Science Center, 2255 N. Gemini Dr., Flagstaff, AZ, 86001 (thare@usgs.gov).

Introduction: For the past 50 years [1], the USGS Astrogeology Science Center has been a resource for the integration of planetary geoscience, cartography, and remote sensing. Here we provide a brief overview of current Astrogeology software initiatives, planetary data products, online services, and infrastructure that support the global planetary science community (Figure 1, see also http://astrogeology.usgs.gov/tools).

Software Services: Astrogeology is a major contributor of software for cartographic data processing for NASA missions and research programs, including the Planetary Cartography and Geologic Mapping (PCGM) Program, Code S flight projects, research and data analysis projects, and the Planetary Data System (PDS).

ISIS: Integrated Software for Imagers and Spectrometers [2] is a specialized image processing package for working with planetary image data. ISIS is an open-source suite of processing tools for Linux and OSX that is designed to operate on single, multi-, and hyper-dimensional data collected by imaging spectrometers. The ability to process data from NASA spacecraft missions such as Voyager, Viking, Galileo, Mars Global Surveyor, Cassini, Lunar Reconnaissance Orbiter and Messenger, uniquely positions ISIS as a key planetary data processing tool.

GDAL: The Geospatial Data Abstraction Library, released by the Open Source Geospatial Foundation (OSGeo), offers powerful planetary data conversion and processing capabilities. GDAL is a format translation library written in C++ for geospatial raster and vector data [3]. In 2007, we updated the ISIS2 and Planetary Data System (PDS) reader and added support for the ISIS3 format. Any application which supports the GDAL library can now easily recognize these planetary data formats, including the planet definition, projection parameters, and label information like pixel offset and multiplier. Some popular applications with GDAL support include, QGIS, MapServer, Esri's ArcMap, Opticks, and GMT. For applications that do not use GDAL directly, the bundled routines released with GDAL can be used to convert ISIS and PDS data into well-supported geospatial formats like GeoTIFF, GeoJPEG2000, ENVI, NetCDF, and FITS.

OpenLayers Planetary Extensions: OpenLayers is an open-source JavaScript library for displaying spatially enabled data in web browsers. Astrogeology has developed and supports several OpenLayers extensions to properly display planetary bodies, including the use of either planetocentric or planetographic latitudes, positive-east or -west longitudes, and correct measures and scale bars.

Infrastructure Services: Several behind-the-scenes online services and databases provide essential support for planetary data access and processing. The databases, described below, use the open-source PostgreSQL database and PostGIS extension for added geospatial support.

UPC: The PDS Unified Planetary Coordinates database standardizes numerous disparate planetary orbital datasets into a single coordinate system (per body) and simplifies data identification and delivery for users [4]. The UPC has two main parts: (1) a spatial database containing improved geometric and positional information about planetary image data that have been computed using a uniform coordinate system and projection onto a common (preferably 3D) planetary surface shape, (2) a process by which continual maintenance and updates to the content of the database are performed.

Astropedia Data Portal: Astropedia is a secure long-term access and storage facility for high-level planetary cartographic data products [5]. The core functionalities of Astropedia support single and bulk data ingestion methods, metadata parsing, cataloging services, website content management, and a local data storage repository.

Astro Web Maps: Astrogeology Web Mapping Services (WMS) and Web Feature Services (WFS) are based on Open Geospatial Consortium standards and allow capable mapping clients to view full-resolution global and polar base maps and access geospatial databases. In short, a WMS service accepts queries for map-projected layers and returns requested data in an image format (e.g., JPEG, PNG). A WFS service returns geographical features representing data such as a name, type, and the spatial geometries (point, line, or polygon). Our services currently support more than 100 image layers and over 30 different planetary bodies [6]. Besides being publicly available, these services are critical for many of the other sites noted here. For GIS users, these layers are also listed on the Esri's ArcGIS Online data portal under the Planetary GIS Group.

PMAPS: The Astrogeology Planetary Maps and Ancillary Products and Services (PMAPS) system provides supporting infrastructure for our online data services.

Planetary Nomenclature: This gazetteer contains detailed information about all names of topographic and albedo features on planets and satellites (and some planetary ring and ring-gap systems) that the International Astronomical Union (IAU) has named and approved since its founding in 1919 [7]. The database provides support to online services, such as our WMS, to uniquely identify features on the surface of a planet or satellite.

Planetary Geologic Mapping: This web site provides access for mappers to lists of completed geologic maps, maps currently in progress, and regions which are not yet funded. Maps are displayed using our WMS base map layers and customized OpenLayers planetary interface.

PILOT: The Planetary Image LOcator Tool [8] is a search tool for the UPC database. PILOT provides SPICE-corrected image locations (footprints), displayed over our WMS base maps using the customized OpenLayers planetary interface, search capabilities using a navigable map and user definable image constraints (e.g., incidence angle, solar longitude, spatial resolution). PILOT directly integrates with POW, above, to facilitate bulk downloads and/or image processing.

POW: The Map Projection on the Web service [9] allows users to convert raw PDS images to science-ready, map-projected products. POW integrates PILOT and the UPC, ISIS3, GDAL, and the Astrogeology processing cluster for its processing needs.

MAP2: Map-a-Planet 2 [10] is a major update to the popular Map-a-Planet web site. Both services allow global, map-projected image products to be re-projected, stretched, clipped, and converted into a variety of useful image formats. This service leverages the capabilities of Astropedia, ISIS, GDAL and the Astrogeology processing cluster.

The Annex: The PDS Imaging Node Annex for Geospatial Products utilizes the Astropedia data portal and is geared toward helping planetary researchers release derived geospatial products created from archived PDS data. Examples of such products are cartographic and thematic maps, 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 likely have been developed as a result of NASA data analysis programs, often years after active missions (and their accumulating archives) have ended.

The Future: The large variety of planetary data and services provided by Astrogeology has evolved to meet the cartographic and scientific needs of planetary scientists. Services and tools have been built by cartographic and software experts to support the unique characteristics of planetary data and these are integrated under the PMAPS banner. This overview is intended to provide context and background for users of these products, and to guide them as to which service to use depending on their specific needs.

References: [1] Keszthelyi, L., (2013), LPI Bulletin, #135, 2-6 [2] Keszthelyi, L., et al., (2014), this volume. . [3] Hare, T.M., et al., (2007), LPSC 39, abs #2536. [4] Akins, S.W., et al, (2009), LPSC 40, abs. #2002. [5] Bailen, M.S., et al, (2014), this volume. [6] http://astrodocs.wr.usgs.gov/index.php/Webservices [7] Blue, J.., et al, (2013), LPSC 45, abs. #2178. [8] Bailen, M.S., et al, (2013), LPSC 45, abs. #2246. [9] Hare, T.M., et at., (2014), this volume. [10] Akins, S.W., et at., (2014), this volume. [11] Hare, T.M., et al, (2013), LPSC 45, abs. #2044.

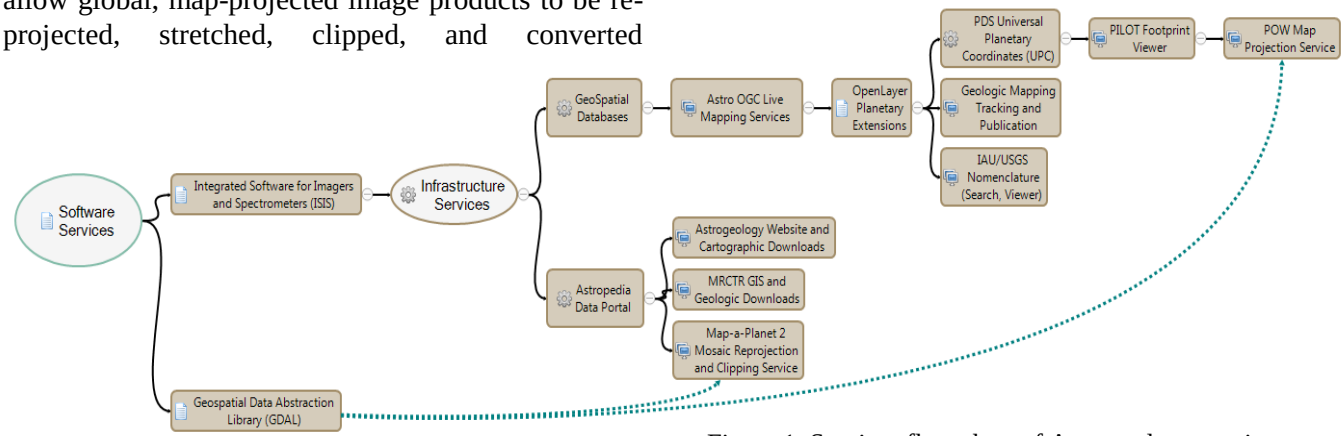

Figure 1. Services flow chart of Astrogeology services.