A CASE FOR A PDS SUPPORTED CARTOGRAPHIC RASTER LIBRARY. Trent M. Hare. U. S. Geological Survey, Astrogeology Team, 2255 N. Gemini Drive, Flagstaff, AZ 86001, USA, thare@usgs.gov.

Introduction: Over the last decade, the Planetary Data System (PDS, [1]) has rapidly evolved to keep pace with advances in technology and mapping applications. To do so, PDS has implemented many necessary changes like format updates, methods to handle increasingly large data volumes, and supporting various 'flavors' of Internet access and distribution. The prime directive for the PDS is to archive the raw Engineering Data Records (EDRs) in perpetuity. However, one of the most subtle, but nonetheless important changes for PDS, particularly the Imaging Node, was the acceptance and distribution of map projected (cartographic-ready) single frame images and not just EDRs or derived mosaics.

This change requires us as a community to reevaluate how these derived products should be released to the science community; the goal being an interoperable format or a community supported library such that existing geospatial utilities and applications can directly (or indirectly) utilize them. Fortunately, an international group has been created, called the International Planetary Data Alliance (IPDA), to help discuss and resolve some of the issues that arise when implementing a new technology and data format [2]. Here, I would like to discuss some of the topics the IPDA working group and the PDS should consider.

Rationale: It has long been recognized that existing geospatial technologies, like Geographic Information Systems (GIS) and Remote Sensing (RS) tools, whether they are open source or commercial, are invaluable tools for planetary science [3,4]. These tools allow researchers to efficiently manipulate, capture, update, fuse, analyze, and display all forms of geographic data. However, the value of these tools (and in some cases the science) are greatly reduced if the data are not made readily usable. To help boost science return, all surficial planetary data (images or data collected of a planetary surface) should be systematically processed in a coordinated manner (e.g. radiometrically calibrated and when needed cosmetically enhanced) and made available spatially registered in an easily accessible map projected form and format. Some of the topics needed to make this a reality include (1) reviewing cartographic map projections, (2) reviewing data formats and services, and (3) support for a generic planetary image library; where the latter can actually help to tie the first two topics together.

1.) Use Well Known Map Projections.

There are already many products in the PDS that use specialized projections or unique parameters which can only be transformed into a more interoperable form using specialized software or require the user to have an intimate knowledge of the data. Using these non-standardized data products across the wide variety of planetary capable scientific applications can be difficult and time consuming. This includes issues like non-standardized radius values, planetocentric versus planetographic latitude systems, atypical rotation parameters, and even unique projection equations.

Thus if PDS data is to be released in a geo-located map projected form, then it should be in a very well known and widely used projection. This can potentially lessen the scientific integrity (i.e. more distortion in image) but the original EDRs would be available for those who must maintain the perfect scientific results. The result of implementing this approach will be more directly usable (a.k.a. interoperable) and should greatly increase their overall research value for the scientists and the public alike.

One could argue that the Earth community has already been down this road and realized the necessity for a simple and well understood projection. Many global Earth-based data repositories store the data referenced to WGS84 (decimal degrees) or Universal Transverse Mercator (UTM). Originally, this also was not the case for Earth products but over the last decade these reference systems have become the most prevalent.

2.) Standardized File Formats

It has always been difficult to try to pigeon-hole planetary data into existing formats. For the raw EDRs this is fittingly true, however, for derived map projected PDS products, using standardized geospatial image formats is feasible and can be very beneficial. In recent years, the PDS has approved the use of the JPEG2000 format. Fortunately, this format also supports an embedded geospatial header. When applied, this format is informally called GeoJPEG2000 (also GeoJP2™). For the geospatial information, the GeoJPEG2000 format uses the same header made popular by the Geotiff standard to store the particulars of the image's spatial location, pixel size, and map projection parameters. In 2008, the HiRISE team was the first mission to release their map-projected PDS archive using a hybrid method which combines the use of the GeoJPEG2000 standard and a detached PDS label [5,6]. The simple text PDS label is necessary to hold image specifics not suitable for the geospatial header but required by the instrument team. This allows the team to support geospatial applications and their required PDS parameters at the same time.

While this hybrid approach sounds like the best of both worlds, the JPEG2000 format does not yet support 32-bit floating point values, although it is part of the specification, and there are other PDS products that may simply not work well in this format. To better support PDS formatted images, a long-term funded library to read the images should also be supported.

3.) IPDA/PDS Supported Image Library: Above, a case has been made for all derived PDS products to use simple projections and more standardized formats, however, it is understood this may not ultimately be ideal for all geo-located PDS holdings. If a mission requires a specialized form or format then the PDS or the instrument team should support these routines (i.e. source code) necessary for conversion or transformation. However, this should not be a single one-off application for a particular data set, but the incorporation of their source code or methods within a PDS supported library for all to utilize within their own infrastructure. This allows the code to be updated and enhanced as the library evolves. Currently, the PDS does support the Nasaview application and while this image viewer is necessary, it does not allow one to maintain higher order bit types, geospatial information, batch conversion, or the ability to use the source within one's own application. Fortunately, there exists a library which could meet these needs called the Geospatial Data Abstraction Library (GDAL) [7].

GDAL: GDAL is a translator library for geospatial raster formats. It provides a single abstract data model to read and write geospatial raster data. It is community maintained and released under an X/MIT style Open Source license. While written in C++, it has bindings for use within JAVA, PERL, Python, .NET and others. GDAL comes with an assortment of stand-alone utility applications for conversion, projection transformations, scaling, stretching, etc. but the real power comes from the application programming interface (API) which allows many other applications and simple image viewers to use the library internally. These attributes make it a perfect fit for long-term support by the planetary community and as an official library for the PDS.

While GDAL already has basic support for several planetary formats including PDS, Integrated Software for Imagers and Spectrometers (ISIS) [8], and Flexible Image Transport System (FITS) formats, there are many improvements that should be made. Also, this library is truly meant for map projected data sets but the PDS could also consider including PDS EDR conversion support.

Thus if specialized parameters or projections are required by an instrument team, then they should be implemented and released within the GDAL library or other library supported by the PDS. This also holds for any newly created PDS formats that the future may hold. In summary, this would give the planetary community a single, open source, and multi-platform library to utilize within their own processing packages or image viewers that is maintained by the whole community.

NAIF - A Successful Architecture to Emulate: Nearly all modern planetary missions utilize JPL's excellent navigation and instrument toolkit called SPICE, by the Navigation and Ancillary Information Facility (NAIF) [9]. SPICE stands for Spacecraft Planet Instrument C-matrix Events and in short assists scientists and engineers in planning and interpreting scientific observations from space-based instruments. Although probably underfunded, there is yearly support from NASA's Planetary Science Division and current planetary missions. While utility applications are available, the major reason SPICE has been such a success is the ability for external facilities to make use of the libraries within their own applications. Like GDAL, SPICE is purposefully generically written and may be used within many computing environments.

Conclusion: Data dissemination will continue to be a challenge for the planetary community. By supporting a long-term PDS raster library for planetary geospatial holdings, the community can help create an environment where planetary data is more readily usable by existing mapping applications and more easily available to researchers and the public.

In closing, and in the context of supported PDS formats and libraries, there should also always be a discussion of real-time web mapping services. Many facilities in the planetary community have embraced support for Open Geospatial Consortium (OGC) web services including WMS, WFS, KML, etc. [10]. In short, services built using OGC technologies, allow one to stream geospatial raster and vector data sets across the Internet to mapping applications or simple web browsers. For more on this topic please review [11-14].

References: [1] PDS, http://pds.jpl.nasa.gov/. [2] IPDA, http://planetarydata.org/. [3] Hare, T.M, et al., (2009), Extraterrestrial GIS chapter, Manual of GIS, ASPRS, ISBN: 1-57083-086-X. [4] Hare, T., et. al., (2008), LPS XXXIX, abs. 2536. [5] McEwen, A. S., et al., (2007), J. Geophys. Res., 112, E05S02, doi:10.1029/2005JE002605. [6] Castalia, B., (2008), LPS XXXIX, abs. 2484. [7] GDAL, http://www.gdal.org/, [8] Anderson, J. A., et al. (2004) LPS XXXV, #2039; Becker, K. et; al., (2007) LPS XXXVIII, #1779, [9] NAIF, http://naif.pds.nasa.gov/. [10] OGC, http://www.opengeospatial.org/. [11] Akins, (2010), this volume, [12] Hare, T., et. al., (2006), LPS XXXVII, abs. #1931. [13] Plesea, L., et. al., (2007), ISPRS WG IV/7. [14] Dobinson, E., et. al., (2006), LPS XXXVII, abs. 1463.