PLANETARY GIS UPDATES FOR 2007. T. M. Hare[1] and L. Plesea[2], [1]U.S. Geological Survey, 2255 North Gemini Drive, Flagstaff, AZ, 86001, [2]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, California 91109-8099, thare@usgs.gov.

Introduction: This year we have seen many new technical innovations for planetary Geographic Information Systems (GIS). These major developments include: (1) enhancements to the JPL planetary Web Mapping Services (WMS), which now supports optimized tile and Google KML support; (2) new support for Integrated Software for Imagers and Spectrometers (ISIS) [1] version 3 format and updates for the existing ISIS2 and basic PDS formats within the Geospatial Data Abstraction Library (GDAL) [2-4]; (3) geographic header support for the Planetary Data System (PDS) released HiRISE images [5].

Supporting GIS tools and web services in the planetary community will continue to be more important. A key objective for the upcoming NASA Lunar missions is to have these tools and capabilities embedded into the foundation from the start.

1. Tiled WMS – KML: There has been a great increase in the interest for web based interactive map browsers, Google Earth/Map, WorldWind and WorldKit being well known examples (fig. 1). Some of these applications are applying the same method to other planets, as MrPrism [6] and American Museum of Natural History's UniView [7]. Requests from such interactive map viewers follow a pre-programmed access pattern or can be configured to use such a pattern.

These application can easily use planetary WMS, but the performance is not optimal, due to the large number of image requests that need to be produced by the server. The JPL OnMars/OnMoon WMS server architecture is reasonably good for this type of use, having a response latency of about two seconds and can handle a couple of users on the existing hardware platform without overloading. Obviously this level of performance is not sufficient for an open, public access application, and a better solution is needed.

A higher performance level can be achieved by eliminating the need for server side processing, essentially having pre-computed image replies to a predefined set of requests. We have proposed and implemented an extension to the WMS standard that allows the server to expose the set of requests that provide a faster response time, essentially a tiled WMS capability.

This is done by adding a new metadata request, <GetTileService>, which returns an XML encapsulated list of WMS requests. These requests can be directly used by a client application, and the complete coverage area can be accessed, by stepping and repeating the coordinate values within the pattern. The map image transfer itself is indistinguishable from normal WMS, making it possible to implement server side tiled WMS support for an uncooperative client. Since the requests have to be WMS compatible, planetary coordinate reference systems (CRS), multilayer requests and all the WMS functionality can be supported using this protocol.

A related subject is the handling of Google's KML specification, which is currently being considered for adoption as an OGC standard. WMS can simply be integrated in KML, by including the proper WMS request as an overlay URL in the KML. Furthermore, the super-overlay mechanism present in KML can be used to map an existing tiled WMS set, allowing a tiled WMS server to support clients with KML support. Since a KML request itself can have parameters, the set of WMS parameters can be used, making the translation between KML requests and WMS requests trivial. The OnMars and OnMoon planetary WMS servers implementation of this translation is integrated with the tiled WMS. Working Examples of this KML integration are available on the OnMars and OnMoon web pages, and can be used within the globe application Google Earth and hopefully to be soon released globe support for Mars and The Moon within the Google Earth application.

Lastly, KML can also be supported as a WMS response format, which makes it possible to extend the use of a WMS server for many more features such as vectors and labels, which could prove very useful for planetary mapping, especially as the number of applications supporting KML is increasing. For example, members of the HiRISE team have released image footprints in KML for HiRISE and CTX (fig. 1) [8]. USGS's Pigwad web site will also host many geologic, structure, crater, and other morphological layers in KML format [9].

2. Planetary support within GDAL: GDAL, released by the Open Source Geospatial Foundation (OSGeo), is a format translation library written in C++ for geospatial raster and vector data sets [2-4,11]. This year we have added support for the ISIS3 [1] format as well as updates to an ISIS2 reader and a simple raw-only Planetary Dataset System (PDS) reader. Any application which supports the GDAL library can now easily understand these formats including the planet definition, projection parameters, and label intricacies like pixel offset and multiplier. Some popular applications with GDAL support include GRASS GIS, Quantum GIS, University of Minnesota's (UMN) MapServer, ESRI's ArcMap©, etc. For applications that do not use GDAL, the bundle routines released with GDAL can be used to convert the ISIS and PDS formats into many well supported geospatial formats like GeoTIFF, GeoJPEG2000, HDF, ENVI©, and many others.

Also included this years release is the IAU2000 based projection codes which reference a list of Well Known Text (WKT) planetary projection definitions for use within the library [10]. WKT strings are a verbose listing of the CRS. Here is the IAU2000 WKT for Mars:

```
GEOGCS["GCS_Mars_2000",DATUM["D_Mars_2000",
SPHEROID["Mars_2000_IAU",3396190.0,
169.89444722361]],PRIMEM["Reference_Meridian",0.0],
UNIT["Degree",0.0174532925199433]
```

This will more easily allows web services to recognize lengthy planetary projection definitions given a single code. Note that a side project for GDAL, called FWTools, includes a version of the UMN Mapserver software which should allow easy WMS server access to the IAU2000 planetary codes.

We felt it was extremely important to support an open source, multi-platform raster library and because it has continued to rapidly mature and now supports more than 50 raster formats. Another code base under the GDAL umbrella, called OGR, also supports more than 20 vector formats. The GDAL/OGR library is widely recognized as the most popular geospatial raster library available. Major GDAL features as listed under the OSGeo website include [11]:

- Library access from Python, Java, C#, Ruby, VB6 and Perl.
- Vector data model closely aligned with OGC Simple Features.
- Coordinate system engine built on PROJ.4 and OGC Well Known Text coordinate system descriptions.
- Utilities for data translation, image warping, subsetting, and various other common tasks.
- Highly efficiency raster data access, taking advantage of tiling and overviews.
- Support for large files - larger than 4 gigabytes.

3. HiRISE Support for GeoJPEG2000: This year we worked with the HiRISE team and the GDAL team to add in a geospatial header into the currently plain PDS JPEG2000 released images. This was a large investment for the HiRISE team to implement within their existing processing pipeline. For map projected products, we have high hopes that this trend to support more geospatial-ready file formats will continue within the PDS. For example, the Lunar Reconnaissance Orbiter Camera (LROC) team is also looking at using JPEG2000 and with help from the HiRISE team could easily support the more capable GeoJPEG2000 images also.

Conclusion: For any of the topics listed above we would like to encourage more planetary community involvement. The tiled WMS specification has not been fully accepted and there is still time to suggest modifications. The planetary format readers within GDAL are all open source and thus can also be improved by the community. We already have plans to add more robust PDS support. Lastly, if you find the new PDS GeoJPEG2000 HiRISE images easier to use please let the PDS and HiRISE team know.

References: [1] Anderson, J. A., et al. (2004) *LPS XXXV, #2039*; Becker, K. J. et al. (2007) *LPS XXXVIII, #1779*; http://isis.astrogeology.usgs.gov/. [2] http://www.gdal.org/. [3] Erle, S., et. al., (2005). *Mapping Hacks*. O'Reilly. ISBN 0-596-00703-5. [4] Mitchell, T., (2005). *Web Mapping Illustrated*. O'Reilly. ISBN 0-596-00865-1. [5] McEwen, A. S., et al., *Mars Reconnaissance Orbiter's High Resolution Imaging Science Experiment (HiRISE)*, J. Geophys. Res., 112, E05S02, doi:10.1029/2005JE002605, 2007. [6] Brown, A.J., et. al., *MR PRISM - an Image analysis tool and GIS for CRISM*, ISPRS Working Group IV/7 Extraterrestrial Mapping, Advances in Planetary Mapping 2007, LPI, Houston, TX. [7] http://www.scalingtheuniverse.com.[8]http://www.orrery.us/node/54. [9] http://webgis.wr.usgs.gov.[10] Hare, T., et. al., (2006), LPSC XXXVII, abstract #1931. [11] http://www.osgeo.org/gdal_ogr.

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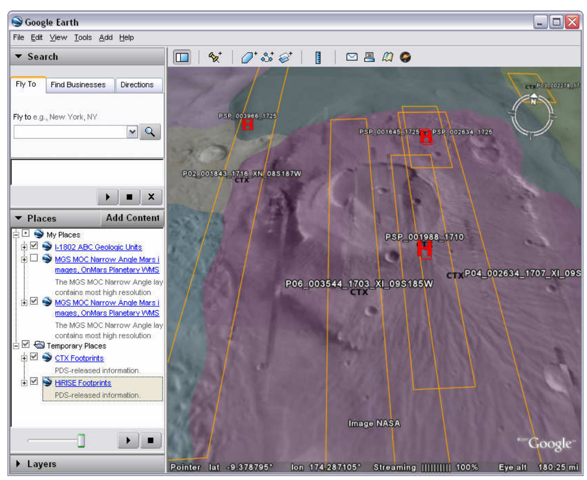

Figure 1. Google Earth zoomed to Gusev Crater on Mars. Layers loaded in the application include the USGS Mars Digital Image Mosaic 2.1 hosted via the KML (tiled WMS) capabilities on the OnMars JPL WMS server, HiRISE and CTX footprints hosted on the Orrery.us web site, and the I-1802 Mars Global Geologic Map hosted on the USGS PIGWAD site.