LUNASERV WEB MAP SERVICE: HISTORY, IMPLEMENTATION DETAILS, DEVELOPMENT, AND USES.
N. M. Estes, C. D. Hanger, A. A. Licht, E. Bowman-Cisneros, School of Earth and Space Exploration, Arizona State University, nme@ser.asu.edu

Introduction: The Lunar Reconnaissance Orbiter Camera (LROC) Science Operations Center (SOC) archives a large global dataset comprised of more than 900,000 observations with a released size of over 200 TB. The challenges associated with making this archive available are compounded by the fact that the LROC continues to acquire approximately 1000 new observations per day. Lunaserv enables the use of these data for LROC operations, LROC science team members, researchers, education, and public outreach. To facilitate all of these uses from a single source in multiple spatial reference systems and for a variety of clients to use, the LROC SOC selected the Web Map Service (WMS) standard from the Open Geospatial Consortium (OGC).

Existing WMS software, such as MapServer and GeoServer, render a wide variety of data, but in the context of planetary science, there are some important limitations in their capabilities. The limitations that most impacted the LROC SOC include accurate rendering of global datasets, support for the JMars software [1], support for the IAU2000 planetary spatial reference systems [2], and fast rendering of non-linear projections (ie. orthographic). The LROC SOC uses WMS software for context maps in the science team portal, full dataset browsing for the PDS data node, LROC operations, public outreach, and other analysis and research projects.

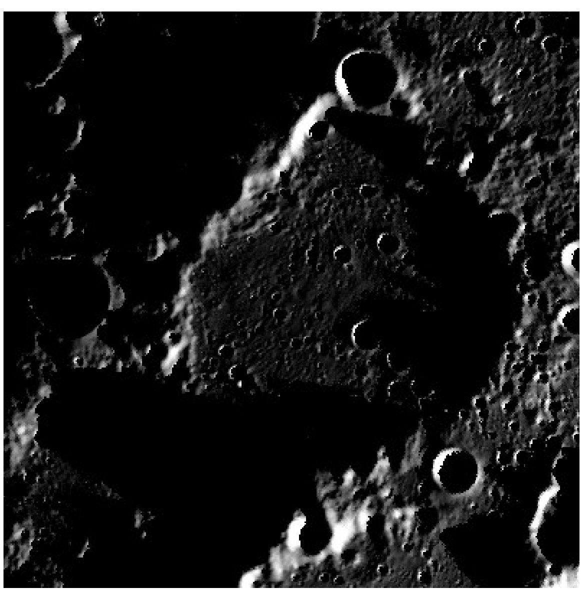

Figure 1: Lunaserv generated illumination map for 2012-357 22:00:00 based on GLD100 DEM.

Objectives: Lunaserv is designed to solve the problems and limitations of other WMS software in meeting LROC SOC requirements. Lunaserv also needs to be fast and agile to support real time web applications and demanding LROC SOC targeting requirements. When targeting using the JMars software, LROC operations staff can have ten or more map layers open. To fill the screen, approximately forty tiles per layer are requested from the WMS server, so even a small decrease in performance can compound into large delays.

Methods: The original implementation of Lunaserv (2009, version 1) was written entirely in the Ruby programming language using the Rails web framework (Ruby on Rails) for the HTTP interface. The current implementation (version 2) still handles the HTTP requests with Ruby on Rails, but layer rendering is now coded in C for performance reasons. The ability to render maps quickly in Lunaserv version 2 increases web responsiveness, decreases the time LROC operations staff waits for map tiles, and decreases the time it takes to render maps for off-line analysis. As an example of the performance gains, a detailed context map that rendered in 120 seconds in Lunaserv version 1 renders in just under 2 seconds in Lunaserv version 2. Global basemaps are stored in the pyramidal TIFF format due to the large size of global datasets and need for fast rendering at multiple resolutions. These base maps can be divided into any number of tiles to avoid the maximum size limitation of the TIFF format. The LROC

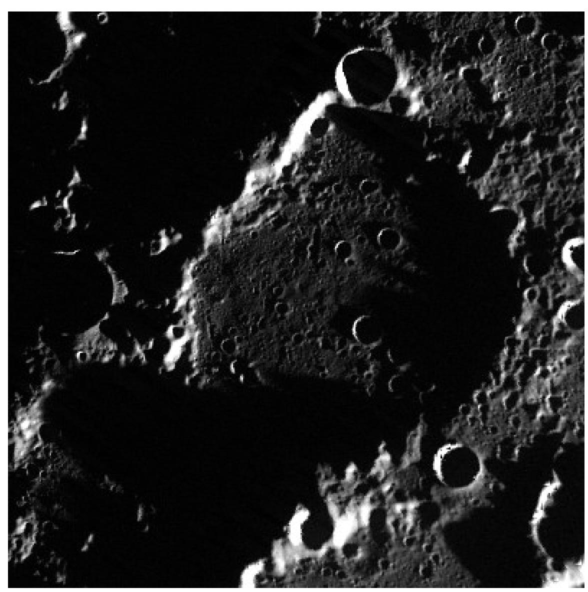

Figure 2: Mosaic composed of 12 WAC polar images taken on 2012-357.

SOC already produces pyramidal tiff products to enable high resolution browsing via the LROC PDS portal, so these same products are reused to support Lunaserv. Layers and projections are defined dynamically with YAML configuration files, and Lunaserv can render a variety of layer types such as raster, DB driven vector, shapefile driven vector, illumination, lat/long grids, and annotation.

Results: Lunaserv version 2 can render 256x256 pixel base map tiles in ~0.1 seconds including HTTP overhead. This rate can be sustained in parallel up to the number of CPU cores in the host. This rendering speed holds for all tested projections and is resolution independent. Whereas version 1 was not a true OGC WMS implementation [3], Lunaserv version 2 was tested successfully with Quantum GIS, ArcGIS, Google Earth, JMars, and in-house web clients.

WMS is a useful tool for exposing multiple datasets for research and analysis [4]. While most WMS users access the server with a GIS software package, Lunaserv can also be used as a standalone tool.

As an example of using Lunaserv as a standalone tool, a script iteratively calling out to Lunaserv can generate a time-series of detailed polar illumination maps from a DEM over an arbitrary timespan; this type of analysis is easier to perform without using a GIS software package. The shadowing in the DEM based illumination map accurately models the actual surface illumination at the requested time (Fig. 1, 2).

In addition to the original goal of supporting the LROC SOC, Lunaserv has proven capable of serving datasets for other planetary bodies as well. As a demonstration of this capability, Lunaserv currently serves layers for Mercury, Venus, Earth, the Moon, Mars, Io, Ganymede, Europa, Callisto, Rhea, Tethys, Iapetus, Dione, and Enceladus [5] (Fig. 3). In response to a WMS capabilities request, Lunaserv will enumerate only the spatial reference systems that are appropriate for the body that each layer represents, and a special URL can be used to limit the listed layers to a specific body.

Conclusions: Lunaserv has successfully met all of the original design objectives. As more capabilities get added to Lunaserv beyond the original requirements, such as the DEM based illumination layer, more types of research and analysis become possible within Lunaserv.

Future Work: Enhancements to Lunaserv are ongoing, and the LROC SOC is continuing to find new ways of leveraging Lunaserv for research, operations, and public outreach. In order to encourage cooperation between research groups and facilitate code reuse, the LROC SOC is working towards releasing Lunaserv as open source for anyone to use. The expected release date for Lunaserv is on or before 1 June 2013.

References: [1] Christensen, P.R., et. al., *JMARS – A Planetary GIS*, http://adsabs.harvard.edu/abs/2009AGUFMIN22A..06C [2] Hare, T. et. al., (2006), LPSC XXXVII, abs. 1931. [3] OGC, http://www.opengeospatial.org/standards/wms [4] Dobinson, E., et. al., (2006), LPSC XXXVII, abs. 1463. [5] Lunaserv, http://webmap.lroc.asu.edu

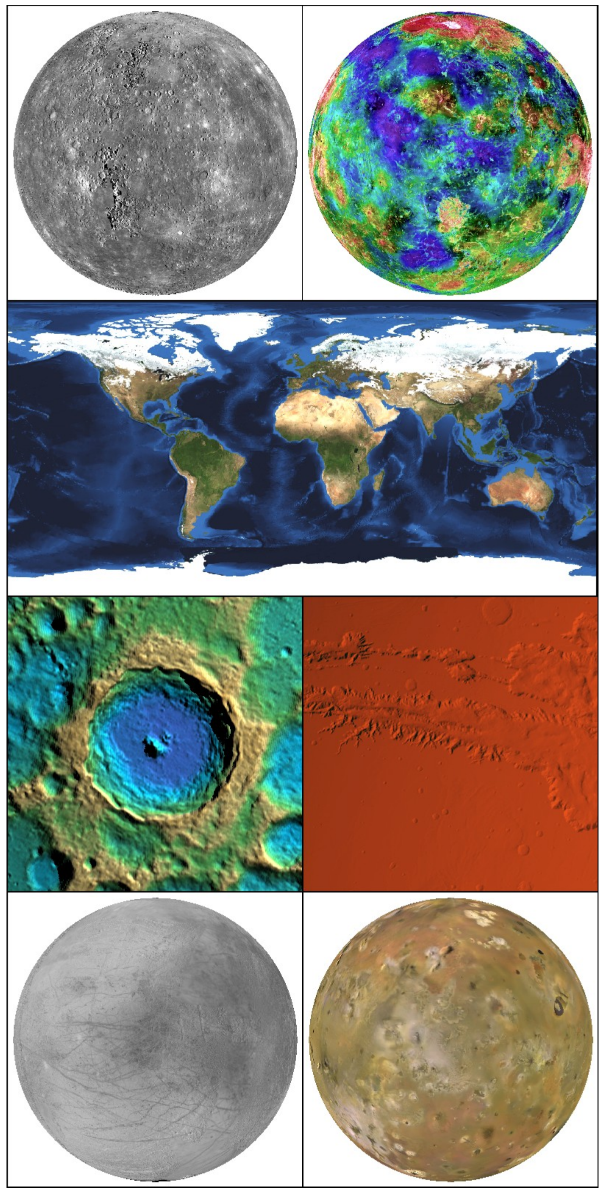

Figure 3: Mercury MDIS mosaic V8 in orthographic; Venus topology in orthographic; NASA's blue marble in EPSG:4326 (simple cylindrical); the Moon, Tycho illumination with GLD100 DEM over color shade; Mars, Valles Marineris illumination with MOLA DEM; Europa in orthographic; Io in orthographic