Lunar Geographic Information Systems (GIS) for Dataset Synthesis and Analysis

Response to "Request for Information (RFI): Developing a Strategy for Future Exploration of the Moon and Beyond"

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1. Introduction

GIS has become an increasingly valuable technology for researchers in the planetary sciences. It allows researchers to efficiently amass, manipulate, capture, update, analyze, and display all forms of geographic data. Use of GIS allowed planetary scientists to perform comprehensive mapping and analyses, sharing information, and aiding in landing site selections for robotic missions. GIS technologies should be used to support future lunar planning, scientific research, and most importantly as a tool for a safe, efficient and effective human return to the Moon and Mars.

2. Data

For any GIS to be successful, datasets must be well designed and accurately gathered, processed, and georeferenced. Thus, we cannot stress enough that a well organized and planned cartographic research program among closely cooperating facilities is an essential component of the development of an effective lunar GIS database. The Astrogeology Program of the U.S. Geological Survey has submitted additional RFIs on "Lunar Coordinates and Cartography", by Brent Archinal, and "A New Program of Lunar Geologic Mapping ", by Lisa Gaddis, to address these issues.

3. Data Accessibility

Dataset accessibility will always be a challenge for any field. In addition, multiple applications will require access to the same datasets to support the diverse activities needed for a planetary mission. The aim is to standardize the formats and/or data distribution mechanisms to allow many applications to utilize the same data in different ways. For on-line data distribution, there are currently many excellent planetary on-line mapping sites. A few of the facilities producing these applications are the Planetary Data System (PDS), USGS, NASA AMES Research Center, and Arizona State University. The ultimate goal for all these facilities to strive for is interoperability for their served on-line datasets. That will allow the end-user to load different co-registered layers from different facilities into the various specialized applications.

Fortunately, the planetary community – and in particular the planetary geoscience community – can benefit greatly from work already done by the Earth geospatial community. The OpenGeospatial Consortium (OGC, website: http://www.opengeospatial.org/) has developed a broad complex of specification and implementation that plays an increasingly important role in linking the similarly huge distributed reservoirs of Earth related geospatial data. With provenance dating from the early 80's, the OGC is now comprised of over 200 international government, university, and commercial organizations. In particular, NASA's Earth Science Enterprise – what is now the Geospatial Interoperability Office – has supported and been active in OGC development since 1994. A term used on the OGC website that describes this process is to "geo-enable" the Web.

Researchers at the Jet Propulsion Laboratory (JPL) and the USGS, with cooperation from other planetary facilities, are adapting the fast developing and well-supported OpenGeospatial standards and technologies for the access, processing, and display of geospatial data to the planetary domain. The basic motivation is that investigators need a unified methodology for accessing higher-level products that serve as substrate, background, and currently known detail pertinent to their ongoing work. The goal and promise is that anyone can build a specialized access points or 'clients' with the assurance that data stored and archived online will be available as a single point of access.

4. Proposed Infrastructure

Currently, the U.S. Geological Survey has proposed to the NASA Cartography Program to support lunar mapping and science data analysis, with the intention to develop a GIS compatible global lunar database. If funded, a variety of digital data for the Moon will be made available for download and hosted in an online mapping viewer. The assembly and distribution of these coregistered data in a consistent map-projected format will also help other facilities and research centers that are supporting upcoming lunar missions and targeting tools. We have proposed to NASA's Planetary and Geophysics Program that in FY07 we will add the following data:

- Global Lunar Orbiter mosaic at 60 m/pixel
- Selected individual Lunar Orbiter frames at high- and very high-resolutions
- Lunar Prospector global maps of derived elemental abundances
- Warped Clementine UVVIS and NIR bands (individual and color-ratios)
- Clementine derived parameter maps (e.g., FeO, TiO_2, optical maturity)
- Clementine lidar-derived products, current versions
- Latest USGS topographic maps
- Latest USGS control network maps and points
- Galileo SSI bands and color-ratio mosaics
- 3.8-cm and 70-cm radar
- Apollo Metric and Pan camera coverage maps
- Apollo historic 'Lunar Consortium' data (e.g., Al, Si, Fe, Ti maps from Apollo)
- Georegistered LAC charts and hotlinks to digital LAC charts (as scanned by the Lunar and Planetary Institute)
- Hotlinks to LPI images, including digital Apollo metric/pan images, Ranger images, Consolidated Lunar Atlas images, etc.

This infrastructure will need further support to include additional data from future Moon and Mars missions and enhanced applications to support human activities and resource utilization on the Moon.

5. GIS Tools for Manned Missions

It has long been recognized that geospatial technology such as that proposed for use in developing a lunar GIS can provide an invaluable tool for future lunar exploration. In FY05, USGS entered into partnership with Radiance Technologies (a small company based in Mississippi) to create a toolkit and decision support system for use in support of a human return to the Moon. Due to NASA cutbacks, the project was cancelled before the first year was concluded (see Press Release below). Tools such as these are crucial to build lunar and Martian bases to help ensure safe habitats. Through this Request for Information, we are hopeful that NASA will recognize the value of such products and tools, and it will take steps in the near future to continue their development.

From: http://www.directionsmag.com/press.releases/index.php?duty=Show&id=10681

Radiance Technologies Selected to Help with Future Space Exploration Using Geospatial Technology
November 28, 2004

In response to a Human and Robotics Technology Broad Agency Announcement (BAA), Radiance Technologies will develop a comprehensive Planetary Geospatial Exploitation Toolkit (PGET) that will enhance, apply and test geospatial technologies in support of sustained human space explorations to Mars and other destinations. Utilizing geospatial databases and real-time information, Radiance Technologies will develop a Decision Support System (DSS) to analyze situations, and present operators and managers with the information necessary to develop scenarios of solutions about the Lunar and Mars environment quickly and reliably.

"This project will impact NASA's spiral development approach long before we return to the Moon by being used as a planning and simulation tool by NASA engineers," stated Tom Strange of Radiance Technologies. "We will be providing a suite of geospatial decision support tools that will allow for efficient and effective conversion of geospatial data into mission-critical information."

The project will positively impact future space exploration by providing tools that will help with layout of facilities and infrastructure such as road networks and landing/launching pad locations. Other critical areas that will be addressed include resource tracking, personnel safety, and best route planning navigation for crew exploration vehicles.

The decision support tools will be built with current and enhanced geospatial technologies. The project will also employ additional advanced technologies including sensors, GPS, DSS, and secure and open communications. Training and support for the operators and system administrators are also included as key components for the PGET.

"Our evaluation team has carefully reviewed all proposals and we are extremely impressed and excited with the quality, broad range of technology, and relevance to the exploration mission," said Jimmie Nehman, Source Selection Official for NASA. "The future of the Vision for Space Exploration depends on our success [with these proposals]."

Radiance Technologies has partnered with several key organizations on this project including the University of Southern Mississippi Department of Geography; the U.S.Geological Survey's Astrogeology Research Program; Kennedy Space Center Launch/Landing and Surface Operation; and Johnson Space Center Human Exploration Office.

6. Recommendations

- Missions need to have a cartographic planning component, and they should follow a consistent cartographic coordinate system.
- Planetary data should be systematically processed in a coordinated way and made available in an easily accessed form (e.g., a GIS).
- Expand/connect planetary GIS-ready (OGC compliant) servers.
- Develop toolkits and decision support system for use in support of a human return to the Moon.
- As noted in Section 4, the current effort to create a Lunar GIS needs to be continued and greatly expanded in the future.