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Concept and Implementation of a Lunar Information System

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Background and Motivation

The current revival of efforts to reach the Moon by orbiting spacecraft and to perform scientific investigations from orbit clearly reflect the importance of the Moon as scientific as well as technologic target. Such undertakings have been planned in detail since the late 1950s and the current strategies of ESA and NASA aim at building lunar manned outposts until the mid 2020s [1]. Until recently, a multitude of spacecraft mission led by NASA (Lunar Reconnaissance Orbiter (LRO), Lunar Crater Observation and Sensing Satellite (LCROSS)), ESA (SMART-1), JAXA (Kaguya/Selene), the Indian ISRO (Chandrayaan-1) and the Chinese CNSA (Chang'e) space agencies were, are or will soon be in orbit above the Moon. Some of them have already collected a wealth of new instrument data that will become available in the next months.

Recent plans for future mission by CNSA involve several new orbiter and lander mission until 2013, sample returns in 2017 and possibly manned missions until 2025-2030. ISRO plans a Chandrayaan-2 rover mission for 2012; JAXA considers a manned mission until 2020 and currently work on designs for a lunar base in 2030; Russia as well as ESA also plan to return to the Moon within the next decades. Such recent efforts and endeavours are accompanied by agency-funded projects in order to make past lunar spacecraft data available to the general public and for future planning purposes. These projects involve the Lunar Orbiter Digitizing Project led by the USGS Astrogeology Research program [2] or the Digital Lunar Orbiter Photographic Atlas [3] and ongoing efforts by NASA Johnson Space Center and partners (ASU and LPI) to make the Apollo 15-17 Metric as well as Panoramic Camera data available to the public and interested researchers through the Apollo Image Archive [4].

Furthermore, the interest in the Moon and planetary exploration in general is also reflected by efforts led by NASA and Google to make image data available to the public in the course of 3D-flyover-tools, such as WorldWind [5] or GoogleMoon [6], respectively.

For the more scientific approach of data viewing, querying and basic analyses, the USGS Astrogeology Branch has been playing a major role in the planetary community by providing not only pre-processed data for download but also by employing a web-based GIS (the USGS Planetary GIS Web Server PIGWAD) to which one can connect either directly via web browser or via WCS/WMS services [7]. However, although state-of-the art technology has been employed for providing web-based information systems, all such systems lack the possibility of not only viewing and querying data, but also to add, analyze, model and as re-organize data. Although these issues are beyond the aim of such systems, such possibilities are of utmost importance for performing proper scientific analyses and modelling and for adding upcoming data as soon as it becomes available.

Terrestrial GIS technology is predominantly used for data organization, data revision, data modelling and data analysis in all sorts of scientific and public branches and it forms a well-established platform for planning purposes. Consequently, such possibilities can easily be transferred to other planning requirements, such as planetary landing site selection, planning of orbital imaging, or for data organization by means of large-scaled database systems. The fundament for such goals is the consistent and coherent storage of data within a proper geospatial context. In this way, a lunar IS, comprising of data from past lunar missions and providing a platform for incorporating new mission data, will be a valuable source of

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information for organizing data, planning of adequate landing sites for automated and manned missions, planning of areas suitable for the constructions of lunar bases, identification of resource potentials, and - most importantly - assessing possible hazards and economic risks.

Data Basis and Implementation

In the context outlined above we have been working on an implementation of a lunar IS within the commercial ArcGIS framework by ESRI for (a) building a consistent database of lunar mission data and file management infrastructure by means of geodatabases and by incorporating additional tools and routines for performing sophisticated analyses making use of different data types and a variety of scales, i.e. global scales for orbiting spacecraft to local scales for manned missions and experiments during the Apollo program. The implementation procedure is aiming at acquiring and referencing data obtained from various sources (USGS, Planetary Data System, Planetary Science Archive, mission/agency sources). This step involves consistency checks and - if possible and necessary - referencing data making use of the Unified Lunar Control Network 2005 [8]. By doing this we transfer data from a simple geographic coordinate system to properly projected data.

During the implementation we focus on consolidating datasets in sequence and by scale so that global datasets are treated first. In parallel, experiment data obtained from in-situ research as conducted by the Apollo astronauts will be transferred to a geodatabase. This will allow for receiving results by selecting certain surface experiments within the GIS. In the course of the implementation, new Apollo Metric and Panoramic camera data scans will become available which will be processed using the commercial ERDAS Imagine environment [9] in parallel to this effort. That way, additional orthoimage data and high-resolution terrain model data will become available. As an upcoming step, implementations of dedicated analysis tools and applications for planetary data analysis as outlined below will be performed. The system will then consist of ground-based data obtained by (a) Ranger (descent imaging animations), Surveyor (e.g., imaging and soil mechanics experiments), the Apollo and Luna programs (e.g., soil, geochemistry, solar wind), as well as orbital data from Lunar Orbiter (1966-67), Clementine (1994), Lunar Prospector (1998-99) as well as SMART-1 (2003-06) and other recent lunar probe data. Orbital data will not be restricted to imagery acquired during the missions but it will also consist of spectrometer, altimetry, and geophysical field data.

Applications

The GIS implementation will allow for performing, e.g.,
- detailed geologic mapping analyses with the help of combined datasets,
- spectral data analyses by means of established remote-sensing methods,
- landing site investigations and hazard assessments (covering geotechnical aspects),
- image-acquisition planning for future orbiter mission,
- absolute age determinations as derived from planetary chronostratigraphic methods.

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