

Proposal for a lunar geotechnical GIS

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ABSTRACT

The Lunar Mapping and Modelling Project (LMMP), (Cohen, et al, 2008) is a NASA led initiative with the aim to create a single, consistent, uniform, intuitive and easy to use NASA portal that accesses lunar mapping and modelling products, tools and media.

The USGS started with the foundation for such a system, known as PIGWAD (Planetary Interactive GIS on the web analysable Database).

It is clear that the nations of the world are going back to the moon in what is termed "The new Race for the Moon". The USA Government committed itself to billions of dollars for the Constellation programme which is the programme aimed at returning humans to the moon. The proposal currently in planning stages is to have unmanned and manned rover missions to the moon by 2012, the beginnings of an outpost by 2015, and the construction of a manned moon base by 2020.

To prepare for the ambitious international plans for advancing lunar research vast amounts of geological and topographical data need to be collected. Geotechnical properties of the lunar surface must be determined for rover mobility, and will also be required to determine construction methods and materials for a permanent moon base.

The GIS proposed in this project will contribute substantially to building the base of relevant data required to enhance and support future missions, target generation for mining of materials for the purpose of propellants, oxygen, construction materials and the planning of excursions as well as the construction of a permanent moon base.

Envisaged data layers to be collected include but are not limited to: Geology, Topography, Slope angle, Slope aspect, Surface roughness, Excavatability, Bearing capacity, Soil density, etc.

Once the abovementioned data, and other data have been collected and geo-referenced in a coherent GIS it would be possible to do GIS analysis of the various datasets, either separately or in combination.

Maps of resources could be created, as well as the most cost-effective paths for excursions, rover missions and travel paths between bases and sampling points. The inherent structure of a GIS allows several permutations of looking at available data.

Key words: Lunar, geotechnical, GIS, Moon base, space

INTRODUCTION

The Lunar Mapping and Modelling Project (LMMP), (Cohen, et al, 2008) is a NASA led initiative with the aim to create a single, consistent, uniform, intuitive and easy to use NASA portal that accesses lunar mapping and modelling products, tools and media.

The proposed Lunar GIS relies heavily on data obtained from the various satellites circling the moon currently and those scheduled for launch in the next few years.

Data will be analysed for various geotechnical and in-situ resource usage. The principle result of the investigation is a decision making tool in GIS format to support the selection of a permanent moon base as well as to determine least-cost paths to resources and experimental outstations.

METHOD AND RESULTS

The first step in any research of this kind always starts with a literature survey of available data. A vast amount

of data was amassed during the Apollo era and the years that followed until the present. Many thick volumes of articles had been written based on research on the data and samples collected from the lunar surface during the Apollo era and from observations earth-based observations.

Very few references however could be found on the use of GIS for lunar observation and or exploration. Interpretation of photographs taken of each landing site were done by hand and very few layers of information was overlaid to determine precise landing localities.

Although a fair proportion of the experiments executed on the lunar surface were focussed on the geotechnical information gathering, no reference to the use of GIS in geotechnical decision making for lunar exploration could be found in the literature.

The use of GIS in many everyday and geoscience fields is commonplace and range from site selection for geological exploration, the placement of a new franchise, utilities mapping in municipal areas and many more.

Similarly, GIS techniques had been researched and applied in earth-based geotechnical research and investigations. (Croukamp, 1998).

A proposal is made for the development of a Lunar Geotechnical GIS. The flexibility that modern GIS technology offers is ideal for use in geotechnical and other research, exploration and utilisation of the moon.

During the selection of a site for a permanent or temporary moon base a number of engineering properties of the soil and rock needs to be assembled and analysed separately and collectively. A GIS is ideally suited for this kind of analyses. The GIS therefore becomes a decision making tool in the selection of the optimal site for a moon base. At the same time, the same set of information combined with other important information layers such as mineral composition, occurrence locality, volume and concentration, etc. can be analysed with the GIS to determine best possible mining sites, either for In-situ Resource Utilisation (ISRU) as well as determine least-cost path to these resources around obstacles and impassable terrain. Scientific important sites could be built in as a parameter during the calculation of such optimal paths.

The data required for such a GIS covers a wide range of scientific fields and will start by collecting all currently available data and have the analogue data converted into digital format. New satellite missions currently circling the moon (Chandraan-1, Kayuga, LRO, etc) and future satellite missions planned for the near the next few years will further contribute to the data and information required to populate the GIS.

Several data layers are envisaged for such a GIS with the main data sets focussing on the physical properties such as:

- slope angle,
- slope aspect,
- geology,
- excavatibility,
- sun/shadow areas,
- topography,
- surface roughness,
- soil density,
- bearing capacity,
- etc.

Other layers that will enhance the decision making aspect of the GIS will include:

- resource type,
- resource locality,
- resource abundance,
- etc.

When combining the physical parameters with the latter data sets a manoeuvre ability map/s could be prepared for rover and manned missions to outposts, site selection of outposts, least-cost path to resource/outpost and optimal scientific localities.

The GIS should follow the criteria as set out by the Lunar Mapping and Modelling Project (LMMP), which is a NASA-led initiative. (Cohen, et al, 2008) The aim of this project is to create a single, consistent, uniform, intuitive and easy to use NASA portal that accesses lunar and mapping modelling products, tools and media. The USGS started the foundation of such a system, known as PIGWAD (Planetary Interactive GIS on the Web Analysable Database).

For such a GIS to be successful and follow the LMMP rules of being consistent and coherent, a good spatial reference needs to be created and used and such a reference framework will be created with the establishment of a Lunar specific GPS (or similar) system. The tracking of those satellites will need earth-based support and tracking such as Satellite Laser Ranging (SLR) and Lunar Laser Ranging (LLR). At the Matjiesfontein Observatory presently being developed in the Karoo, South Africa a SLR and LLR system will be deployed together with other co-located geodesy instruments.

As a very first start the GIS will be populated with the following data sets where available:

- Geology
- Surface roughness
- Topography
- Slope angle

- Slope aspect

- Potential for finding solutions for earth based geotechnical problems
- Design of future decision making systems

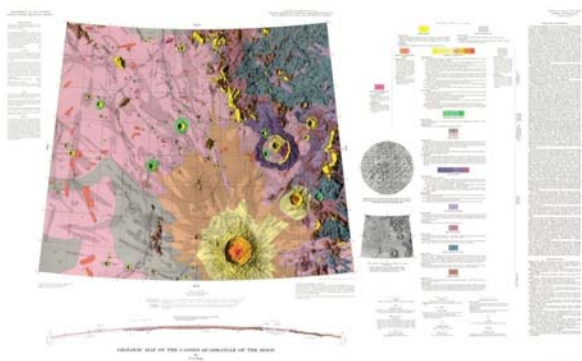


Figure 1. Example fo printed geological map of the Kepler Region of the moon.

Cohen BA, *et al*, 2008; The Lunar and Mapping and Modelling Project (LMMP), Lunar and Planetary Science XXXIX, 2008.

Croukamp. L (1998): An engineering geological information system for land-use planning in South Africa: Results from the Pretoria-Johannesburg region, 8th IAEG Congress, 21 - 25 September 1998, Vancouver, Canada.

Some information such as bearing capacity and soil density will be inferred from the interpretation of known geology and information gathered during the Apollo missions. This will allow for the creation of a probability map of certain geotechnical properties that could influence site selection of a moon base or manoeuvre ability of rovers and manned craft.

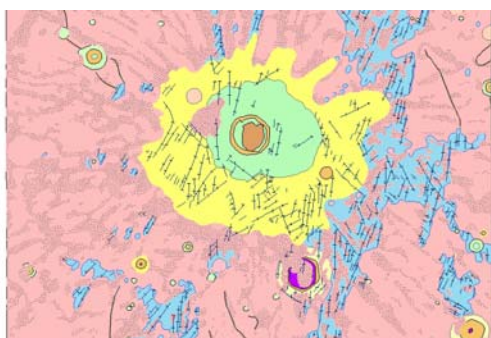


Figure 2. Sipliefied geological map of Kepler Region showing ray patterns as stippling

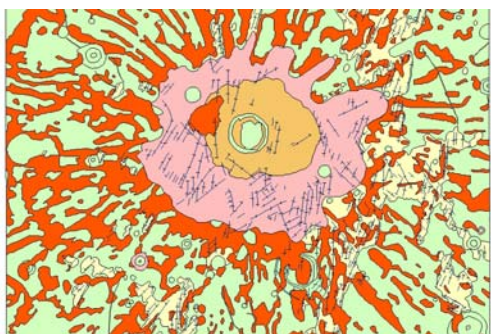


Figure 3. Surface roughness map derived from geological map and based on Apollo data

Financial spin-offs:

- GIS Service to other space fairing countries