



EARTH - MOON - EARTH:

THE GEOKNOWLEDGE PARADIGM

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“Che sulla luna... non intendo già come tuttalvolta che non vi si generino cose simili alle nostre”

(Galileo “Dialogo dei Massimi Sistemi”)

SUMMARY

The Moon Base Program represents an unique opportunity for humanity. It is a challenge that can be overcome thanks to the existing scientific and industrial competences and to the reuse of experiences already acquired in Space Exploration.

This paper deals with the Knowledge Segment in the Program, with particular emphasis to the paradigms of development and transfer of the knowledge, from the Earth to the Moon to support the process of colonization.

For Moon Base missions a geoknowledge approach is foreseen, similar to the one used on the Earth for the management of anthropic and natural processes.

We consider the Moon as the Seventh Continent of the Earth so maintaining the geoknowledge terminology for the Moon and so retaining ontology, semantics and methodologies used for the knowledge of the Earth. The geoknowledge of the Moon will be referred to Earth sciences (such as geophysics, geology, topography) and processes (such as mobility, production of energy, exploitation of soil resources).

The development of an infrastructure, both on the Moon and on the Earth, to support the Knowledge Segment is considered. Some of the relevant components are outlined in which the scientific and industrial Italian space sector can play a valuable role on the basis of actual competences and past experiences.

The development of a Web GIS infrastructure to share the knowledge of the Moon among various worldwide players involved in the Program is proposed.

In this context an early implementation of a Moon Portal is the key instrument to ensure the support by all stakeholders (government, science, university, industry, public opinion) who must share vision and objectives of Space Exploration.

INTRODUCTION

The Moon Base Program is an opportunity for mankind that cannot be missed, but at the same time it is a challenge that must satisfy the requirements of:

- Economic and industrial sustainability;
- Scientific and technological credibility;
- Accomplishment in a span not exceeding community's interest;
- Re-use of previously acquired experiences

Consistent with these mission requirements the following road-map has been hypothesized:

2008-2012	Moon Remote Sensing Missions
2012-2015	Robotic Missions for on site Observation and Survey
2015-2020	Man's Return to the Moon Missions
2020-2030	Activities on the Moon among which: <ul style="list-style-type: none">- Development of a Condominium of Large Observatories of Cis-lunar and Trans-lunar Space;- Development of test beds for the exploitation of resources and the production of energy on site, life sciences, CELSS.

The Program success will make available an intermediary platform for human voyages to Mars.

Two main segments can be identified in the Program:

- Colonisation Segment
- Knowledge Segment

both correspond to the same mission and timing requirements.

In the first Segment unmanned or manned objects will be transferred, in the second informations (from the Earth to the Moon and vice versa) will be transmitted.

In other words in the Colonisation Segment atoms will be transferred, while in the Knowledge Segment bits. Therefore the economic laws of ΔV and of distance (according to von Thunen) are not applicable to the Knowledge Segment.

This paper deals with the Knowledge Segment with particular reference to the paradigms of development and use of knowledge that must accompany the

life cycle of the colonisation process from the preparatory phase to operations.

The paradigms of knowledge have a circular course that has characterised the transfer of ICT applications from the Earth to the Space and from the Space to the Earth since the beginning of Space Exploration.

GEOKNOWLEDGE

The space mission contribution to knowledge up to now has mainly been spacecraft-centric. Both in manned and un-manned missions attention was concentrated on what happened inside the spacecraft and on what can be seen or "covered" by the same spacecraft.

For the Moon Base missions a different approach similar to that used to manage anthropic and natural processes based on the "geographic knowledge" will be necessary.

In this regard one could ask if from an etymological viewpoint one should not pass from the term "geography" ($\gamma\eta$ = earth) to "selenography". We consider the Moon as the Earth's Seventh Continent the colonisation of which would lead to enlargement of the ecumen. For this reason we maintain the ontology, semantics and methodologies used for the knowledge of the Earth, confirming Galilean intuition that "on the Moon.....things similar to ours are generated".

The knowledge of the Moon will be referred to Earth sciences (such as: geophysics, geology, seismology) and georeferenced processes (such as: mobility, exploitation of resources, production of energy).

The geographic knowledge of the Earth will also be enormously enriched by using the Moon as an ideal "long dwell" observation platform in the Earth's orbit not affected by sensor dimension or power supply limitations.

The Moon will supply a privileged observation point to continuously observe the planet Earth in the context of cosmic phenomena in the outer space (e.g. phenology of the magnetosphere, influence of Sun-Earth interactions on the climate), without resorting to Lagrangian missions that where necessary could be more effectively build up from a Moon base.

Further the presence of Observatories on the Moon, will allow the sphere of Homeland Security to be widened through the long distance identification and continuous tracking of potentially dangerous objects (such as meteorites and asteroids whose orbit intersects that of the Earth), otherwise hardly possible.

INFRASTRUCTURES FOR THE KNOWLEDGE SEGMENT

The Knowledge Segment must be equipped with infrastructures on the Moon to support the robotic and in situ observation phases as well with infrastructures on the Earth to collect and process data from the Moon; among these we would point out the following:

MOON INFRASTRUCTURES

To support deployment of the Knowledge Segment it is necessary to:

- i. Develop a Communication and Positioning satellite constellation in the moon's orbit to:
 - ✓ Provide Wide Band communications between fixed and mobile points Moon - Moon and Moon - Earth, including the "back side" of the Moon;
 - ✓ Permit the precise navigation of men, robots and vehicles and the positioning of structures on the moon's surface, to carry out the mission activities.

- ii. Develop high resolution Moon Observation missions, in particular through active and passive microwave sensors to characterise the moon's soil and subsoil from a geophysical and geological viewpoint and exploit the local natural resources.
- iii. Develop cooperative missions for the Condominium of Large Observatories on the Moon.

EARTH INFRASTRUCTURES

Facilities capable of supporting the following activities must be made available for:

- i. Collection and processing of lunar data

The relevant activities foresee:

- ✓ The use of VLBI (Very Long Base Interferometer) to link the earth reference system to the lunar reference system through the fixed star system;
- ✓ The use of SLR (Satellite Laser Ranging) techniques that through moon tracking capability permits the positioning of retroreflectors on the moon to establish a networks of geodetic reference points on the Moon's surface.
- ✓ The development and experimentation of Metrology Models to support precise navigation and positioning on the Moon's surface;
- ✓ The acquisition and processing of Moon Observation data and data collected from the Moon Observatories Condominium.

These activities to support the Moon Mission can be performed using and expanding the systems and operative capabilities of the "Giuseppe Colombo Centre" in Matera.

In this regard it should be remembered that the Matera Centre began its activities in 1983 through a cooperative Program with NASA under the scientific guidance of Bepi Colombo. A renewed collaboration with the USA, within the sphere of Space Exploration initiatives, could give the "Giuseppe Colombo Centre" a pre-eminent role in Usa - Italy - Europe cooperative activities, in a long-term prospective.

ii. Sharing and re-use of lunar knowledge

To share Moon Knowledge a GIS Web infrastructure has to be implemented. This infrastructure would link and integrate the involved Competence and Operative Centres through the Net Technology. This infrastructure will operate initially on the Earth and in the future will be extended on the Moon, in the framework of Moon Base missions.

The GIS solution is motivated by the fact that in a colonisation process all the information must have a geographic reference.

GIS portals make platforms available to bring geographic information to an ever wider audience, ensuring wide collaboration in the creation of the knowledge of the Moon. This new method of creating knowledge is enabled by development of the Net Technology. The Web is not only the point of interconnection for millions of people, but it is also the instrument of integration of resources and competences able to generate cognitive multiplication, based on sharing and re-use. The conceptual model of this GIS portal for the Moon (Moon Portal) could be the Federal Portal for the sharing of geographical information, created in the in USA with the "geospatial one-stop" philosophy.

CONCLUSIONS AND RECOMMENDATIONS

The success of this Conference will be commensurate to the extent of the collaboration initiatives among the principal leaders in Space Exploration (USA, Europe, Russia, Italy) that could be established in the short-term to keep the Moon Base Program in the time limits previously hypothesised. As far as the Knowledge Segment is concerned the Italian Space Sector could have an important role due to competences and experiences previously acquired.

Furthermore it has to be noted that the proposed Moon Base Program requires a considerable economic commitment that has to be supported by all the stakeholders (government, science, universities, industry, public opinion) which must share its aims and objectives. Therefore it is necessary to create a model to promote the awareness of the importance of Space Exploration into the culture of our Society.

For this reason it would be opportune to anticipate the deployment of the Moon Portal Web-GIS infrastructure to support sharing and re-use of available knowledge among the stakeholders and to attain the objectives of "The Inspiration Programme" for the new generations of researchers and students. ESRI Italia in collaboration with ESRI (Environmental Systems Research Institute) can contribute to an early creation of this Portal.