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Moon Trek: An Interactive Web Portal for Current and Future Lunar Missions

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Abstract

NASA's Moon Trek (https://moontrek.jpl.nasa.gov) is the successor to and replacement for NASA's Lunar Mapping and Modeling Portal (LMMP). Released in 2017, Moon Trek features a new interface with improved ways to access, visualize, and analyse data. Moon Trek provides a web-based Portal and a suite of interactive visualization and analysis tools to enable mission planners, lunar scientists, and engineers to access mapped lunar data products from past and current lunar missions.

1. Introduction

This presentation will provide an overview of the uses and capabilities of NASA's Moon Trek online mapping and modeling portal, a web based suite of data visualization and analysis tools designed to support mission planning, scientific research, and education/outreach.

2. A Comprehensive Online Web Portal

Moon Trek provides a suite of interactive tools that incorporate observations from past and current lunar missions, creating a comprehensive lunar research Web portal. The online Web portal allows anyone with access to a computer to search through and view a vast number of lunar images and other digital products. The portal provides easy-to-use tools for browsing, data layering and feature search, including detailed information on the source of each assembled data product and links to NASA's Planetary Data System. Interactive maps, include the ability to overlay a growing range of data sets including topography, mineralogy, abundance of elements and geology. Originally designed for mission planning, Moon Trek also addresses the lunar science community, the lunar commercial community, education and outreach, and anyone else interested in accessing or utilizing lunar data. Its visualization and analysis tools allow users to measure the diameters, heights and depths of surface features, perform analyses such as lighting and local hazard assessments including slope, surface roughness and crater/boulder distribution. Moon Trek features a generalized suite of tools facilitating a wide range of activities including the planning, design, development, test and operations associated with lunar sortie missions; robotic (and potentially crewed) operations on the surface; planning tasks in the areas of landing site evaluation and selection; design and placement of landers and other stationary assets; design of rovers and other mobile assets; developing terrain-relative navigation (TRN) capabilities; deorbit/impact site visualization; and assessment and planning of science traverses. Significant advantages are afforded by Moon Trek's features facilitating collaboration among members of distributed teams. Team members can share visualizations and add new data to be shared either with the entire Moon Trek community or only with members of their own team. Sharing of multi-layered visualizations is made easy with the ability to create and send URL-encoded visualization links. Moon Trek is also a powerful tool for education and outreach, as is exemplified by its being designated as key supporting infrastructure for NASA Science Mission Directorate's STEM Activation Initiative, and its serving of data to a growing community of digital planetariums.

Developed at NASA's Jet Propulsion Laboratory (JPL) and managed as a project of NASA's Solar System Exploration Research Virtual Institute (SSERVI) at NASA Ames Research Center, Moon Trek is a browser-based web portal. There is nothing additional to buy or install.

3. Moon Trek Enhancements

The new Moon Trek interface provides enhanced 3D visualization and navigation. Standard keyboard gaming controls allow the user to maneuver a first-person visualization of "flying" across the surface of the Moon. User-specified bounding boxes can be used to generate STL and/or OBJ files to create physical models of surface features with 3D printers. This interface will become the standard across all of the Trek products including the portals for Mars, Phobos, Vesta, and more.

Moon Trek offers additional data products and improved data analysis tools. As an example, a new surface potential analysis tool based on algorithms from the DREAM 2 SSERVI team led by William Farrell at NASA GSFC, will allow users to model effects of the plasma environment on the lunar surface.

The features of the new client are supported by significant improvements to the back end server infrastructure. A new automated pipeline facilitates the production of high-resolution mosaics and digital elevation models. In addition to the web-based client, Moon Trek's data is being served to exciting, new prototype clients including touch tables and virtual reality environments. An open set of APIs allows us to serve Moon Trek's data to a wide range of external clients and customers.

The Moon Trek team is currently working with the Astromaterials Office at NASA's Johnson Space Center to integrate their database of the returned Apollo lunar samples into Moon Trek. For a given sample, Moon Trek will display images and information about the sample, and allow the user to put the sample into context by providing visualizations of the location on the lunar surface from which it was retrieved. We plan to augment this with linkages to the Apollo Lunar Collection of the Virtual Microscope produced by JISC, The Open University, and The OpenScience Laboratory.

4. Summary and Conclusions

Moon Trek's new features make it especially useful for the planning of a new generation of lunar exploration missions, conducting a wide range of lunar science research, and facilitating exciting visualizations and exploration in the realms of education and outreach. Moon Trek is currently working with NASA and its Resource Prospector mission, KARI and its Korean Pathfinder Lunar Orbiter mission, and ESA in its range of upcoming lunar exploration. The user community is invited to provide suggestions and requests as the development team continues to expand the capabilities of Moon Trek, its related products, and the range of data and tools that it provides. As the EPSC community looks forward to a new generation of surface and orbital lunar robotic activities, as well as preparation for human return to the Moon, tools such as Moon Trek will become increasingly essential.

Acknowledgements

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The possibility of the existence of volatile compounds in the area of the proposed mission landing sites Luna-25

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Abstract

The possibility of the existence of hydrogen-containing compounds in the area of the proposed landing sites of the Luna-25 mission is investigated.

1. Introduction

Currently, as the possible landing areas of the mission Luna-25 (Luna-Globe), three areas are selected, located in the southern polar region of the Moon: the landing ellipses 1, 4 and 6. The landing ellipse 1 with its center at the point (68.8° S, 21.2° E) is located south-west of the Manzinus crater (67.3° S, 26.2° E), the landing ellipse 4 (coordinates of the center: 68.6° S, 11.6° E), is located northwest of the Simpelius A crater (69.9° S, 16.1° E), and the landing ellipse 6 with the center at the point (69.5° S, 43.5° E) lies to the south of the Boussingault crater (70.1° S, 53.4° E).

The neutron spectrometer onboard probe Lunar Prospector (LP) has revealed the decreasing of epithermal flux from the surface in this region, which was interpreted as of enhanced abundance of hydrogen: 61,9 ppm, 56,7 ppm and 77,9 ppm at ellipses 1, 4 and 6 respectively [1], at the average abundance hydrogen in lunar regolith about 50 - 55 ppm [2]. These results were supported by data from neutron spectrometer LEND of probe Lunar Reconnaissance Orbiter (LRO), which also observed the enhanced abundance of hydrogen in these regions 0,15% for ellipses 4 and 6 and about 0,12 ± 0,15% for ellipse 1 [1]. Such, the abundance of hydrogen in the region of ellipse 4 is near to the average value for the lunar regolith, but the hydrogen abundance at the ellipses 1 and 6 regions above. Deposits of volatiles compounds were revealed in permanently shaded areas in Cabeo crater during the impact experiment of probe LCROSS [3]. The water content in impact vapor estimated as 1,5 - 4 % according to I.G. Mitrofanov et al. [4] or 5,6 - 2,9 % to A. Colaprete et al. [3]. In addition to water, a number of other hydrogen-containing compounds, such as H_2, NH3, H2S, C2H4, and CH3OH, were discovered in the crater Cabeo.

Time the existence of such deposits is determined by the rate of their evaporation, which is a function of temperature. Earlier we conducted a study of the temperature regime and insolation of these landing sites [5]. According to these results, there are no permanently shaded areas in these regions and diurnal temperatures are exceeding 300 K. As the calculation results show, in the area of the landing ellipses 1, 4 and 6, the maximum temperatures are too high, and the deposits of volatile compounds similar to those found in the area of the Cabeus crater, including water ice, cannot exist on the surface.

The neutron spectrometer of the LP probe has received data on hydrogen content ~~for~~ in the upper layer of regolith with a thickness of 0.4-0.5 m. Information obtained by the LEND neutron spectrometer refers to ~~a~~ the soil layer with a thickness of 1-1.5 m. Thus, it can be assumed that the deposits of water ice or other hydrogen containing compounds can be under a layer of regolith with a thickness of 0.4 to 1.5 m. If the hydrogen in the area of the landing ellipses is in the form of water ice, its fraction should be ~ 1.2 wt% for the landing ellipse 1, and ~ 1.3 wt% for ellipses 4 and 6.

We investigated the rate of evaporation of water ice and such hydrogen-containing compounds as NH3, H2S, C2H4, and CH3OH in the areas of landing ellipses. The sublimation rate of deposits of substances under a layer of silicate material was calculated from the model of Schorghofer N., et al. [6]. Regolith has been modeled as consisting of two layers, similar to how it has been in calculating the temperature conditions [5]. It was found, that for the layer with a thickness of ~~a~~ 0.4 m, the lifetime of such deposits does not exceed 1 million years for the area of the landing ellipse 1, and 10 million years for the landing ellipse 4. A longer existence of water ice and other compounds (> 100 Ma) is possible in the area of the landing ellipse 6 (in its northeastern part) (fig. 1).

If the thickness of the shielding layer reaches 1,5 m, the lifetime of existence of the deposits of hydrogen-containing compounds increases to ≥ 10 million years in the area of the landing ellipses 1 and 4, and exceeds 100 million years in the area of the landing ellipse 6 (fig. 2).

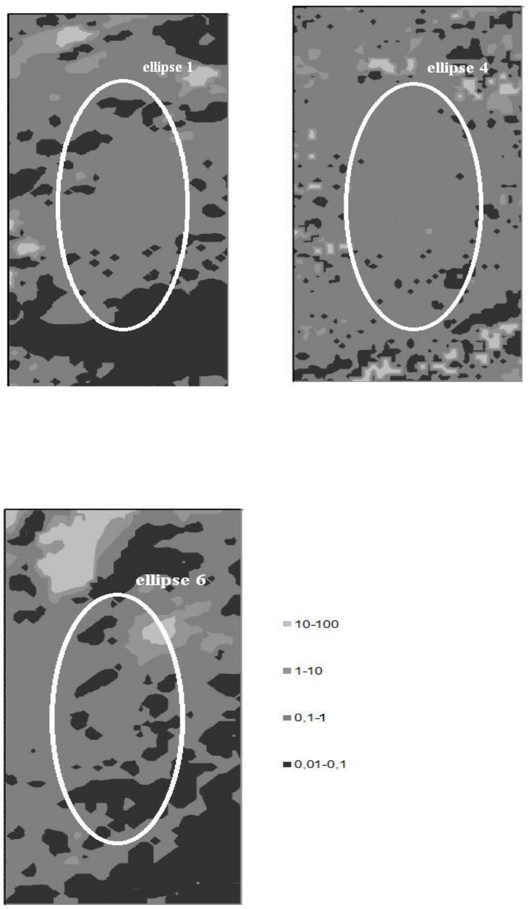

Figure 1. The time (in millions of years) of the existence of water ice deposits under a layer of regolith 0.4 m thick in the region of the landing ellipses 1, 4 and 6.

Summary and Conclusions

In this paper, we investigated the possibility of existence of the hydrogen-containing volatile compounds, similar to those found in the Cabeo crater, in the area of the proposed landing ellipses of the Luna-25 mission. We found that the existence of water ice and other hydrogen-containing substances is possible only in the presence of a shielding layer of regolith. The time of existence of such deposits does not exceed 10 million years for a layer of regolith with a thickness of 0.4 m and 100 million years for a layer of regolith 1.5 m thick.

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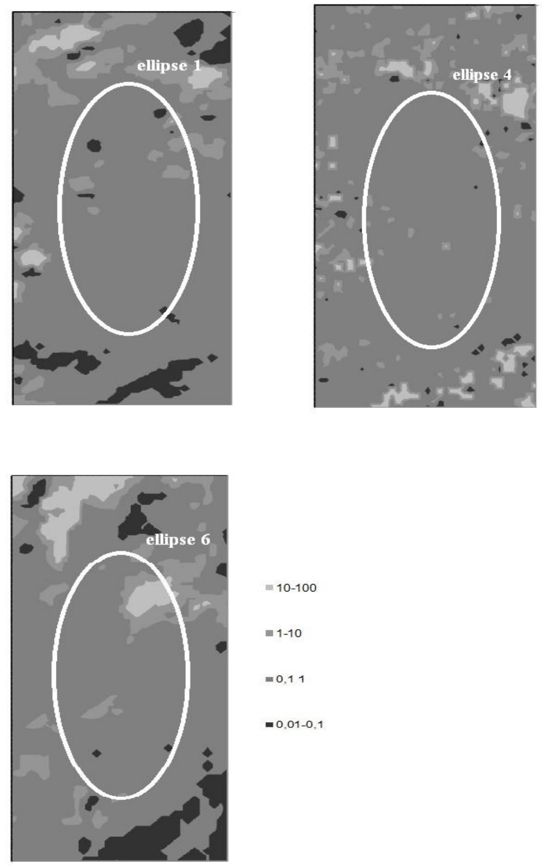

Figure 2. The time (in millions of years) of the existence of water ice deposits under a layer of regolith 1,5 m thick in the region of the landing ellipses 1, 4 and 6.

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International, private-public, multi-mission, next-generation Lunar/Martian laser retroreflectors

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Abstract

We describe an international, private-public, multi-mission effort to deploy on the Moon next-generation lunar laser retroreflectors to extend (also to the far side) the existing passive Lunar Geophysical Network (LNG) consisting of the three Apollo and the two Lunokhod payloads. We also describe important applications and extension of this program to Mars Geophysical Network (MGN).

1. Goals and Opportunities

Since the 1970s Lunar Laser Ranging (LLR) to the Apollo/Lunokhod Cube Corner Retroreflector (CCR) arrays supplied some of the best tests of General Relativity (GR): possible changes in the gravitational constant, weak and strong equivalence principle, gravitational self-energy (PPN parameter beta), geodetic precession, inverse-square force-law. LLR has also provided significant information on the composition of the deep interior of the Moon. LLR physics analysis also allows for constraints on extensions of GR (like spacetime torsion) and on new gravitational physics that may explain the gravitational universe without Dark Matter and Dark Energy (like Non-Minimally Coupled gravity). LLR is the only Apollo/Lunokhod experiment still in operation. In the 1970s LLR arrays contributed a negligible fraction of the ranging error budget. Since the capabilities of ground stations of the International Laser Ranging Service (in particular APOLLO in USA, Grasse in France and MLRO in Italy) improved by more than two orders of magnitude, now, because of the lunar librations, current CCR arrays dominate the error.

With the Italy/US project MoonLIGHT/LLRRA21 (Moon Laser Instrumentation for General relativity High accuracy Tests/Lunar Laser Retroreflector Array for the 21st Century) INFN (Italian National Institute for Nuclear Physics) and UMD (Univ. of Maryland) developed a new-generation LLR payload made by a single, large CCR (100 mm diameter), unaffected by the effect of librations, that will improve the LLR accuracy by a factor of ten to one hundred. The performance of this 'big CCR' is being characterized at the SCF-Lab test facility at INFN-LNF, Frascati, Italy. INFN also developed INRRI (INstrument for landing-Roving laser Retroreflector Investigations), a microreflector payload for the lunar surface to be laser-ranged by orbiters. This will further extend the physics and lunar science reach of LLR. INRRI can also provide positioning services on the far side (it is proposed for CNSA's Chang'E-4 mission). INRRI has been deployed on ESA's ExoMars lander "Schiaparelli" [3] and it has been requested by NASA to ASI for the Mars 2020 Rover and InSight 2018 Lander missions. LLR data are analized/simulated with the Planetary Ephemeris Program developed by CfA. INFN, UMD and MEI signed a private-public partnership, multi-mission agreement to deploy the big and the microreflectors on the Moon. Through existing MoUs between INFN and the Russian Academy of Sciences, international negotiations are also underway to propose the new lunar reflectors and the SCF_Lab services for the next robotic missions of the Russian space program..

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Identification of best particle radiation shielded region through Energetic Neutral Atoms mapping

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Abstract

The lunar surface is directly exposed either to direct solar wind, or to Earth's magnetospheric plasma due to the Moon's lack of a magnetosphere or a dense atmosphere. This exposure could create inhospitable conditions for a possible human presence on the Moon, so it is crucial to investigate the close-to-surface environment for establishing the best reliable locations for future human bases. Although it lacks a global magnetic field, the Moon possesses magnetic anomalies that create mini-magnetospheres, where the solar wind is partly deflected. The local protection of the surface from the solar wind radiation inside the mini-magnetospheres could make these sites preferred for future lunar colonization. In this paper, an investigation based on the detection of Energetic Neutral Atoms (ENA) from the surface for identifying the best particle radiation shielded region is proposed.

1. Introduction

Plasma precipitation results in intense space weathering of the regolith-covered surface. Whenever any precipitating particle population hits the surface, a fraction of it is back-scattered as charged particles [1] or as neutral atoms [2][3]. The impacting ions also produce surface release via ion-sputtering. The back-scattered neutral population (mostly hydrogen) has a typical spectrum peaking at hundreds of eVs, while the ion sputtered population spectrum peaks at few eVs, its energetic tail includes remarkable fluxes up to hundreds of eVs [4]. Since the particles are neither deflected by magnetic field nor by gravity (negligible at these energies), the detection with high angular resolution of the Energetic Neutral Atoms (ENA) emitted from the surface could produce a real image of the bombarded regions, similar to the albedo imaging obtained by photons [5]. The observations obtained by Chandrayaan-1 Indian mission demonstrated the feasibility of such measurement [6], even if the low angular resolution of the CENA sensor was only able to produce a low resolution ENA image of the surface (pixel projected instantaneous field-of-view bigger than ~ 80 x 10 km^2 [7]. The regions of local magnetization, referred as magnetic anomalies, with magnetic field strengths of up to 100 nT at the surface [8], create a sort of mini-magnetospheres, where the precipitating plasma is significantly deflected. In fact, the observed ENA intensity reduces by a factor 2 (respect to the directly exposed regions) within the mini-magnetosphere while it increases at the border of the region [9]. Simulations indicate that even a much higher shielding of solar wind is possible [10].

2. ALENA

A Cubesat mission for Lunar Exploration, like the LUCIANUS (LUnar Cubesat Initiative Aimed to Novel and Unique Science) mission would allow an optimal opportunity to host ALENA (Analyser for Lunar Energetic Neutral Atoms), a reduced version of the ELENA sensor for ENA mapping on board of the BepiColombo mission to Mercury [11]. ALENA should be flown on board a low-altitude orbit (between 75-120 km) cubesat, so that it would be able to resolve intensity and direction of the neutral flux coming from the lunar surface [12]. Thanks to the very high angular resolution of ALENA (< 5°) in the low-altitude orbit a detailed mapping of the lunar surface at spatial resolution lower than 8 x 8 km^2 will be possible. The instantaneous FoV will provide a mono-dimensional array, the satellite cross track will provide the second dimension of the image.

The scientific objectives of ALENA will be:
- investigation of the interaction of the solar wind with the mini-magnetospheres at the magnetic anomalies;

- evaluation of the effectiveness of the ‘space weathering’ on the Lunar surface;
- interactions between the Moon and its environment (Earth’s magnetospheric plasma and solar wind);
- paradigm for Mercury and other airless bodies and feasibility test for the SERENA-ELENA instrument. In fact, even if the Moon and Mercury differ in important aspects, their lack of atmosphere and similar regolitic surface make these bodies frequently compared [13]. Given the long cruise of BepiColombo, this cubesat mission could also be the opportunity for testing ELENA before the science operation at Mercury (2025).

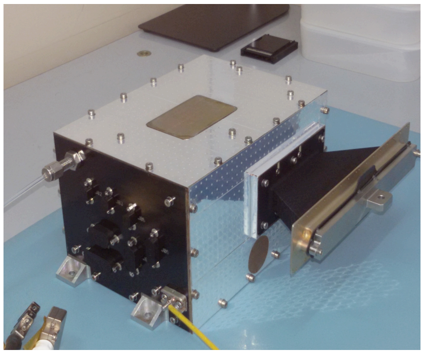

Figure 1: BepiColombo/SERENA-ELENA sensor.

Table 1: ALENA proposed performances and expected resources

Parameter	Value
Energy range	>0.01 – 5 keV
Viewing angle	$4.5^o \times 60^o$
Angular resolution	$4.5^o \times 4.5^o$ (actual) 4.5° × 1.9° (nominal pixel)
Optimal temporal resolution	>=5 s
Pixel Geometric factor G	$3\ 10^{-5}$ cm^2 sr
Integral Geometric factor	$8\ 10^{-4}$ cm^2 sr
Mass	1.5 kg
Power	10 W
Telemetry	100 bit/s

3. Summary and Conclusions

The local protection of the surface from the solar wind radiation inside the mini-magnetospheres could make these sites preferred for future lunar colonization. It is crucial a detailed characterization of these sites. A high spatial resolution mapping via ENA is a feasible and it is powerful way for reaching this goal.

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SUBSURFACE LUNAR ICY SAMPLES COLLECTION: THE TOOL-SOIL ENERGY EXCHANGE MODEL TO DRIVE PENETRATORS DESIGN

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Abstract

In the frame of the current exploration mission studies which include in situ science, scientists are greatly interested in icy and volatiles specimen retrieval and analysis, from the Moon first, but from icy planets like Europa and Enceladus as well.
Such a scientific target translates in a very challenging set of design and operational constraints on tools devoted to soil sample collection and delivery to either the scientific instrument or the preservation box to be returned to Earth. Moreover, a set of beneath surface samples are requested, to get material unmistakably representing the local chemical\physical history and not affected by exogenous factors acting on the surface. The combination of the beneath surface sampling and volatile\ice preservation translates into the development of soil penetrating tools with low energy exchange with the surrounding soil during perforation, coring, collection, delivery, to ensure the sample to keep its few tenths of Kelvin temperature to preserve its volatiles and icy structure.
Several exploration missions would benefit from icy sample collection capabilities, some of those may be part of a Moon focused space program. Volatiles search and analysis in the Moon Polar Regions is already a matter of scientific research and the technology is mature to seriously discuss on low temperature sample retrieval feasibility.
Politecnico di Milano developed an experimentally validated Energy Exchange Model (EEM) tool to support for the design and operation definitions of the icy soil penetrators. In particular, the penetrator mechanical energy transferred to the soil and the sample during the whole tool operations is modelled, taking into account the detailed drill geometry and the thermo\physical soil characteristics; radiation, conduction and convection mechanisms occurring among the tool, the free space and the soil are modelled. The penetration velocity and power, the drill geometry and materials are kept as parameters to run the sensitivity analyses and drive the design; the soil thermo-physical properties and its stratification are treated as parameters as well and tuned through the experimental campaign run at Finmeccanica premise, which is responsible for the penetrator development. The EEM offers - as output - the 3D temperature profile - along the whole penetrator operational window - the cored specimen inside the tool, the tool, the surrounding soil and. The EEM is presented in details highlighting its beneficial exploitation to support the design of tools for current and future icy Moons sampling missions in which the specimen thermal control is mandatory.

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Landing sites and settlement infrastructures for Lunar exploration

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Abstract

The selection of a landing site on the Moon is a complex issue because it will imply a long-lasting and permanent occupation. The landing site will have to cope with a large number of surface operations.

1. Introduction

The exploration of the Moon will be achieved by a strong and efficient human presence on the surface. This human exploration will consist of a permanent Lunar base (mimicking the ISS experience) and several outposts for the exploration of the surface. Selecting a landing site to construct a permanent base is a complicate task because it is necessary to keep in mind the large number of issues involving, among the other, personnel safety, resource availability, mobility, etc. Moreover, it is necessary to base the selection on the type of operations that must be performed. Therefore, it is of paramount importance to have a clear idea of the logistic, the scientific goals, the technological developments and the type of operations.

2. Surface operations

Several scenarios can be adequate for the establishment of a human settlement. However, it is probable that the first goal of the Lunar exploration is science. This goal is also complex because some sub-goals such as geological studies of the surface and subsurface, observation of the Universe, and observation of the Earth and its nearby space. Several other goals can be envisaged such as the human physiology in the space and in low-gravity bodies. In-situ resources are also an important item useful for the future exploration of more distant bodies, as well as increase the exploration capability by monitoring the infrastructure and their maintenance. However the most demanding operations are those that involve long outdoor activities (EBA: Extra Base Activities).

3. Landing site

The selected landing site must be selected bearing in mind that the locale will be the site of a long-lasting base. Most of the permanent base in remote areas of the Earth have been constructed according the experience acquired from short-term explorations. The area must be flat with a rather large open space for further development. Construction material, mostly the one for shielding, from space radiation must be readily available and the presence of lava tube for temporary shielding would be greatly welcome due to the efficient shield capability. The locale must have nearby launch and landing pads at a safe distance from the other infrastructure. The area must display geological feature suitable for the production of resources such as oxygen, hydrogen, water, etc. Transportation of the ore require large, sturdy and smooth ways. The locale must be also well connectable to the surrounding regions for exploration activities and maintenance of the remote infrastructures such as radio antennas or telescopes.

4. Exploration scenario

The base will be located in an area central to the scientific exploration and resource availability. Long-lasting itineraries will be performed with a manned rover. Outposts will be available for shelter and emergency. Several operations may require the transport of heavy equipment and a unmanned rover aid must be taken into consideration.

5. Moon analogue test of operations

Test of the infrastructures, operations and end2end mission can be performed in Moon analogue Terrestrial environments. A long-term campaign must be envisaged to increase efficiency and, mostly safety

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NU-LHT-2M lunar simulant outgassing characterisation

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Abstract

Nowadays interest towards ice in space is increasing. One of the reason why stays in the great importance icy the volatiles elements play in the exobiology and pre-biotic components potential existence.

The ESA Juice mission towards the Jupiter icy Moons, in preparation for flying in 2022 is just an example, as well as the on going, proposed and future missions focusing on asteroids with samples return.

More nearby in time, the first incoming challenge is represented by the lunar 27 ESA-Roscosmos mission, supposed to land n the Moon south Pole to collect and analyze in situ icy volatiles.

Icy volatiles sampling in vacuum is quite a tough operation: icy gases immediately sublimate as soon either the pressure decreases – because of the extraction – or the temperature increase – because of the friction provoked by the mechanical energy injected in the soil to crack it and collect the specimen. The risk is, therefore, to penetrate the soil, collect subsurface samples supposed to have the volatiles content required to run scientific analysis and to release to the instruments soil with no volatiles at all inside, because of the occurred sublimation in vacuum.

Currently, no validated model exists on sublimation phenomenon for gases trapped in a soil composite while in vacuum. Therefore experimental tests would be beneficial to characterize it and tune both the tool to sample and the operations to run while sampling the icy planetary soil.

At Politecnico di Milano-Aerospace Science & Technology Dept. the design and setup of a dedicate experimental facility to assess the gasses and icy volatiles sublimation phenomenon in vacuum are under development. A vacuum chamber, equipped with soil inside – either dry or wet - which correctly reproduces the polar Moon conditions is a challenge also in the setting up activities: soil is prepared in air at sea temperature, therefore, even the dry soil traps air molecules which contribute to the sublimation as soon as the soil undergoes a vacuum creation procedure; the amount of gases coming from trapped air has to be distinguished from gases being part of the simulated icy volatiles purposely inserted in the soil to run the scientific test.

Previous tests, performed at Glenn Research Center[1,2], have identified how lunar soil simulants, inserted in a thermal vacuum chamber, increase the time needed to reach the target pressure because of the gas load, coming from the simulant, provoked by the air trapped between the soil particles, and the water vapor absorbed by the simulant when exposed to atmospheric conditions.

Therefore, to correctly support the design of a planetary icy soil sampler the terrestrial infrastructure must firstly quantify the gas load produced by the soil during the chamber pressure decreases and provoked by the trapped air; then it must be equipped to monitor and measure the gas load, in vacuum, provoked by the tool-soil energy exchange.

Th NU-LHT-2M is used as Moon highlands simulant. A scaled experimental set up, made up of a soil chamber and a vacuum chamber, connected by a pressure regulated line is currently under integration. The two chambers scheme allows to better control the potential soil sputtering and boiling as soon as the pressure starts decreasing. Moreover, the two chambers scheme is required to keep the experiment completely independent from a classical TVAC internal chamber with suffer from any particle which can enter the pump line, jeopardizing the complete plant because of pump failure. Last, the sytem can be easily cooled down just inserting the whole in a freezing plant, dcouling the vacuum from the temperature variation processes. The vacuum chamber is connected to a classical TVAC, to create a 10^{-5} bar pressure conditions; then it is disconnected from the TVAC and connected to the soil chamber to start the experiment. Gases emission quantification is obtained by vacuometers located on the line and in the scaled vacuum chamber which will receive the amount of sublimated gases. A different n mass on the soil will be the added measurement as well. A trap along the line is also inserted to quantify the amount of solid soil particles sputtered with respect to the flow rate imposed by the flow control valve located between the soil and te vacuum chamber.

The two chambers are cylindrical and stay in a 70x 80 cm envelope at most.

Tests will run first on the dry soil, room temperature to characterize the amount of air and vapour trapped during the soil preparation and to assess the admissible flow rate while decreasing the pressure for vacuum preparation to avoid surface particles sputtering and boiling.

Wet soil test will then run, at temperature conditions as well, leaving the low temperatures vacuum tests as last.

The facility design, implementation and calibration will be critically discussed and presented, together with the preliminary results of the tests which are supposed to be performed shortly.

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[1] Julie E. Kleinhenz and R. Allen Wilkinson. "Development and testing of an ISRU soil mechanics vacuum test facility". In: (2014).

[2] Julie E Kleinhenz. "Lunar polar environmental testing: Regolith simulant conditioning". In: 7th Symposium on Space Resource Utilization. 2014, p. 0689.