Space Exploration - Why Humans Should Go to the Moon First

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Abstract

The need and motivation for space exploration in general will be identified considering several aspects. Reasons to do this on the moon first will be depicted, for the benefit of moon exploration from a scientific point of view as well as for preparatory aspects of future exploration missions. Techniques and systems for lunar exploration and sortie missions are shown as developed or being developed. The economic benefit is described and can be presupposed with backing on historical knowledge. If humans want to explore the solar system, which is assumed, they have to start as soon as possible with a mission beyond Earth orbit, most likely to the moon first.

Keywords

Exploration; Moon Landing; Habitat; Resources; Volatiles; InSitu; ISRU

Introduction

Since the era of Apollo, we not only miss this magnificent view from our 'satellite' the moon on our blue home planet, we also don't utilize benefits resulting from trips to the moon.

In view of Exploration the moon is able to offer advantages, so, it may be emphasized, that the recent focus on moon again can be worthwhile.

If something was done in near history, it was done assuming the undisturbed geological record of the moon and subsequently its upper crust for billions of years, predestined to broaden the view of existence of our universe.

In addition to this historical archive view, discussions concerning resources were raised, mining of rare minerals and metals and bringing back the harvest to earth. In general, in the timeframe of 2005 to 2008, moon exploration experienced an enormous momentum.

Various investigations on new examined resources of the moon such as In-Situ Resource Utilization (ISRU) methods (e.g. for oxygen release/ generation), search for favored landing sites therefore and mission scenarios including operation of rovers have been performed.

International Exploration Strategy

At the time as President Barack Obama overruled the George Bush's Space Exploration Vision (*Human and Robotic Missions to Moon, Mars and beyond*) with the comment: *humans have been on the moon and will not go back there*, mars was set instead as the preferential human space exploration destination. On the way to mars, asteroids and Lagrange points were also declared as of interest. Obviously this could mean that the moon would be 'neglected' as human exploration goal, by the US-site.

But the moon is experiencing a renaissance or even better, it was never dead. In international aspirations, e.g. concluded in the International Space Exploration Coordination Group ISCG (with 14 space agencies, inclusive the European space agency ESA), the moon is (despite asteroids or the Lagrange points) still a favorite goal in the roadmap with the final destination mars.

Whereby a realistic reflection shows that human missions to mars are, despite of several today's unsolved technical solutions, out of budgetary scope at the moment and probably it can be assumed, that a future sophisticated exploration mission has to be understood as a global effort.

On the other hand questions are raising what should or what has to be done between "now" and mars? Whatever we do at the end it should be in the direction to mars.

Exploration of the Moon

What is the reason for moving moon exploration again into the foreground? Even in the USA and also within NASA can be observed growing interest in future lunar missions.

In the US exploration scenario, within the Space Launch System Initiative (SLS) from NASA with its ORION, the fly-by of the moon will be the first goal for this new crew transport vehicle.

Other agencies could follow with exploration activities e.g. China, Russia, Japan or India, for whom the moon is also of growing interest, even for sortie missions. Another strong reasonable driver could be the new results gained by remote sensing of water, detected by the Indian Chandrayaan mission, the lunar reconnaissance orbiter and the Chinese Chang'e mission. It is foreseeable that the moon turns out to be a testbed for long duration missions which will be a necessary experience for any mission beyond moons orbit

In 2008, ESA ESTAG, the European Space Technology Advisory Group recommended a lunar landing mission as a challenging mission proposing to land in the south pole region [1, 2]. Unfortunately, due to budgetary constraints, the related phase B1 activities were no longer supported after the European ESA ministerial conference took place at the end of 2012.

A general prerequisite for this mission concept was an excessive study of the illumination condition of the moon's south-pole region, showing a possible sustainable surface stay at this location and irrespective of the ministerial decision, the mission concept remains valid.

The mission idea/ concept is being seen as a human exploration preparation, scientific or robotic mission concept. As stated before, the feasibility is based on the recent illumination analysis resulting in a mission of a sustainable surface operation of about a half year.

Equipped with a new designed guidance and navigation system and a simplified "throttleable" propulsion system the landing vehicle should be able to select automatically - up to two - landing sites depending on scanned topological shapes and slopes during the landing sequence.

Meanwhile, this exploration scenario is also matching with the roadmap drawn up by the ISECG.

As scientific objectives of this lunar exploration scenario experiments were identified mostly related to the lunar exosphere, the lunar dust and the lunar regolith (Geo-chemistry) and volatiles of the regolith. The measurement of volatiles is important due to water indication and its abundance in different forms and at different locations.

Water on the Moon Surface

Besides the water ice in cold traps of craters in the polar-regions (measured by LCROSS/ NASA) there is water also in form of H_2O molecules or OH hydroxyls, spread over the whole moon surface.

Already those indications of water, remotely measured during the Chandrayaan mission (India) with the experiments Mineralogy Mapper M^3 (NASA) and the SARA sub-keV Atom Reflecting Analyzer (cooperation ESA/ ISRO), predestine the moon even more as an exciting exploration outpost.

It should be remembered that in the Apollo samples water has been found too, but at that time water did not fit in the lunar concept and therefore it simply did not exist. Traces of water where declared as terrestrial contamination which occurred during handling.

Whereas the trapped ice water (found by NASA's LCROSS mission end of 2009) is difficult to reach, the 'spread forms' of water may be easy to utilize in simple processes.

This 'surface water' is able to revolutionize In-Situ Resource Utilization (ISRU) processes while the extracted water will sustain habitats/ stations or could even be used for the generation of propellants. But for harvesting useful amounts of this 'water' a thin layer of the surface has to be 'gardened' or 'mined'.

This new 'source' certainly has influence on the actual moon ambitions by e.g. Japan (with Selene-2), China (Chang'e), India (Chandrayaan-2) or Russia (LunaGlob).

Primary, the SARA and M^3 (Chandrayaan-1/ India) experiments were responsible for these new surprising results[3,4] beside this millions of tons of water ice are trapped in shaded craters at the poles. This water ice

[1] THE FIRST EUROPEAN LUNAR LANDER AND THE ESA-DLR APPROACH TO ITS DEVELOPMENT, GLUC-2010.3.1.5, A. Pradier, R. Fisackerly, B. Houdou, C. Phillipe, J. Carpenter, D. de Rosa, S. Espinasse, B. Gardini ESA, N. Henn, German Aerospace Center

[2] Moon Exploration, IAC 2010, R. Fisackerly, A. Pradier, C. Philippe, B. Houdou, J. Carpenter, D. de Rosa, S. Espinasse, B. Gardini, ESA, N. Henn, German Aerospace Center, A. Jojaghaian, B. Vanoutryve ESA

[3] NASA Instruments Reveal Water Molecules on Lunar Surface, DC Agle, Jet Propulsion Laboratory, Pasadena; Dwayne Brown, NASA Headquarters, Washington 09.24.09

[4] How the Moon produces its own water, D. Koschny, ESA Chandrayaan-1 Project Scientist, Oct. 2009

could probably originate from different sources, whereas the bombardment by comets or asteroids is one of it but it could also be partly out of glassy minerals of the moons crust.

In the case of spread 'water' charged particles of the solar radiation are interacting with bound O_2 of the lunar surface which creates H_2O molecules. Another effect is that particles of the solar radiation lead to adsorbtion of molecules in the interspaces of the regolith. When these are solar protons they can interact with the O^2 of the regolith, which can consequently lead to hydroxyls (OH). Although the concentration of such generated 'water' is of about 1% weight in the first millimeter of regolith a harvesting over large surface areas will lead to useful amounts for consumption.

In general the generation process/ the charging of the volatiles is periodic and depending on the (local) temperature. At higher temperatures they may evaporate.

The knowledge about deposits and the possibility for In-Situ resource utilization is of great importance and will influence ISRU [5] equipment, developments and field tests.

The Moon as a Test Bed

In view of future exploration the moon offers an excellent platform to verify important steps e.g. forsortie missions. What is commonly called 'habitable environment' means in the view of human exploration missions: safe living compartments including resources and energy supply, being able to withstand in a hostile environment.

In all these relevant fields we have experience or know-how and relevant developments have been started; all taking reduced gravity into account. In detail these are systems/ applications like Environmental Control and Life Support Systems (ECLS) including regenerative biological systems or their combination the so-called hybrid systems. Additionally, past measurements let anticipate that the effect of space radiation also influences biological (algae) systems and therefore counter measurements may be required. In Situ resource utilization (ISRU) and regenerative energy provision and storage systems are being studied.

ECLS Systems are already in use on the International Space Station ISS. All systems, the Russian and the US systems are containing water treatment subsystems to reclaim waste water, for the O_2 generation via an electrolysis process. Developments (in Europe) regarding a greater system cycle closure by using the Sabatier process a/o by integrating biological systems (hybrid) are under construction.

Radiation influence a/o its prevention on biological systems can be studied In-Situ on moon's surface, e.g. with bio-reactors containing/equipped with different algae cultures.

For radiation shielding, interesting methods e.g. the use of regolith as construction material are being investigated and positive effects have already been calculated.

In the case of ISRU several classic methods were discussed or studied but due to the new results of water deposits on the moon's surface, easier methods are applicable. Probably 'simple' heating chambers/ processes are sufficient to release water volatiles which may subsequently be condensed.

For the energy generation and storage regenerative fuel cell system (RFCS) have been developed and tested with good performance at laboratory level. Due to the moons 14 day's brightness/ darkness cycles such systems are predestined for moon applications. Instead of secondary batteries, where the system mass increases linearly with the energy provided, the mass will be influenced only by the size of tanks for the supply of water and the storage of produced H_2 and O_2 gases. For all those innovative technologies, processes and systems the moon is not only a simple 'laboratory'. Quite the contrary, the moon is the only possibility to demonstrate and approve those future exploration technologies or plants in 'reality' and before use e.g. on mars.

We could describe it with the words of the honorable moon scientists *Paul Spudis "We're going to the Moon to learn the skills needed to live and work productively on other planets"*

Programmatic

The exploration of the moon is an important step within the preparatory activities and necessary on the way to destination mars. The moon offers various opportunities for reaching other destinations later in

[5] FIRST EUROPEAN MOON LANDING MISSION, In-Situ Resource Utilization (ISRU) related mission objectives (unpublished), Submitted to the Lunar Exploration Definition Team, LEDT at 25th September 2009 N. Henn, German Space Agency

our solar system. The moon is the candidate to exercise necessary first steps. The moon is fully in line with the International Space Exploration Coordination Group's roadmap showing benefits in several fields of technologies. Besides the scientific goals the moon offers solutions for priority exploration technologies, shelter and habitats, resources and sustainable/ sortie surface scenarios. Moreover, all this fits within current the global exploration efforts and leaves room for complementary solutions as well as cooperation for future missions beyond the moon. Moreover, in such scenario also robotic/ lander elements on the moon surface in collaboration with various international partners are an option. This is also true for the Orion/ MPCV scenario within the US space launch initiative (SLI), planned for a maiden flight into moon's orbit in 2017.

Social-Cultural Aspects

Exploration has ever been a striving for mankind. In general the view on space exploration is growing in importance over time, considering that humans shall have the possibility to leave their planetary home and expand their 'horizon' and territory; this may even become necessary in the view of future demands for environmental needs. Needless to mention, that this expansion of territory will be in long term the colonization of mars as the most possible habitable candidate in our solar system.

For exploration it can be assumed an enormous emphasis on cultural ambitions and impulses for humanity. Another aspect is the economic momentum which has been demonstrated during the Apollo mission era.

Economic Impacts as a Positive Side Effect of Exploration

Economic impacts of the Apollo program can reasonably be considered as an example of the aftermath of future exploration. A study of NASA[6], November 1971, assumed that the $25 billion in 1958 dollars spent on civilian space R & D during the 1958-1969 has returned $52 billion through 1971, and producing pay offs through 1987 to a total pay off of $ 181 billion, a factor of 7. Furthermore there were several sources[7, 8, 9, 10] which conclude the enormous economic benefit of the (past) Apollo era. Also in the so-called Chapman Report, a statistic was shown of about 350,000 created jobs (mostly skilled or saved) or of about 260 non space applications, approx. 1% of the estimated approx. 25,000 spin-offs. All this shows an enormous momentum of this outstanding space era.

Conclusions

The Momentum for space exploration has been identified. In particular, exploration means: curiosity of mankind, the foreseeable future need of resources and the expanding human horizon and territory. Reasons to demonstrate the next exploration steps on the moon have been depicted based on technological developments and systems. The benefit on society has been shown and can also be presupposed in the future backed on historical knowledge. Today, we harvest the fruits of research and technology demonstration of the International Space Station ISS, as the only human outpost, perhaps until 2025. It seems realistic to assume that similar effects for the next human exploration mission(s) to come are achievable.

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