EPSC2017

MT12 abstracts

13 Sep 2017 11:35:29

EPSC Abstracts
Vol. 11, EPSC2017-666, 2017
European Planetary Science Congress 2017

TELEROBOTICS CONTROL OF EXOGEOLAB LANDER INSTRUMENTS

A. Lillo [1,3] (arthurlillog@gmail.com), B. H. Foing[1] (bernard.foing@esa.int), L. Maller[2,3], V. Da-Poian[2,3], A. Cowley[2], [1]ESA/ESTEC, Noordwijk, The Netherlands, [2]ESA/EAC, Cologne, Germany, [3]ISAE-Supaero, Toulouse, France

Introduction: The ExoGeoLab lander is a project at ESA/ESTEC initiated in collaboration with ILEWG task groups [1]. It is a structure with a rover deployment hatch, that can be equipped with several instruments such as UV-VIS, NIR and Raman spectrometers and a telescope. Those payloads can be remotely operated using a laptop connected via a Wi-Fi network. Some improvements need to be made to improve the lander's autonomy and operational capabilities. Those tasks are performed in cooperation with a team at EAC, which works on remotely operating cameras, spectrometers, a rover, a telescope and a radioastronomy system in the 20 MHz band [2]. The spectrometers were calibrated using a database of mineral established at ESTEC [3].

Figure 1 Deployment of the lander with instruments during an on field analogue campaign.

Goals: In 2016, the former Arduino+computer architecture was replaced by a centralised Raspberry-Pi architecture, allowing development of a more robust, modular and user-friendly interface for remote control [4]. The K-Stars Ekos module used by amateur astronomy community was then adapted on the lander to allow modular control of all the instruments and the lander's actuators on a single community supported GUI. Further improvements have to be made to enhance stability of the interface and replace the remnant Arduinos by Raspberry shields. Two new aspects are being investigated to improve the lander's autonomy for exploration. On the first hand, a light robotic arm has been developed at EAC [5] and has to be adapted to the lander's architecture to allow astronauts to remotely place samples on the spectrometer bench. On the second hand, distant geological feature spotted with the telescope could be explored using two drones piloted by astronauts and working together to bring back samples to the lander, thus reducing the need for EVA. For that purpose, a tool has to be developed to determine the target location knowing the telescope's orientation, and field tests will be carried out with buddy-system drones to write protocols.

Preliminary results: The remote control of the telescope focus and orientation is now successful but there is still a lack of orientation feedback for automated use or target localization. A proof of concept of drones piloted in buddy-system is currently being done.

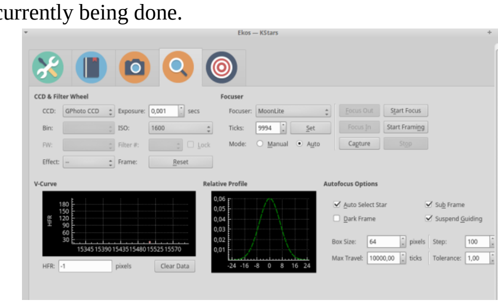

Figure 2 Interface for remote control of the telescope focus.

We shall present at EPSC latest results from teleoperations of ExoGeoLab lander and instruments from ESTEC & EAC, and prospects for their utilisation in field research campaigns in Moon-Mars analogue environments [6].

Acknowledgements: We thank Spaceship EAC, Samantha Cristoforetti, ESTEC supporting colleagues, EAC supporting colleagues, ILEWG, ISAE-Supaero.

References: [1] Foing B. et al, (2010) *LPI 41*, #1701. [2] Guinet V. et al, (2016) *ELS*, Preparation of human-telerobotics operations using EAC & ESTEC facilities. [3] Kamps, O. et al, (2016) *LPI 47*, #2508. [4] Jonglez C. et al, (2016), ESTEC internship final report. [5] Monnerie M. et al, (2016) EAC internship final report. [6] Foing B. et al. (2011) *IJA 10 (3)*, 141-160.

EPSC Abstracts
Vol. 11, EPSC2017-796, 2017
European Planetary Science Congress 2017

LUNAR INDUSTRY & RESEARCH BASE CONCEPT

J. Lysenko, M. Kaliapin, G. Osinovyy
Yuzhnoye State Design Office, Dnipro, Ukraine, (info@yuzhnoye.com / Fax: +38-056-7700125)

Abstract

The current paper presents the goals of Moon exploration, Yuzhnoye SDO's concept of a Lunar Industry & Research Base, phases and terms of its development, as well as a conclusion of the project's feasibility.

1. Introduction

The experience of Moon exploration started almost along with the beginning of space age, but peculiarity of the tasks to be resolved with the direct human participation in expedition as well as a high cost of projects have pushed away the idea of further expansion for several decades.

Currently, all main space industry players, such as Europe, USA, Russia, China, etc., are looking back again at the idea of Moon exploration building there a manned lunar base. Alongside with other world spacefaring nations, Yuzhnoye State Design Office with its long-time development experience, technological and intellectual potential, organized its own conceptual work on development of the Lunar Industry & Research Base.

2. Moon exploration goals

Besides the fact that the Moon is the closest available object for humanity to colonize it, the Moon and its reach resources are the key to reducing costs for interplanetary missions. Lunar resources will allow producing rocket propellant, constructional materials, and necessary resources for crew life support and base on the whole – all this will provide a stimulus in development of space activities of mankind in the near and outer space. Lunar industry & research base is a platform for testing of space equipment and technologies necessary for lunar exploration and interplanetary manned missions, and a springboard to the development of next manned bases on Mars and its moons, as well as to exploration of asteroids, etc. The Moon will become the first place in the Solar system where people will get the experience of living in space without support from the Earth.

3. Yuzhnoye SDO's Lunar Industry & Research Base concept

In the frames of conceptual project "Lunar Industrial & Research Base¨ were formed its appearance, preliminary configuration and infrastructure at different stages of operation, trajectory and flight scheme to the Moon, as well as terms of the project's realization, and main technical characteristics of the systems under development (such as space transportation system for crew and cargo delivery to lunar surface and return to Earth, standardized designs of lunar modules, lunar surface vehicles).

Table 1: Phases of lunar base development

Phases of lunar base development	Terms of lunar base development, years
Phase #1 – Preparation	~ 10
Phase #2 – Minimal configuration base	~ 2
Phase #3 – Base expansion	~ 10
Phase #4 – Transition to production	~ 20
Phase #5 – Permanent base	

The main phases of lunar base development are:

Phase #1 Preparation: establishment of international cooperation, Moon exploration by means of unmanned spacecraft, development of Earth-Moon-Earth space transportation system, lunar base infrastructure components, and take-off/landing pad.

Phase #2 Minimal configuration base: delivery of first lunar base modules and power plant;

minimal configuration lunar base assembly, systems check-out and testing.

Figure 1: Development phase #2.

Phase #3 Base expansion: building up of lunar base infrastructure, lunar surface exploration, selection and preparation of territories for production base and lunar observatory.

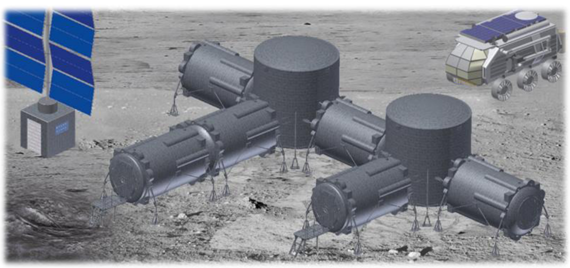

Figure 2: Development phase #3.

Phase #4 Transition to production: development of closed-cycle life-support system, production base and lunar observatory.

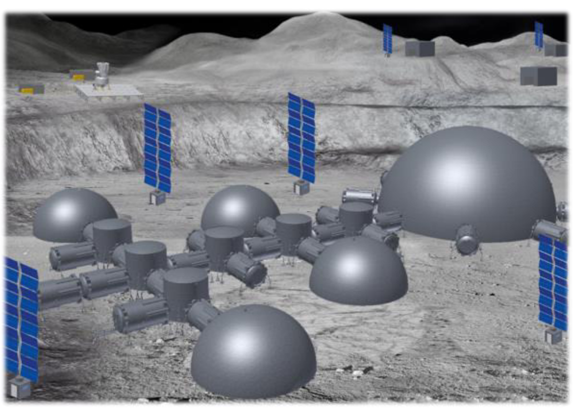

Figure 3: Development phase #4 and #5.

Phase #5 Permanent base: human constant presence and life activity on the Moon, development of space tourism center.

4. Summary and Conclusions

The "Lunar Industrial & Research Base" project's preliminary risk assessment has shown a high value of its overall risk due to the lack of reliable information about the Moon, technical risks, long-term development of its elements, very high financial costs and dependence on state support.

This points to the fact that it is reasonable to create such a global project in cooperation with other countries. International cooperation will expand the capabilities of any nation, reduce risks and increase the success probability of automated or manned space missions. It is necessary to create and bring into operation practical mechanisms for long-term space exploration on a global scale. One of the ways to do this is to create a multinational agency which would include both state enterprises and private companies.

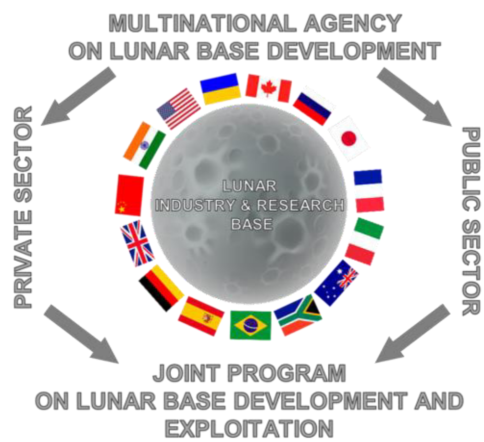

Figure 4: International cooperation model on lunar base development.

By finding a common language in space research, the countries will be able to effectively divide the efforts to achieve common goals, and leaning on their own potential and coordinating the joint efforts, they will come to global cooperation and partnership. Such an international cooperation directed towards a single global goal will help to reduce conflicts, increase global security, and lead to establishment of the peace.

EPSC Abstracts
Vol. 11, EPSC2017-814, 2017
European Planetary Science Congress 2017

MaMBA – a functional Moon and Mars Base Analog

C. Heinicke (1,2), B. Foing (1,2,3)
(1) VU Amsterdam, Netherlands (2) ILEWG, (3) ESTEC, Noordwijk, Netherlands

Abstract

Despite impressive progress in robotic exploration of celestial bodies, robots are believed to never reach the effectiveness and efficiency of a trained human. Consequently, ESA proposes to build an international Moon Village in roughly 15 years and NASA plans for the first manned mission to Mars shortly after.

One of the challenges still remaining is the need for a shelter, a habitat which allows human spacefarers to safely live and work on the surface of a celestial body. Although a number of prototype habitats has been built during the last decades and inhabited for various durations (e.g. MDRS, FMARS, HI-SEAS, M.A.R.S.), these habitats are typically equipped for studies on human factors and would not function in an extraterrestrial environment.

Project MaMBA (Moon and Mars Base Analog) aims to build the first functional habitat based on the lessons learned from intermediate and long duration missions at the mentioned habitats. The habitat will serve for testing technologies like life support, power systems, and interplanetary communication. Special attention will be given to the development of the geoscience laboratory module. Crews will live and work inside the habitat to ensure its functionality.

1. Motivation

Simulations are crucial in today's space exploration by helping prepare astronauts for their missions in space. By principle, simulations focus on one or few aspects of the entire mission, be it physiology (such as bed rest studies, or prolonged stays at Antarctic research bases), psychology (such as the HI-SEAS [1] or (discontinued) FMARS [2] missions), or technology (Desert RATS [3], Rio Tinto expeditions [4], [5]) to name a few.

However, the most vital factor for a surface stay on the Moon or Mars is the astronauts' shelter, the so-called habitat. Although a number of habitats have been built for the purpose of simulating life on Mars, the ones that have been inhabited by crews for a significant amount of time typically focus on human factors rather than providing a realistic prototype. Today's habitats (MDRS, FMARS, HI-SEAS, M.A.R.S.) are

- located at the surface, even though space radiation is a known threat to crew health,
- built with a single (central) module, even though one single catastrophic event may then render the entire habitat uninhabitable,
- designed around the crew's living space, with limited attention to the realistic instrumentation of the laboratory which arguably is the most important module for a scientific mission.

2. Goals

As a consequence of the above stated problems, we aim to build a habitat that would be functional under extraterrestrial conditions. Center piece of the habitat will be the laboratory module

2.1 Basic habitat features

MaMBA will consist of a minimum of connected modules which can be shut off independently from each other. An example arrangement of the modules is shown in Figure 1, it is possible to add further modules and to re-arrange them (to some extent).

At the final stage, MaMBA will have closed loops for water and air and a self-sufficient power supply.

MaMBA' communication systems will address the added challenges of an underground habitat (see below) and the iron-rich environment on Mars.

MaMBA's interior design addresses the possibility of astronauts (temporary) incapacitation.

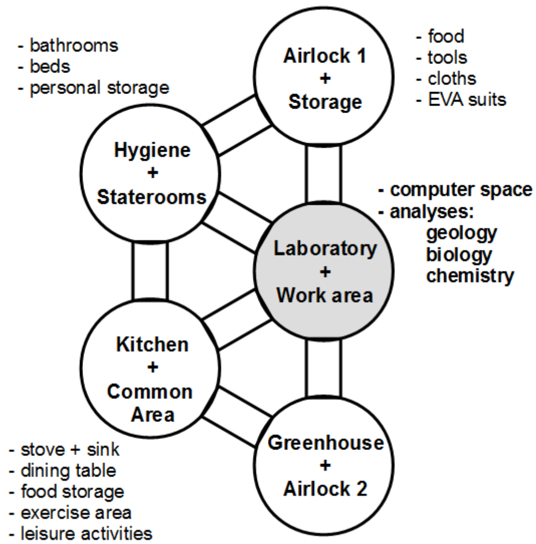

Figure 1: Rough layout of MaMBA, with the science module being the central module.

2.2 Laboratory Module

The laboratory module will feature equipment such as microscopes, spectrometers, etc. intended to allow comprehensive geological and (astro-)biological analyses.

Unlike previous habitat laboratories, MaMBA will be flexible in accommodating a range of needs for different, possibly simultaneous analyses, and provide efficient space for storage.

2.3 Testing

Crews will occupy the habitat during various stages of the design and construction process to ensure functionality.

At the final stage, MaMBA will be tested under non-laboratory conditions, that is in harsh terrestrial environments and caves.

3. Outlook

3.1 Next steps

Our first step will be to design, construct, and test the laboratory module. This prototype module will serve two main purposes: (1) be a testground for the systems mentioned in section 2.1 and (2) provide a site for short-duration simulations of exploratory work.

3.2 Long-term plans

Afterwards, the single module will be extended to the full habitat. Initially, the full habitat will be located at its home institution; later it will transported to and used in areas of extreme environmental conditions.

Acknowledgements

The authors would like to thank M. Avila, A. Kołodziejczyk, and A. Wasniowski for their support and fruitful discussions.

References

[1] Binsted K., Basner M., Bedwell W., Caldwell B., Chang D., Hunter J., Kozlowski S., Nasrini J., Roma P., Santoro J., Seibert M., Shiro B., and Wu P.: Investigations at HI-SEAS into Team Function and Performance on Long Duration Exploration Missions, NASA Human Research Program Investigators' Meeting, 8-11 February 2016, Galveston, TX, 2016.

[2] Bishop, S.L., Kobrick, R., Battler, M. and Binsted, K.: FMARS 2007: Stress and coping in an arctic Mars simulation, Acta Astronautica, Vol. *66*, pp.1353-1367, 2010.

[3] Ross, A., Kosmo, J., and Janoiko, B.: Historical synopses of Desert RATS 1997–2010 and a preview of Desert RATS 2011, Acta Astronautica, Vol. 90.2, pp.182-202, 2013.

[4] Fernández-Remolar, D.C., Morris, R.V., Gruener, J.E., Amils, R. and Knoll, A.H.: The Rio Tinto Basin, Spain: mineralogy, sedimentary geobiology, and implications for interpretation of outcrop rocks at Meridiani Planum, Mars, Earth and Planetary Science Letters, Vol. 240, pp.149-167, 2005.

[5] Cannon, H. N., Stoker, C. R., Dunagan, S. E., Davis, K., Gómez-Elvira, J., Glass, B. J., Lemke, L.G., Miller D., Bonaccorsi, R., Branson, M., and Christa, S.: MARTE: technology development and lessons learned from a Mars drilling mission simulation, Journal of Field Robotics, Vol. 24, pp. 877-905, 2007.

EPSC Abstracts
Vol. 11, EPSC2017-983, 2017
European Planetary Science Congress 2017

MoonVillage Technology Foresight Workhop

B.H. Foing (1,2) (1) ESA ESTEC ; (2) ILEWG (Bernard.Foing@esa.int)

Abstract

We shall have a Technology foresight workshop in the context of elaborating the concept of a Moon Village with the goal of a sustainable human presence and activity on the lunar surface [1-3] as an ensemble where multiple users can carry out multiple activities. This enterprise can federate all interested Nations and partners. The Moon represents a prime choice for political, programmatic, technical, scientific, operational, economical and inspirational reasons.

Previous MoonVillage projects

COSPAR and its ILEWG International Lunar Exploration Working Group (created 20 years ago) have been supporting opportunities of collaboration between lunar missions and exchange on future projects [4-8]. A flotilla of lunar orbiters has been deployed for science and reconnaissance in the last international lunar decade (SMART-1, Kaguya, Chang'E1&2, Chandrayaan-1, LCROSS, LRO, GRAIL, LADEE). De facto, collaborative opportunities and elements of a Robotic Village on the Moon exist, as China landed in 2013 the Chang'E3 and its Yutu rover, and from 2017 other landers are planned (GLXP, Chang'E 4&5, SLIM, Luna 25-27, LRP, etc..)

Precursor technical studies

Previous roadmaps and technical studies held in international groups [4- 15] such as COSPAR, ILEWG, ISECG, IAF, IAA or national and regional groups (eg LEAG). We shall present the status of these reflections, and give an overview of on-going activities being carried out to enable the vision and implementation of a Moon Village.

How to prepare next steps?

The Moon Village will rely both on automatic, robotic and human-tendered structures to achieve sustainable moon surface operations serving multiple purposes on an open-architecture basis. This initiative will rally all communities (across disciplines, nations, industries, partners, individuals) and we should plan the technology.

References

[1] Jan Wörner, Driving #MoonVillage http://www.iafastro.org/events/iac/iac-2015/plenaryprogramme/the-moon-a-continent-and-a-gateway-for-ourfuture/ (IAC 2015, Jerusalem);

[2]http://www.iafastro.org/events/iac/iac2016/globalnetworking-forum/making-the-moon-village-and-marsjourney-accessible-and-affordable-for-all/ (IAC 2016) ;

[3] B. Foing et al , Highlights ESTEC Moon Village Workshop, http://www.hou.usra.edu/meetings/lpsc2016/pdf/2719.pdf, http://www.hou.usra.edu/meetings/lpsc2016/pdf/2798.pdf

[4] P. Ehrenfreund et al. "Toward a Global Space Exploration Program: A Stepping Stone Approach" (Advances in Space Research, 49, n°1, January 2012), prepared by COSPAR Panel on Exploration (PEX)

[5] http://www.lpi.usra.edu/leag/GER_2011.pdf;

[6] http://sci.esa.int/ilewg/47170-gluc-iceum11- beijing-2010lunar-declaration/;

[7] http://www.lpi.usra.edu/meetings/leagilewg2008/

[8] http://sci.esa.int/ilewg/41506-iceum9-sorrento- 2007-lunar-declaration/

[9] National Research Council (2007), The Scientific Context for Exploration of the Moon

[10] P. Ehrenfreund , B.H. Foing, A. Cellino Editors, The Moon and Near Earth Objects), Advances in Space Research, Volume 37, Issue 1, pp 1-192, 2006

[11]http://sci.esa.int/ilewg/38863-iceum8-beijing-2006declaration/

[12] W. Huntress, D. Stetson, R. Farquhar, J. Zimmerman, B. Clark, W. O'Neil, R. Bourke& B. Foing,'The next steps in exploring deep space - A cosmic study by the IAA', Acta Astronautica, Vol 58, Issues 6-7, 2006, p302-377

[13] http://sci.esa.int/ilewg/38178-iceum7-toronto-2005-declaration/

[14] H. Balsiger et al. Eds, International Lunar Workshop, 1994 May 31-June 3, Beatenberg, Switzerland. Proceedings. Ed. European Space Agency, 1994. ESA-SP-1170

[15] R.M. Bonnet et al, 'Mission to the Moon, Europe's Priorities for Scientific Exploration and Utilisation of the Moon', European Space Agency, ESA SP-1150, June 1992