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A truly international lunar base as the next logical step for human spaceflight

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Abstract

A human mission to Mars has been highlighted as the long term goal for space exploration, with intermediate stages such as missions to the Moon and/or to asteroids, but a human mission to Mars will not be feasible before several decades. For the time being the major ambitious accomplishment in the field of human spaceflight is the International Space Station but a human spaceflight programme which would be restricted to Low Earth orbit (LEO) has indeed little interest. Thus the next step in the field of human exploration should be the definition of a new exploration programme beyond LEO, built within a long term perspective. We must acknowledge that science is not the main driver of human space exploration and that the main success of the ISS is to have allowed its partners to work together. The main goal of a new human exploration programme will be to promote international cooperation between the major space-faring countries. The only sensible and feasible objective of a near/mid-term human spaceflight programme should be the edification of a lunar base, under the condition that this base is built as a truly international venture. The ISS in the 1990s had illustrated a calmed relation between the USA, together with Europe, Canada and Japan, and Russia; a lunar base would be the symbol of a similar calmed relation between the same partners and China, and possibly others such as India. For the benefit of all humankind this extra continent, the Moon, should be used only for peaceful purposes like Antarctica today, and should not become the theatre or the stake of conflicts. Such a programme is technically feasible and financially affordable in a rather short term. So let us go to the Moon, but let us get there together.

Keywords: Space exploration; Lunar base; Human spaceflight

1. Introduction

Space exploration can be defined as "open-ended project relying on both human and robotic activities to extend access to unknown terrains and environments, by means of direct (humans) and/or indirect (automated missions and robots) presence through a systematic approach, including preparatory activities, to open new frontiers for the progress and acquisition of new knowledge, and to present options to extend the range of human actions and inspire future generations".[1] With this very wide definition, any observation device as it is an extension of our senses can be considered an exploration tool; in that respect, looking for extra-terrestrial planets via an astronomical observatory is indeed related to the exploration but usually space exploration is meant to be restricted to the celestial bodies where in situ investigations are possible i.e. the objects of the solar system, and in a still more narrow fashion to the locations that likely could be reached by humans in a not too far, but still undefined future, which

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[1] Advisory Group to the ESA DG on Exploration, *Exploration scenarios working group: Preliminary Findings*, presentation to ESA member-states and cooperating states (May 2010).

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limits the scope of "exploration" to the Moon, Mars, and the Near Earth Asteroids (Ehrenfreund et al., 2012). In parallel, there are robotic, purely scientific missions toward the giant planets and their satellites, Mercury, Venus, and most of the small bodies (asteroids and comets).[2]

2. Where we are

Recently, the International Space Exploration Coordination Group (ISECG), a working group composed of representatives of 14 space agencies,[3] has released in 2013 the second edition of its Global Exploration Roadmap (GER) highlighting a human mission to Mars as the long term goal for space exploration, with intermediate stages such as missions to the Moon and/or to asteroids (ISECG, 2013) and the third edition will be released soon. From a scientific viewpoint, whereas on the Earth erosion and plate tectonics have erased the prints of its early stages, Mars has kept the traces of its evolution from a warm and humid past around 4 Gyears ago to its cold and dry state today; the extraordinary interest of its geological, climatic and possibly biological history (Bibring et al., 2006) is not questionable as Mars is the only planet of the solar system, except the Earth, where life as we know it may have emerged; it is also the only planet where it seems possible to send humans in a reasonable timeframe. There are several motivations for space exploration, without even mentioning the irrational ones: politics, technology, economy, science, education etc. Science is one of them but we must acknowledge that science is not the only driver of exploration, and not even the main one.

However there is not one clearly defined path to-date, inasmuch as the detailed individual strategies of the potential main actors seem to be still far away from each other.

In addition, a human mission down to the Martian surface and back does not seem to be feasible before several decades. Many important issues are still to be solved: (i) the duration of such a mission, typically 2 years (short stay) or 3 years (long stay), with no possibility of a premature return because the Earth-Mars transfer windows are open every 26 months, and the logistic problems of such a long trip (air, water, food, waste), (ii) the crew safety issues (radiations in the first place but also weightlessness, confinement and stress), (iii) the problem of safely delivering a heavy lander on the Martian surface, much heavier than the present robotic vehicles, and the need of a powerful Mars ascent vehicle to lift off the Martian surface (Mars's gravity is about twice larger than the Moon's). In the meantime robotic missions such as MSL-Curiosity, ExoMars, and Mars 2020 will provide an enormous amount of information on the geological, climatic and possibly biological history of the red planet and on its present environment and habitability,[4] at a rather moderate cost; in particular a robotic Mars Sample Return (MSR) mission is a pre-requisite for any human Mars exploration mission (see for instance i-MARS, 2008).

For the time being the major ambitious accomplishment in the field of human spaceflight is the International Space Station (ISS), whose assembly started in 1998 and should be completed in 2018. Within a decade or less, its operations will come to an end and we can already try to make an assessment of this colossal venture. The ISS is often presented as a large research facility but actually the great expectations expressed in the 80s and the 90s about the economical outcomes of microgravity research have not been met.[5] It does not mean that microgravity research has little value, indeed quite good science is performed in the ISS labs in physical sciences[6] and in life sciences,[7] but no major breakthrough has emerged to date; actually the main outcomes have been mainly beneficial to the space sector itself: life and medical sciences for better monitoring the health of the crews, fluid sciences for better understanding the behaviour of the fluid systems in the space assets. On the technology side, many examples of spin-in and spin-offs between ground-oriented R&D and space-oriented R&D can be evidenced (e.g. microelectronics, waste management, batteries) but it is not clear whether those progresses would not have happened without the space context.

We must acknowledge that the main success of the ISS is to have allowed its partners to work together.

On their side, the Chinese have developed their own human spaceflight programme ShenZhou which includes the man-tended modules TianGong 1 & 2 and the future space station TianGong 3 whose construction should start in 2018.

3. What then?

A long term human spaceflight programme which would be restricted to LEO has indeed little interest; thus the next step in the field of human exploration should be the

[2] A list of the numerous acronyms used in this paper is given in a dedicated Appendix A.

[3] Website: https://www.globalspaceexploration.org/wordpress/.

[4] Some people talk about "Mars terra-forming", i.e. modifying the Martian atmosphere and climate so as to make the planet habitable. However, because of its small size and the vanishing, early in its history, of an internal magnetic field generating a magnetosphere able to protect the atmosphere from the solar wind, Mars has lost the largest part of its atmosphere (Jakosky et al., 2015); that evolution explains its present climate and its physical causes are still there.

[5] In the 80s some people were promising billions of dollars generated by the products (alloys, crystals, medicines) manufactured in space; those promises have not been materialized, except of course for the industries who had built the space assets.

[6] For example in the physics of supercritical fluids and granular media, although the presence of astronauts may be a drawback because their activity perturbs the microgravity level.

[7] Valuable progresses have been made in the understanding of certain neuro-sensorial processes and cardiovascular mechanisms thanks to LEO investigations.

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