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Report

Activities of the COSPAR Panel on Exploration supporting the Global Exploration Roadmap

P. Ehrenfreund [a,*], C.P. McKay [b], and the COSPAR Panel on Exploration (PEX)

[a] Space Policy Institute, Elliott School of International Affairs, Washington, DC 20052, USA
[b] NASA Ames Research Center, Moffett Field, Mountain View, CA 94035, USA

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ABSTRACT

The Global Exploration Roadmap (GER) is driven by several goals and objectives that include space science, the search for life as well as preparatory science activities to enable human space exploration. The Committee on Space Research (COSPAR), through its Commissions and Panels provides an international forum that supports and promotes space exploration worldwide. COSPAR's Panel on Exploration (PEX) investigates a stepwise approach of preparatory research on Earth and in Low Earth Orbit (LEO) to facilitate a future global space exploration program. We summarize recent activities and workshops of PEX in support of the GER.

1. Introduction

The Committee on Space Research (COSPAR) is a Scientific Committee of the International Council of Science (ICSU). COSPAR represents national science institutions from 45 member countries, 13 international and scientific unions and 5 associated companies.[1] Its objectives is to promote on an international level scientific research in space for the benefit of mankind and to provide a forum, open to all scientists, for the discussion of problems that may affect scientific space research. COSPAR has 8 Commissions (A-H) and 11 Panels. In response to the growing importance of space exploration, the COSPAR Panel on Exploration (PEX) was founded in Montreal in 2008.[2] PEX provides high quality, independent science input to support the development of a global space exploration program while working to safeguard the scientific assets of solar system bodies.

2. A stepping stone approach

PEX has recently published an extensive report elaborating a stepping stone approach to achieve a new level of space cooperation that can help develop worldwide capabilities in space science and exploration and support a transition that will lead to a global space exploration program [1]. PEX, working with COSPAR Scientific Commissions and Panels, supports science-driven national and international space exploration working groups, as well as space agency groups such as International Science Exploration Coordination Group (ISECG) that draft the implementation of possible architectures for global space exploration. In fact, PEX directly supports the Global Exploration Roadmap (GER) in the coordination of exploration preparatory activities and by creating opportunities for partnerships.

PEX has recently defined specific stepping stones to explore Earth–Moon–Mars space that should be conducted in synergy with several stakeholders in the transition period toward a global program of space exploration [1]:

- International field research program in analog environments on Earth preparing for planetary exploration
- Enhanced exploitation of the International Space Station (ISS) enabling exploration
- Worldwide CubeSat program supporting exploration
- Global Robotic Village on the Moon (ILEWG, PICES)
- Joint Mars Sample Return Mission
- International Human Base on the Moon

With a focus on stepping stones, COSPAR can support a global space exploration program that stimulates scientists in current and emerging spacefaring nations. By engaging developing countries and emerging space nations to participate in an international space exploration program, it will be possible to create a critical bottoms-up support structure to support program continuity in the development and execution of future global space exploration frameworks.

* Corresponding author. Space Policy Institute, Elliott School of International Affairs, 1957 E Street, Suite 403, Washington, DC 20052, USA.
E-mail address: pehren@gwu.edu (P. Ehrenfreund).

[1] https://cosparhq.cnes.fr/.
[2] https://www.gwu.edu/~spi/pex.cfm.

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0265-9646/

3. International field research program in analog environments on Earth

In March 2011 PEX organized a workshop in cooperation with the European Science Foundation (ESF) and the COSPAR Panel on Planetary Protection (PPP) entitled *"International Earth-based research program as a stepping stone for global space exploration – Earth-X"*.[3] The workshop focused on the general structure of an international program that pursues compelling science goals and prepares for future robotic and human exploration of Earth, Moon, and Mars and other space exploration targets. For the moment Earth is our primary laboratory and the investigation of habitability in extreme environments through field research and supporting satellite observation establishes a bridge between Earth science and space exploration. PEX has recently compiled the numerous projects and programs relevant to worldwide activities in Earth-based field research [2]. Many of these programs include bilateral or multinational cooperation with established funding mechanisms.

Uniting these common efforts could lead to a global, cross-disciplinary program that supports space exploration missions beyond LEO. The exploitation of synergies between Earth science and space exploration provides an important element in securing sustainability and can be an important argument vis a vis funding organizations.

In a recent COSPAR report we have discussed the governance structure of an international framework of Earth-based field research in support of future space exploration, *Earth-X*. In order to coordinate international teams working together in the field some logistical, cross-cultural, proprietary and legal obstacles have to be overcome, see Fig. 1. Lessons learned from established International Earth Science and Technology Programs such as the International Polar Year, the Census of Marine Life, the Integrated Ocean Drilling Program and the Scientific Committee on Antarctic Research provide insights into the mechanisms of high level coordination and support functions for large terrestrial science and technology endeavors.

The two most important aspects that were identified are:

- Leadership and governance of international programs should be broadly-based with representation by all stakeholders
- Data consolidation and sharing through an open access database may represent the most important tool and legacy to a program

A framework with regular meetings (virtual and real), data exchange through reports, coordination with national and international funding sources, a website portal for coordination of field trips, samples, meetings, future opportunities and lessons learned as well as the development of knowledge transfer through an accessible database have been identified as important activities. A well-coordinated international Earth-based field research program can serve as a truly global exploration testbed upon which a united, multidisciplinary research program may be initiated that enables established and new space actors to work together to prepare for future planetary exploration missions.

4. Enhanced exploitation of the International Space Station (ISS) enabling exploration

Large-scale space exploration endeavors require not only a coordinated interdisciplinary preparation phase on Earth but also in space. Many facilities on the International Space Station (ISS) enable scientific research that prepares for space exploration beyond LEO.

A recent NRC Decadal Survey on Biological and Physical Sciences in Space[4] (2011) discusses the multidisciplinary challenges of future space exploration activities. PEX cooperates with COSPAR Scientific Commission F: *"Life Sciences as Related to Space"* that deals with the effects of extraterrestrial environments on living systems such as biological effects of changes in gravitational forces and/or of the radiation environment in space, biological and medical studies of human beings in spaceflight, life support systems and radiation risk estimations. Given the newly integrated facilities and enhanced crew on the ISS, PEX investigates pathways how the ISS can be exploited by a wider variety of space and non-space actors (including emerging space powers, developing countries, academic institutions, private organizations and others) in cooperation with the ISS partners. The recently announced possible extension of the ISS to 2024 may provide a further opportunity to advance human and robotic space exploration through investigating the effects of long-duration space exposure and testing technologies and materials for future exploration systems in a larger consortium of nations.

5. Worldwide CubeSat program supporting exploration

CubeSats represent nanosatellites with specified base shape of 10 × 10 cm dimensions, and then extending in length from 10 cm onward. The basic 10 × 10 × 10 cm units weigh ~1 kg. CubeSats have university heritage and began as an affordable educational tool for science and engineering university students [3]. The low cost and short cycle from development to operation and data analysis for cubesats represents an ideal aid for science education [2]. In the last decade cubesats have undergone a revolution and are becoming interesting science research and technology development platforms [4] that can timely integrate the latest technologies. By the end of 2012, more than one hundred cubesats have been launched, and many more were manifested for launches in the coming years [5].

The UN Basic Space Technology Initiative (UNBSTI) also recognized the value of these small satellites and supports cubesat science and technology applications for emerging space nations and developing countries [6]. A major bottleneck for cubesat is the availability of affordable launch opportunities [5].

Due to their small size and low power, payload instruments that have flown on small satellites can contribute opportunistically to planetary science missions and now include research areas such as astrobiology, atmospheric science, astronomy, planetary science and others [5,7]. By utilizing mass and power margins, and due to their previous space qualification, they can be integrated reasonably late in the overall mission development cycle, when such margins are well defined. Future applications for cubesat technology are under consideration for hitchhiking on planetary exploration missions on Mars orbiters and cube accommodation slots on various landers. A "planetary hitchhiker" carries a payload system or complete small satellite along on a mission to a planet, moon, or other solar system body, the small sat or payload having its own separate and independent set of science or technology goals from the primary mission [8].

The number of research areas for cubesats is ever increasing and payload technology provides an outstanding opportunity to enable innovative technological advances in sensor and miniaturized instrument design for astrobiology applications in terrestrial field

[3] https://www.gwu.edu/~spi/pexmarchworkshop.cfm.

[4] http://www.nap.edu/catalog.php?record_id=13048.