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Report

ESA strategic planning for space exploration

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ABSTRACT

The European Space Agency (ESA) is pursuing an independent strategic planning process for consolidating a destination driven (LEO, Moon, Mars) space exploration strategy. ESA's space exploration strategy is driven by the goals to maximise knowledge gain and to contribute to economic growth. International cooperation is a key pillar of ESA's strategy as it is considered both, an enabler for achieving common goals and a benefit, opening new perspective for addressing future challenges. The achievement of ESA's space exploration strategy is enabled through international partnerships. The interagency coordination process conducted within the framework of the International Space Exploration Coordination Group (ISECG) plays an important role in laying the foundations for future partnerships. It has achieved so far the development of a common vision for space exploration, a common plan for implementing the vision in the form of the Global Exploration Roadmap, as well as a common approach for articulating the value of global space exploration. ESA has been a strong promoter and supporter of the interagency coordination process conducted within ISECG and thanks to its unique expertise in international cooperation the Agency has contributed to its success.

1. Introduction

Within its independent planning process the European Space Agency (ESA) considers international cooperation both, as an enabler for achieving common goals and a benefit, opening new perspective for addressing future challenges. ESA has been a strong supporter of and participant in the work of the International Space Exploration Coordination Group (ISECG) since its inception. ISECG has been for the past seven years the recognised forum where 14 space agencies strive to advance a long-range human space exploration strategy consolidated in the Global Exploration Roadmap (GER) [1]. The second edition of the GER was released in August 2013. This up-dated roadmap reflects a common vision of a step-wise approach to human exploration. It enables agencies to advance their capabilities to expand human presence in the solar system in a step-wise approach through international missions carried out in cooperation, with a long-term goal of achieving human missions to Mars. It demonstrates how the global space-faring community can work together in achieving common space exploration goals. The last meeting of the International Space Exploration Forum (ISEF), held in Washington D.C. in January 2014 at political level, reiterated the importance of ISECG to foster international cooperation for a sustainable exploration endeavour. The ESA Director General in his address to ISEF stated that the strategic approach of the GER represents a good starting point on which ESA future mission concepts can be further defined, and the necessary technology preparation carried out in full coordination with all partners. He added that in the future ISECG can play an instrumental role in identifying opportunities for exploring synergies between agencies' interests and plans, as well as facilitating the inclusion of new members and promoting global engagement in space exploration at agency level. This paper outlines in Section 2 some key principles of ESA's Space Exploration Strategy and then discusses in Section 3 the role of ISECG and how ESA considers the work of ISECG in its strategic planning process.

2. Key elements of ESA's strategy for space exploration

Space Exploration is an open-ended process started 50 years ago. It enables access to unknown terrains with robots and humans, thereby opening new frontiers. It is an international endeavour fostering international partnerships and benefiting society at large [2], while addressing fundamental questions related to the history, existence and future of life. It stimulates knowledge gain,

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innovation and inspiration. As a global endeavour it creates new opportunities for addressing humanity's future global challenges.

In line with the ESA vision of space exploration introduced above, the ESA Space Exploration Strategy is based on clearly articulated strategic goals highlighting the link between space exploration and its value to society, focussing on selected destinations and international cooperation.

2.1. Strategic goals

Significant work has been done in Europe and at international level on the value and benefits of space exploration for society at large. Reflecting the results of this work and focussing on the core opportunities space exploration offers, ESA's engagement in future international space exploration missions is driven by the following overarching strategic goals:

- Maximise knowledge gain by fully utilising human infrastructures in LEO and extending the boundaries of human experience and presence beyond LEO, leveraging on the complementarity and partnership of humans and robots;
- Strengthen the European academic and industrial competence, and thereby European economic growth, leveraging on the unique potential of space exploration for driving innovation;
- Leverage on and maximise the value of past investments in human spaceflight (ISS), robotic exploration (ExoMars), transportation (Ariane) and relevant science missions (e.g. Mars Express, Rosetta).

2.2. ESA's exploration destinations

ESA activities and planning in space exploration are focused on three priority destinations: Low Earth Orbit (LEO), Moon and Mars. LEO is currently the only destination within reach by humans and permanently occupied by six Astronauts of different nationalities on-board the International Space Station (ISS). 12 US Astronauts visited the lunar surface from 1969 to 1972 during the Apollo programme. Achieving human missions to Mars is considered at international level the common long-term goal for human exploration, to be achieved in a step-wise approach, through robotic scouting of the Martian surface and human missions to the Moon as a stepping stone and destination in its own right. These destinations have been selected insofar as they answer the following criteria:

- Accessibility and resulting ability to implement a series of robotic and/or human missions implemented incrementally, each mission building on the results achieved by the previous one;
- Ability to achieve human (surface) missions within a time span of less than 20–30 years;
- Potential for advancing knowledge gain and addressing priority science questions;
- International context and opportunity for establishing international partnerships.

Each of those three destinations offers unique opportunities for knowledge gain. Research on-board the ISS advances knowledge in many domains, in particular in life and physical sciences and in the ability for humans to work in a hazardous environment. Past and ongoing missions to the Moon and Mars allow us to learn more about these destinations (resources, hazards for humans, environment) and advance broader scientific questions related to the history of the Solar System and the emergence and co-evolution of life on Earth within its planetary environment [3]. Future space exploration missions to, and development of infrastructures at, these destinations will provide opportunities for advancing science in many other domains, as demonstrated by the ISS which also host payloads in the field of Earth observation and fundamental science [4] .

Human missions to LEO and Moon will play an important role in the step-wise extension of human reach and presence beyond LEO. LEO has proven to be an ideal platform location for advancing human research, demonstrating operational concepts, demonstrating technologies and maturing capabilities in preparation for deep space exploration. The international architecture that supports future human exploration and the associated roles and responsibilities of partners, will be shaped during the lunar exploration phase. Early human missions beyond LEO to the vicinity of the Moon, taking place at the same time of robotic assets operating on the lunar surface, will enable us to advance the concept of human/robotic partnership and foster innovative mission concepts. Recent discoveries of volatiles at the lunar polar regions make the Moon an ideal place for demonstrating the potential for in-situ resources utilisation in support of human exploration [5]. Furthermore, human missions to the lunar surface are a key component for reducing risk of human missions to the surface of Mars to an acceptable level.

2.3. International cooperation

Exploration of space is a global undertaking. All ESA space exploration activities are implemented in the context of international cooperation. In this context ESA has to rely on the capabilities of its international partners in the domain of human transportation. However, with its ATV-programme ESA has demonstrated autonomous capabilities in support of human spaceflight. International cooperation enables achieving more value for money by pooling resources, complementing each other's capabilities and sharing resulting benefits.

ESA's approach for establishing international partnerships is guided by the following principles:

- Ensure robustness of cooperative activities through occupying critical path roles; structuring partnerships on the basis of complementarity and mutual benefits with a view to incrementally build long-term strategic partnerships.
- Become the partner of choice demonstrating areas of excellence, a track record of mission successes and reliability in delivering on commitments.
- Create a strong foundation for future partnerships and global engagement through fostering international coordination in planning future activities and promoting a flexible cooperation framework.

2.4. Programmatic approach

ESA's space exploration programmes and programmatic priorities are structured around ESA's exploration destinations (LEO, Moon, Mars), strategic partnerships with its international Partners and the time-period up to 2020 and post 2020. The Table 1 below recalls major ESA programmatic objectives.

ESA has so far identified the following strategic building blocks it intends to contribute to international exploration missions in the post 2020 time period. ESA intends to prepare its participation in such international exploration missions through advancing and demonstrating priority technologies and integrated capabilities (at subsystem and system level) associated with the following building blocks:

- Visual navigation, hazard detection and avoidance;
- Sample acquisition, processing and containment system;
- Sample return Earth re-entry capsule;