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GLOBAL SPACE EXPLORATION POLICIES AND PLANS: INSIGHTS FROM DEVELOPING THE ISECG GLOBAL EXPLORATION ROADMAP

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The International Space Exploration Coordination Group (ISECG) was established in response to *"The Global Exploration Strategy: The Framework for Coordination"* developed by fourteen space agencies[1]. This strategy, commonly referred to as the GES, recognizes that preparing for human space exploration is a stepwise process, starting with basic knowledge and culminating in a sustained human presence in space. Robotic exploration is considered an important component of expanding human presence in space in order to increase the knowledge of future destinations, take steps to reduce risks to human explorers, and ensure the human missions can deliver maximum scientific discoveries. The ISECG enables interested agencies to develop the products considered important to inform their individual decision making, enabling decisions to be made in a coordinated manner.

In developing the *Global Exploration Roadmap*[2], participating agencies have further elaborated the vision introduced in the GES and demonstrated their intention to maximize partnership opportunities in order to enable sustainable human exploration beyond low Earth orbit. They see the roadmap as a tool in facilitating this coordination and cooperation. They also recognize that the long-term nature of exploration endeavors necessitates identification and discussion of strategic considerations which affect their desire for an international human exploration effort. Participating agencies feel these considerations are important to understand and seek agreement early in the conceptual formulation effort.

Agencies have shared the status of their programs and plans as they pertain to space exploration. In doing so, they share insights into existing and emerging policies within their nations. Understanding these policies and plans, common elements, and common trends is important to ultimately reaching the necessary strategic consensus. This paper will review the status and common trends within ISECG participating agencies which have affected development of the first iteration of the Global Exploration Roadmap. It will

[1] In alphabetical order: ASI (Italy), CNES (France), CNSA (China), CSA (Canada), CSIRO (Australia), DLR (Germany), ESA (European Space Agency), ISRO (India), JAXA (Japan), KARI (Republic of Korea), NASA (United States of America), NSAU (Ukraine), Roscosmos (Russia), UKSA (United Kingdom). "Space Agencies" refers to government organizations responsible for space activities.
[2] Released in September 2011.

discuss the common strategies and findings as they pertain to ISECG's foundational work advancing the GES.

For more information on the ISECG please consult the ISECG website at www.globalspaceexploration.org or contact the ISECG Secretariat at: isecg@esa.int.

INTRODUCTION

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In developing the *Global Exploration Roadmap*, participating agencies have further elaborated the vision introduced in the GES and demonstrated their intention to maximize partnership opportunities in order to enable sustainable human exploration beyond low Earth orbit. They see the roadmap as a tool in facilitating this coordination and cooperation. They also recognize that the long-term nature of exploration endeavors necessitates identification and discussion of strategic considerations which affect their desire for an international human exploration effort. Participating agencies feel these considerations are important to understand and seek agreement early in the conceptual formulation effort.

Space agencies participating in ISECG believe that through coordination and cooperation, they will be able to reach their individual agency space exploration objectives in a more timely and robust manner. They have started the necessary dialog to enable this, and recognize that the global economic situation makes it essential that they succeed. This paper reviews the status and common trends within ISECG participating agencies which have affected development of the first iteration of the Global Exploration Roadmap. It will discuss the common strategies and findings as they pertain to ISECG's foundational work advancing the GES.

GLOBAL OUTLOOK ON SPACE EXPLORATION

Agencies have shared the status of their programs and plans as they pertain to space exploration. In doing so, they share insights into existing and emerging policies within their nations. Understanding these policies and plans, common elements, and common trends is important to ultimately reaching the necessary strategic consensus.

General Outlook for Space Exploration

Every agency participating in the ISECG recognizes the importance of a coordinated dialog which enables space exploration in a manner consistent with established or emerging strategies. A common element is the acknowledgement of the importance of the ISS as the test bed and the starting point for the human space exploration. This is followed by a step-by-step approach, were individual capabilities and technology developments are leveraged. All agencies feel the impacts of the current global economic situation and look for initiatives to make ISS operations and space exploration more affordable. Lastly, the retirement of the U.S. Space Shuttle and completion of ISS assembly creates industrial base issues which are under discussion in many nations.

Agency Specific Highlights

CNES

CNES is contributing to European Space Agency's science and robotic exploration programs, and in particular to ExoMars. Several other international cooperation's (Phobos Grunt, Mars Science Laboratory, Selene-2 and Maven) are also on the way. In addition, France is involved in ISS exploitation and utilization, notably through the ATV control center and the CADMOS operational center at CNES, as well as the procurement of several instruments.

CSA

Canadian space exploration plan has been established in 2007, and the space exploration became one of the four programs in CSA. The major activities in CSA based on the plan include continuous operation and upgrade of Mobile Servicing System, full utilization of ISS to prepare for exploration, play key role in Mars exploration, and to develop Canadian rovers & technologies on the Moon, and analogue field test in Hawaii in cooperation with NASA.

DLR

Space Strategy of German Federal Government was released on Nov. 30, 2010. DLR is in process to align and consolidate its national and international activities with the strategy, ESA's Scenario Studies and ISECG. DLR is involved in ESA's exploration program such as ISS exploitation, Lunar Lander, Philae Lander, and ExoMars. Also, international cooperation with JAXA for Hayabusa-2 is under discussion.

JAXA

After the successful return of Hayabusa in June 2010, extensive and detail examination of the samples from Itokawa is on-going. Also, Hayabusa-2 project targeting C-type asteroid has started. For lunar exploration, based on the report issued by the study group for Japanese lunar exploration strategy, project planning succeeding SELENE is on going. On the other hand, utilization of JEM is accomplishing achievements with the support of Japanese astronauts. Furthermore, the HTV-1 & 2 missions have successfully completed.

ESA

ESA activities in human spaceflight are focused on the operations and effective utilization of ISS for research and development. For enhancing efficiency of ISS operation and using ISS as a test-bed for exploration, ESA plans to install on-board ISS by 2016 an advanced closed-loop life support system for air revitalization. The ATV-1 &2 missions have been successfully completed. ESA collaborates with NASA in the area of robotic Mars exploration for the implementation of the ExoMars missions and develops furthermore a robotic lunar lander as precursor for future human exploration missions. Furthermore, ESA advances exploration technologies in selected fields and is engaged in, several analogue actives such as Mars500 in collaboration with Roscosmos, and campaigns for testing exploration capabilities in fields such as robotics and health-management. An important political process has been initiated in 2008 for the development of a European vision and strategic plan for exploration. One outcome of this process is the proposal to establish a High-level International Space Exploration Platform at political level.

NASA

The FY 2010 Authorization Act is being executed, with continued operation of ISS until at least 2020, development of Commercial Cargo and Crew to LEO access, development of the Space Launch System and Multi Purpose Crew Vehicle, and research for exploration. U.S. Planetary Science Decadal Survey continues to inform NASA decision making. NASA celebrated the accomplishments of the Space Shuttle program, with the last flight of STS-135 in July 2011. Furthermore, many scientific exploration missions or launches were successfully performed this year such as Stardust NExT encounter to Comet Tempel, MESSENGER orbit insertion at Mercury, Dawn in orbit around asteroid Vesta, Juno launch to Jupiter, and GRAIL launch to the Moon. HQ Mission Directorate Merger and Reorganization has done this summer.

OVERVIEW OF THE INTERNATIONAL SPACE EXPLORATION COORDINATION GROUP

In 2006, fourteen international space agencies began a series of discussions on space exploration. Together they expressed their shared interest in "creating a common language of exploration" to enhance mutual understanding among partners and to identify areas for potential cooperation. This vision was articulated in 'The Global Exploration Strategy: The Framework for Coordination' and released in May 2007. A key finding of the so-called Framework Document was the need to establish a voluntary, non-binding international coordination mechanism through which individual agencies could exchange information regarding interests,

objectives, and plans in space exploration with the goal of strengthening both individual exploration programs as well as the collective effort. The coordination mechanism was called the International Space Exploration Coordination Group (ISECG).

It was in this spirit that in July 2008 the members of ISECG agreed to collectively explore ideas and plans for the human exploration of the Moon. From the latter half of 2008 through early 2009 interested agencies participated in a series of Lunar Architecture Workshops to begin the process of discussing human exploration of the Moon in the international community and considered how to best satisfy the human lunar exploration objectives. The work resulted in the ISECG Reference Architecture for Human Lunar Exploration serving as a global 'point of departure' (commonly referred to as the Lunar GPoD). In June 2010, senior exploration managers representing space agencies recognized that this architecture is an interesting concept for human-robotic exploration of multiple locations across the moon's surface.

They also reached consensus on expanding the work to all key exploration destinations and on determining the critical building blocks required to reach these destinations. This would form a "global exploration roadmap" - a key element of an evolving international architecture effort.

Since then, the main focus of ISECG's activities has been the development of a Global Exploration Roadmap reflecting shared concepts for human exploration as well as plans in the areas of planetary robotic exploration, advanced technology development and the use of the ISS in preparation for exploration. The initial version of the Global Exploration Roadmap has been reviewed by senior agency managers on August 30, 2011 and was released on September 22, 2011.

Participation in ISECG

The ISECG Reference Architecture for Human Lunar Exploration represents one international approach, reflecting the best ideas and concepts of engineers and scientists from participating agencies. The development of the Global Exploration Roadmap expands the work to all key exploration destinations recognizing that such a roadmap will be evolving and responding to new programmatic priorities, scientific discoveries and technological breakthroughs.

Both products demonstrate the usefulness of ISECG in:

- Performing studies which can subsequently lead to partnerships enabling the realization of joint missions;
- Informing large and small agencies of the cooperation opportunities presented by their participation
- Enabling them to see how their capabilities and long term interests may lead to specific contributions to an international exploration endeavor;
- Facilitating the synergy of international space exploration mission plans, programs and policies and thereby enhancing opportunities for collaboration and coordination;
- Maximising the benefits resulting from each planned mission, in particular when considering potential follow-on missions ;
- Encouraging timely investments in enabling technologies and their demonstration, with a special emphasis on the full use of the International Space Station (ISS) for preparing future human exploration missions.

A next step to be considered is to identify robotic missions for which some payloads could serve as precursor to human missions. This could enhance the synergy between robotic missions and human exploration missions.

ISECG Product Overview

The first important product of ISECG was the ISECG Reference Architecture for Human Lunar Exploration which reflects the agency commitments to finding an effective balance between conducting important scientific investigations of and from the Moon, as well as demonstrating and mastering the technologies and capabilities to send humans farther into the Solar System. The lunar gPoD begins with a robust robotic precursor phase that demonstrates technologies and capabilities considered important for the success of the campaign. Robotic missions will inform the human missions and aim at reducing their associated risks. This work informed agencies preparing to play a role in a human lunar exploration program.

The second important product is the Global Exploration Roadmap (GER). The first iteration of this product has been released in September 2011. The GER enables agencies to work collaboratively on long-range exploration scenarios and look for opportunities to coordinate and cooperate on preparatory activities. The first iteration of the GER captures the common long-range human exploration strategy, which starts from the International Space Station (ISS) and expands human presence throughout the solar system, leading to human missions to the surface of Mars.

THE GLOBAL EXPLORATION ROADMAP

In order to effectively inform individual agency decision making, the Global Exploration Roadmap creates a framework for technical discussions. This framework has 3 elements: Common Goals and Objectives, Long-Range Exploration Scenarios, and coordination of exploration preparatory activities. Each of these elements is considered important in preparing for an international exploration program of the future. Each will be summarized below.

Common Goals and Objectives

Agencies have shared their space exploration objectives with the intent of looking for commonality. Agencies recognize that they don't need to have a completely common set of goals and objectives; however, agencies must be able to see a path towards meeting their individual objectives through the common effort. More information can be found in IAC-11.A5.4.2, *ISECG Space Exploration Goals, Objectives and Benefits* (Ref 1).

Long-Range Exploration Scenarios

The roadmap focuses on two pathways: "Asteroid Next" and "Moon Next". Both the "Moon Next" and "Asteroid Next" pathways are deemed to be practical approaches which address common high-level exploration goals developed by the participating agencies and inform near-term decisions faced by individual agencies. Each pathway is expanded through a "Mission Scenario". More information can be found in IAC-11.D3.1.2, *ISECG Mission Scenarios and their Role in Informing Next Steps for Human Exploration beyond Low Earth Orbit (Ref 2).*

Near-Term Opportunities for Coordination and Cooperation

By working together on long-range exploration mission scenarios, agencies have a common reference regarding needed technologies, research and capabilities for exploration. With this, they have a basis for making individual decisions regarding near term investments in a coordinated manner. The work of ISECG is but one important input to their national decision making effort.

EMERGING TRENDS AND ISSUES

In developing products jointly within the ISECG, participating agencies have identified several strategic considerations which deserve further reflection. In some cases, these strategic considerations represent emerging trends observed in overall space exploration efforts. In other cases, these considerations represent issues to be discussed and tackled collectively in order to enable international partnerships for space exploration. Several of these considerations are discussed below.

Interdependency

Human exploration will require agencies to accept and manage interdependency at different levels: architecture, mission, capabilities and systems. This is because no one nation can invest in all the capabilities necessary to sustainably explore. Enablers for interdependency include:

- Availability of a long-term plan reflecting agency consensus
- Long-term political commitment
- Common transportation policy
- Clear identification of exit strategies
- Redundancies/ programmatic robustness
- Gradual inclusion of new Partners through confidence building measures
- Common agreement on role of commercial initiatives which may evolve

Interdependency will be a key driver for discussion on governance schemes and cooperation framework. Products such as the GER help participating agencies to gain insights in needs for and implications of interdependency. Understanding the importance of interdependency at this early stage will help agencies take steps to define partnerships in a way that can best enable their successful implementation.

High-Level International Space Exploration Platform

As stated above, long-term political commitment at international level is an essential enabler of a

sustainable exploration endeavour which is based on international interdependency. The Intergovernmental Agreements between the ISS Partners have created the necessary stability for the successful implementation of the ISS programme over a long period of time. The GES already debated extensively the need for global exploration as an enabler for sustainable space exploration and the GER strongly builds on this assumption. Clearly, the implementation of a long-term exploration roadmap leading to a human mission to Mars will not be implemented through one large international programme, like it has been the case for the development and operations of the ISS. Exploration will rather be implemented through a multitude of programmes, some nationally others based on international cooperation. Larger international exploration programmes will be based on specific cooperation frameworks, of which some may require agreements at intergovernmental level. To succeed in the implementation of the GES vision and the implementation of the Global Exploration Roadmap, the various programmes to be implemented need to fit into a "bigger picture" at political level, and leverage on each other.

International political vision, guidance and commitment will be required to enable the implementation of a robust and sustainable space exploration programme. With this in mind and recognising the importance of early political engagement at international level, the political process initiated in Europe in 2008 under the joint leadership of the European Commission (EC) and ESA has led to the proposal to establish a non-binding High-level International Space Exploration Platform at political level. This Platform, will be discussed in Lucca (Italy) on 10 November 2011, and should provide the necessary frame in which Europe (ESA, EC and their Member States) and its International Partners will discuss and exchange on their respective plans and possible cooperation, at the level of the Ministers in charge of space.

The importance of a cadence of Astronaut flights

Astronaut flights are the most visible return of investments in human spaceflight programs to the public; Astronauts are the ambassadors of the overall program and provide a unique perspective and benefit of space exploration. In short, they are essential for mobilising and sustaining significant investments in human spaceflight activities. Designing mission scenarios which provide a cadence of astronaut opportunities to all participating nations is essential.

Human robotic partnership

Human-robotic partnership is an indispensable element in any effort of exploration. This includes robotic missions designed primarily to meet scientific objectives, those implemented in preparation of human missions and robotic systems which travel together with human explorers.

Development of robotic technologies is considered a key priority for many agencies participating in GER development. This is because exploration requirements can help to drive innovation in robotic systems which benefit terrestrial markets.

Robotics missions in the near to medium term are the most visible expression of agency's intent and commitment to explore the target destination of interest. Human spaceflight activities will focus in the next 10 years on missions to ISS/ LEO and development of capabilities for exploration, while robotic scouts will advance our knowledge of the solar system and prepare for human missions to follow.

The GER process contributes to identifying opportunities for international coordination and cooperation in robotic missions. It also ensures that interoperability standards are defined such that the human-robotic partnership maximizes the overall return of space exploration investments.

NEXT STEPS AND CONCLUSION

To advance the global space exploration effort, the important work of ISECG should continue. The ISECG is open to any national space agency who shares the desire to advance the globally coordinated space exploration vision contained in the GES. Yet, decisions regarding space exploration will not be made by ISECG. As a non-binding forum, ISECG is useful for advancing a common understanding of potential missions and the technical and political enablers. To this end, the GER will be updated regularly to reflect changes to agency policies and plans, as well as the emerging consensus on global efforts which responds to these plans.

In addition, a political dialog is expected to contribute to advancing a coordinated

exploration effort. The concept of a high-level or political platform is recognized as being an important element of a successful international endeavour. Such a platform can ensure that the commitment of participating nations is maintained over time, and that the joint effort delivers the desired benefits to stakeholders. It is a question of timing.

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