



# Annual Report 2017



## **International Space Exploration Coordination Group – ISECG**

ISECG was established in response to the “The Global Exploration Strategy: The Framework for Coordination” (GES) which was released in May 2007. This GES Framework Document articulated a shared vision of coordinated human and robotic space exploration focused on solar system destinations where humans may one day live and work.

The purpose of ISECG is to provide a forum to discuss interests, objectives and plans in space exploration and to support promotion of interest and engagement in space exploration activities throughout society. The work of ISECG agencies results in documents, papers, findings and recommendations that are critical in informing individual agency decision making. In 2016, ISECG’s membership counted 15 space agencies.

### **INTERNATIONAL SPACE EXPLORATION COORDINATION GROUP**

ISECG Secretariat

Keplerlaan 1, PO Box 299, NL-2200 AG Noordwijk, The Netherlands

+31 (0) 71 565 5069

[ISECG@esa.int](mailto:ISECG@esa.int)

All ISECG documents and information can be found on:

<http://www.globalspaceexploration.org/>

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## 1 Executive Summary

Throughout 2017, ISECG pursued various activity lines, from which many findings contributed to the update of the “ISECG Global Exploration Roadmap” document, released in January 2018.

The importance of the Moon (lunar vicinity and lunar surface), on the path to Mars, has been recognised by space agencies and supported by a strong interest from academia and the private sector. ISECG study work comprised an international deep space Gateway around the Moon, also involving ISS partners, which are all members of ISECG. They continued to demonstrate their commitment to expanding the partnership of nations involved in human space exploration.

Additionally, the work to engage the various science communities around the globe in 2016 and 2017 identified recommendations for exploration priorities. In December 2017 ISECG published the full Science White Paper on “Scientific Opportunities Enabled by Human Exploration Beyond Low-Earth Orbit”. The document highlights scientific opportunities in the near term mission themes of the Global Exploration Roadmap as well as the horizon goal of Mars. Two scientific themes are strongly associated with exploration missions: ‘Understanding Our Place in the Universe’ and ‘Living and Working in Space’.

Efforts were continued to understand lunar volatiles, also engaging agencies’ experts, and to identify opportunities for collaboration across the numerous planned lunar polar robotic missions. Advancements in private sector concepts for human space exploration in both LEO and beyond LEO enabled agencies to assess possible future partnership opportunities.

ISECG architectural work has enhanced the integration of the deep space Gateway and the concept development for elements like an advanced human lunar ascent stage, robotic and human rated landers as well as small pressurized rovers.

ISECG agencies have significantly advanced the characterisation and assessment of critical technologies related to the GER mission scenario. This has allowed participating agencies to inform their technology investment planning to create synergies and maximise their readiness to play a critical and visible part in the exploration endeavour. These technology “pulls” have been mapped to corresponding agency technology development activities, allowing a high-level and global technology gap assessment.

In 2017, ISECG agencies also started two detailed study activities to assess technology gaps in discipline areas that traditionally had not been examined on an international level. Teams of subject-matter experts were assembled from participating agencies to assess gaps in the areas of ‘Autonomous Systems’ and ‘Telerobotic Control of Robotic Systems with Time Delay’; identifying, amongst others, opportunities to coordinate technology investments amongst agencies. Both studies are expected to be completed early in 2018.

## 2 ISECG Highlights, Achievements and Special Projects in 2017

### Preparations for the Updated “Global Exploration Roadmap”

During 2017, ISECG work and discussions focused on strategic areas of importance to space agencies as they prepare for upcoming decisions regarding participation in an international effort to explore. Discussion topics included:

- The importance of the Moon (lunar vicinity and lunar surface) on the path to Mars, including a reference architecture which enabled agencies to meet goals and objectives and responded to the agreed set of strategic principles. Agencies recognise the strong interest in the Moon, including from academia and the private sector and were interested in identifying government investments which could also set the stage for future lunar exploration led by government or private sector entities.
- Maintaining focus on Mars as a driving horizon goal for human space exploration. Space agencies believe that significant benefits will come from continued expansion of human presence into the Solar System and seek to use the goal of future Mars missions to inform technology and capability investments.
- An international deep space Gateway around the Moon, which is considered the next important step in human exploration beyond LEO. Study work performed by ISS partner agencies was shared within ISECG, including Gateway conceptual design and draft interoperability standards. ISS partners, who are all members of ISECG, continued to demonstrate their commitment to expanding the partnership of nations involved in human space exploration.
- Recommendations from a global science community. The work to engage the various science communities around the globe in 2016 and 2017 identified recommendations for exploration priorities.
- Advancements in private sector concepts for human space exploration in both LEO and beyond LEO. Understanding the interests, priorities and capabilities of the private sector enabled agencies to assess future partnership opportunities.

These discussions culminated in the release of the updated “ISECG Global Exploration Roadmap” in January 2018.

Intensifying the efforts to understand lunar volatiles ISECG formed a dedicated team, also engaging agencies’ experts, to look for opportunities to collaborate and cooperate across the numerous planned lunar polar robotic missions. The ISECG website on lunar volatiles continues to be an excellent community resource for information (<https://lunarvolatiles.nasa.gov>).

During 2017, both ISECG and participating agencies continued planning for human missions in the lunar vicinity. NASA’s progress with the Space Launch System (SLS) and the Orion spacecraft towards a first integrated test flight in late 2019 will establish a transportation system for Solar System exploration, and enable build-up of the deep space Gateway. Detailed work focused on crew missions to lunar vicinity to begin assembly of an evolvable deep space habitat, will support missions to Mars and will also be used as a staging post enabling human lunar surface missions. China launched the Tianzhou-1 cargo vessel to Tiangong-2, demonstrating successful docking and refueling operations which will be needed for the future China Space Station.

## Refinement of Architecture Elements

On architectural level ISECG integrated with the ongoing Gateway formulation activities to form the technical basis for the Global Exploration Roadmap. In a dedicated paper a “Global Exploration Roadmap Derived Concept for Human Exploration of the Moon” was presented at the Global Exploration Conference (GLEX) in Beijing, including an advanced human lunar ascent element concept with reduced mass, establishment of a control mass for human lunar lander and robotic lunar lander concepts for use by Gateway formulation teams, and refinement of the potential power concepts for surviving the lunar night in the small pressurized rovers.

## Publication of ISECG Science White Paper

ISECG published the full Science White Paper on “Scientific Opportunities Enabled by Human Exploration Beyond Low-Earth Orbit” in December 2017. The 36-page document followed the publication of the 6-page summary in November 2016, highlighting in detail the scientific opportunities in the near term mission themes of the Global Exploration Roadmap – humans to a gateway in the lunar vicinity, humans to the lunar surface and humans to a near-Earth asteroid – as well as the horizon goal of Mars. The opportunities for scientific discovery associated with exploration missions are captured in the two scientific themes: ‘Understanding Our Place in the Universe’ and ‘Living and Working in Space’.

The development of the document was led by ISECG’s Science Advisory Group and incorporated the diverse inputs from the international science community as well as the ISECG participating agencies. The key science aspects have been introduced into the updated “ISECG Global Exploration Roadmap”.

## Technology and Gap Assessment Analysis

In the area of technology analysis ISECG achieved several milestones in 2017. Subject-matter experts from participating agencies were engaged and validated the individual technology descriptions, performance characteristics and categorisation into the reference NASA Technology Area Breakdown Structure (TABS). This categorisation is a key for the portfolio analysis and mapping to agency technology development plans and activities. Dedicated topical gap assessments have been conducted in the areas of ‘Autonomous Systems’ and ‘Telerobotic Control of Robotic Systems with Time Delay’ with the focus of the analysis on cislunar and lunar mission themes as well as long-lead items for human Mars exploration. Autonomy enables the crew to conduct operations under nominal and off-nominal conditions independent of assistance from Earth-based support. Capabilities for autonomy must also sense, perceive, reason, and act in order to safely and reliably control the spacecraft and mission support systems/infrastructure. The expert group has found that advances in electronics, computing architectures and software that enable autonomous systems to interact with humans are needed and can be leveraged from commercial markets to support maturation of needed capabilities. Collaboration amongst the space industry and partnerships with commercial providers are needed to develop affordable, radiation-hardened electronics, mature capabilities in perception and reasoning. Tele-robotic operations with time delay can make human-in-the-loop commanding and monitoring of robots at remote distances less effective. The gap assessment team found that while manual command modes may be used in some contingency cases, nominally for safety and efficiency with time delays greater than five seconds, it is recommended that robots be operated as autonomously as possible.

Generally, analysing technology and knowledge gaps it evolved that in many cases, the technology exists on Earth but on-orbit applications often require greater reliability and/or

specialised hardware such as rad-hardened high speed processors and smaller lighter, lower power versions of the sensors and systems used for terrestrial applications. Additionally, off-Earth operations have unique challenges that cannot be properly defined or addressed without knowledge of the constraints and experience under actual conditions.

## Outlook for 2018/2019

### ISECG Working Groups

#### Exploration Roadmap Working Group (ERWG)

The Exploration Roadmap Working Group will continue its efforts to find cooperation and collaboration opportunities across planned lunar polar robotic missions, including promoting data sharing of important information on the lunar volatiles. The Analogue Team will also continue to meet quarterly and share lessons learned and collaboration opportunities.

#### International Architecture Working Group (IAWG)

The International Architecture Working Group will continue to refine the beyond-LEO architectures. The IAWG will primarily focus on the Gateway and lunar surface architectures, but will keep anchoring capabilities and technologies pointed to the horizon goal of humans to Mars. As agency plans continue to mature, the architecture will be updated to fit accordingly. Specifically, IAWG will work with agencies to identify and refine the goal to evolve the capability of robotic lunar landers from small scale cargo landers to full scale human landers including consideration of plans identified by potential commercial providers. In addition, as international human lunar surface goals and objectives evolve, details on the design of the lunar surface assets and supporting technologies will be advanced.

#### Strategic Communications Working Group (SCWG)

The SCWG will continue to implement and coordinate communication of the ISECG mandate, its products and activities. Major activities will comprise the following:

- Issuing ISECG webnews as appropriate;
- Preparation of the ISECG Annual Report 2018;
- Providing support of ISECG publications, ISECG outreach activities and ISECG contributions to international conferences;
- Preparation of key messages and success stories to communicate benefits from space exploration.

#### Technology Working Group (TWG)

In 2018, the TWG will continue to advocate coordination and collaboration in technology development efforts of individual ISECG space agencies in support of the GER. In particular, the TWG will perform a technology gap identification and closure analysis focused on the critical technologies in relation to the implementation of the latest GER as well as continue to identify opportunities for collaborative technology development.

### Major Events (status February 2018)

- |   |                                    |
|---|------------------------------------|
| • International Space Exploration Forum (ISEF2)               | Tokyo/Japan, 3 March 2018          |
| • 2 <sup>nd</sup> International Mars Sample Return Conference | Berlin/Germany, 25-27 April 2018   |
| • Humans to Mars Summit 2017                                  | Washington D.C./USA, 8-10 May 2018 |
| • 68 <sup>th</sup> International Astronautical Congress (IAC) | Bremen/Germany, 01-05 October 2018 |

## Annex I

# Publications

## ISECG Webnews 2017

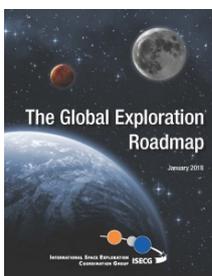
[Simulating Mars on Earth](#)

February

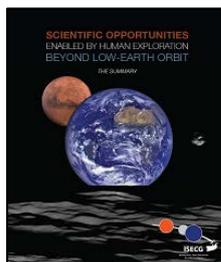
[ISECG Annual Report 2016 published](#)

March

## Major ISECG Documents



[The Global Exploration Roadmap \(GER\), January 2018](#)

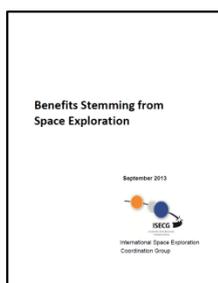


[Scientific Opportunities enabled by Human Exploration beyond Low Earth Orbit – The Summary](#)

(summary version)

[Scientific Opportunities enabled by Human Exploration beyond Low Earth Orbit – An ISECG Science White paper](#)

(full version)



[Benefits Stemming from Space Exploration](#)



[ISECG Terms of Reference](#)

More ISECG documents and published papers can be found at [ISECG Publications](#).

## Annex II

### ISECG Members and Working Groups

#### Members



[Agenzia Spaziale Italiana](#) (ASI), Italy



[Canadian Space Agency](#) (CSA), Canada



[Centre National d'Etudes Spatiales](#) (CNES), France



[China National Space Administration](#) (CNSA), China



[Commonwealth Scientific and Industrial Research Organisation](#) (CSIRO), Australia



[Deutsches Zentrum für Luft- und Raumfahrt](#) (DLR), Germany



[European Space Agency](#) (ESA)



[Indian Space Research Organisation](#) (ISRO), India



[Japan Aerospace Exploration Agency](#) (JAXA), Japan



[Korea Aerospace Research Institute](#) (KARI), Republic of Korea



[National Aeronautics and Space Administration](#) (NASA),  
United States of America



[Russian Federal Space Agency](#) (Roscosmos), Russia



[State Space Agency of Ukraine](#) (SSAU), Ukraine



[United Arab Emirates Space Agency](#) (UAE Space Agency), United Arab Emirates



[United Kingdom Space Agency](#) (UKSA), United Kingdom

## **ISECG Working Groups**

### Exploration Roadmap Working Group (ERWG)

The Exploration Roadmap Working Group leads the human spaceflight roadmapping effort which is intended to establish a common roadmap, and common framework to promote partnerships in realizing exploration missions. A summary of their work is communicated in regular updates of the Global Exploration Roadmap.

### International Architecture Working Group (IAWG)

The International Architecture Working Group leads multilateral reference architecture work, develops shared requirements, identifies critical functions and technologies and shares innovative architectural concepts. The IAWG is currently building concepts to augment the GER mission scenario, focusing specifically on characterizing human missions to the lunar surface based on robust international partner contributions.

### Strategic Communications Working Group (SCWG)

The objectives of the SCWG are to provide a clear, consistent and coordinated communication of the ISECG mandate, its products and activities, to support the development of ISECG products, as well as to support the exchange amongst agencies on stakeholder engagement activities. Major activities of the SCWG include the development of ISECG webnews, the preparation of the ISECG Annual Report and the facilitation of topical exchanges amongst agencies. The SCWG is fostering an exchange on lessons learned and best practices among ISECG agencies in communicating and delivering benefits resulting from investments in space exploration.

### Science Working Group (SWG)

The Science Working Group coordinates with the international science communities on exploration planning and activities as required for the generation of ISECG products. It has recently focused on the finalization of the Science White Paper for the articulation of science opportunities in the GER.

### Technology Working Group (TWG)

The goal of the Technology Working Group is to identify and raise awareness on critical technology gaps related to the GER, and to advocate coordination and collaboration in technology development efforts of individual ISECG space agencies in support of the GER. The strategic nature of technology investments and the desire of space agencies to focus investments to maximise their contribution potential while enabling meaningful and achievable opportunities for all participating agencies must hereby be recognised.”

## Annex III

### **ISECG at a Glance: Scope and Background**

ISECG, the International Space Exploration Coordination Group serves as the forum where space agencies work together on means of strengthening individual exploration programs, facilitating collaborations and advancing the Global Exploration Strategy (GES) through the coordination of participating agencies' mutual efforts in space exploration. ISECG also supports promoting interest and engagement in space exploration activities throughout society. In 2016, ISECG membership counted 15 space agencies<sup>1</sup>.

The **scope of ISECG** is broad and strategic. Its activities are based on the following **principles**:

- Open and inclusive
  - ISECG receives inputs from all interested agencies that invest in and perform space exploration activities.
  - ISECG provides for consultations among all agencies with a vested interest in space exploration.
- Flexible and evolutionary
  - Existing consultation and coordination mechanisms are taken into account.
- Effective
  - ISECG workshops and products provide value to individual participating agencies.
- Of mutual interest
  - ISECG activities benefit all participants and respect national prerogatives.
  - ISECG activities allow for optional participation based on the level of interest.
  - ISECG participants focus on developing non-binding products - findings, recommendations and other outputs as necessary – based on consensus.

#### **Background**

In May 2007, an initial group of 14 space agencies jointly released "[The Global Exploration Strategy: The Framework for Coordination](#)". It describes a shared vision of coordinated human and robotic space exploration focused on solar system destinations where humans may one day live and work.

The GES identifies a common set of **exploration themes and benefits**:

- New knowledge in science and technology
- A sustained presence – extending human frontiers
- Economic expansion
- A global partnership
- Inspiration and education

One of the many Framework document findings was the need to facilitate information exchange among individual agencies regarding their interests, plans and activities in space exploration. Therefore, the GES called for a voluntary, non-binding coordination mechanism among interested space agencies. This call led to the establishment of **ISECG** by the participating agencies including the formulation of [Terms of Reference](#) (ToR).

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<sup>1</sup> 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), SSAU (Ukraine), Roscosmos (Russia), UAE Space Agency (United Arab Emirates), UK Space Agency (United Kingdom). "Space Agencies" refers to government organizations responsible for space activities.