The 2009 Annual Report of the International Space Exploration Coordination Group

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Introduction

This third Annual Report of the *International Space Exploration Coordination Group* (ISECG), like the 2007 and 2008 editions, provides an overview of the ISECG activities over the past year, and highlights the main exploration activities of participating agencies during the past twelve-months.

2009 marked another year of progress in which ISECG fulfilled its mandate to provide a forum for space agencies to share their space exploration interests and plans with a view to working collectively towards the further development and implementation of the Global Exploration Strategy.

The ISECG Annual Report is intended to keep all exploration stakeholders better informed of ISECG's work and progress in implementing the Global Exploration Strategy.

Part 1: ISECG Background and Working Group Activities

1.1 Background

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] and 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. Among the many Framework Document findings was the need to establish a voluntary, non-binding international coordination mechanism through which individual agencies may exchange information regarding their interests, plans and activities in space exploration, and to work together on means of strengthening both individual exploration programs and the collective effort.

Terms of Reference (TORs) for the ISECG were formally adopted at the first meeting of ISECG held in Berlin, Germany in November 2007. Successive meetings were held in July 2008 (Montreal, Canada), March 2009 (Yokohama, Japan), and most recently in December 2009 in Noordwijk, The Netherlands. The ISECG chairmanship rotates, with the host of the meetings assuming the role as Chair. ESA assumed ISECG Chairmanship from JAXA on May 20, 2009.

[1] In alphabetical order: ASI (Italy), BNSC (United Kingdom), 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). "Space Agencies" refers to government organizations responsible for space activities.

The scope of ISECG is broad and strategic. ISECG participants focus on the development through consensus of non-binding products – findings, recommendations and other outputs as necessary – for use by participating agencies. The bulk of the work leading to ISECG products is performed by ISECG working groups between meetings and is guided by full ISECG teleconferences held monthly (or more if needed). The degree of participation in ISECG working groups varies by agency, and by product, but all products are shared with all ISECG participating agencies throughout the development process. This "open and inclusive" approach – a key principle established in the GES – is typical of all ISECG business. Throughout 2009, ISECG has demonstrated strong adherence to other key GES founding principles. For example, ISECG performs its work through an evolving workplan which is updated as required to reflect the evolving needs of the participating agencies, demonstrating the "flexible and evolutionary" nature of ISECG. And also, as established by the GES, ISECG continues to focus on the development of products that are at once "effective" and of "mutual interest" to address the needs of the participating agencies.

ISECG and its working groups receive support by a small permanent Secretariat, provided by ESA. Among the Secretariat's responsibilities is the establishment and maintenance of an ISECG website dedicated to the public distribution of information related to the work of ISECG. The website can be reached via the following link: www.globalspaceexploration.org

For more information on the ISECG, its publications and for Agencies to request membership please contact the ISECG Secretariat at: isecg@esa.int.

1.2 ISECG Working Groups

Those ISECG working groups which were acknowledged as of the Yokohama (March 2009) meeting are as follows:

1.2.1 Enhancement of Public Engagement

This working group is focused on the identification of exploration-related public engagement activities (including education) that could benefit from coordination. A successful Public Engagement Workshop was held in the German city of Oberhausen on November 3-4, 2009. The workshop was organized to define an appropriate role for ISECG in furtherance of the "Inspiration and Education" theme of the Global Exploration Strategy, to share experiences and best practices, and to evaluate communication activities as well as education programs.

A large number of excellent, successful public engagement experiences and initiatives were presented by the participating agencies, which enabled the workshop participants to learn from each other.

The key findings resulting from the workshop are as follows:

- The most successful initiatives are as those with "hands on" experiences; those focused on the development of role models – "human" or "personal" factors (e.g. "NASA People," "DLR Portraits," etc.); personal ambassadorships; and high impact events such as a national astronaut in space.
- It is important to evaluate public engagement initiatives and to use feedback channels and to increase or leverage use of social media.
- There is potential for common/joint activities:
    - Sharing of educational materials
    - Use of touring exhibitions
    - International **Y**ear of the **E**xploration of ***S***pace – **YES**
- It was recognized that ISECG could be a very useful platform for networking on public engagement activities.

The workshop also developed recommendations related to the relevant Reference Architecture Goals (see Section 1.2.3 below) and additional goals for enhancement of public engagement, e.g.:

- Plan a set of competitions run by each interested ISECG agency to solicit ideas from the public for participatory engagement,
- Leverage and align international resources to maximize returns/minimize duplication of efforts
- Improve collaboration with the International Space Education Board

1.2.2 The International Space Exploration Coordination Tool (InterSECT)

The InterSECT Working Group is focused on development of a web-based, interactive database which, when fully developed and maintained, is to provide a single reference source for ISECG members on the type and status of exploration-related missions and capabilities. During 2009, the Working Group finalized a data template for exploration "missions" for which participating agencies developed input. Further progress was made in the definition of the data template for exploration "capabilities" which will be reviewed by the ISECG members when the final version is available. A User Manual was prepared to provide guidance on completing data forms for exploration "missions."

1.2.3 The International Architectures Working Group (IAWG), supported by the International Objectives Working Group (IOWG)

The IAWG was established at the second ISECG meeting in Montreal in July 2008. The IAWG was assigned leadership of the development of multilateral lunar reference architecture definition. Its first task was to progress coordinated plans for human exploration of the Moon. In so doing, ISECG recognized that this process could contribute to a variety of needs, including: defining priorities for future international interface standards, informing future technology development needs, defining precursor robotic priorities, and identifying potential areas of cooperation.

Through the course of several face-to-face architecture workshops held over the past year, significant progress has been made toward development of an ISECG Reference Architecture for Human Lunar Exploration. Multilateral "Function Element Teams" were established to identify key lunar exploration functions and a "Campaign Integration Team" was established to integrate those functions into architecture elements. Such elements would be deployed over time to meet shared goals and objectives defined by a supporting International Objectives Working Group (IOWG) . The reference architecture is planned for completion in June 2010.

To inform the reference architecture, the IOWG collected initial lunar exploration objectives developed individually by the participating agencies, and compared and mapped these objectives against the five Global Exploration Strategy themes. This led to the development of a set of common human lunar exploration goals that will be used to guide development of the Reference Architecture:

- Embrace a long-term strategic view for enhancing and expanding global partnerships for sustainable exploration of the Moon and beyond.
- Maximize early international partnership opportunities for lunar exploration.
- Use lunar exploration as a stepping stone for the demonstration of technologies, operational concepts, and cooperation approaches for Mars and other destinations.
- Take maximum advantage of ISS assets and other opportunities in LEO to advance technologies and capabilities for exploration beyond LEO.
- Develop, demonstrate and apply innovative capabilities, technologies and processes for improving resource and energy management and environmental protection, driven by the challenge of sustaining human life and operations in the hostile environment of space and the lunar surface.
- Develop a flexible, robust and reliable architecture that allows humans to safely explore the Moon.
- Stimulate economic development and industrial innovation to enhance global economic prosperity via exploration of the Moon.
- Understand the origin and evolution of the Moon

- Interpret the uniquely preserved record of Solar System evolution on the Moon and its relation to the origin and evolution of life
- Extend human presence in the Solar System and improve the health of humans on Earth, by understanding and mitigating the risks to astronaut health in the lunar environment.
- Maximize science return by leveraging human-robotic partnership for lunar exploration and/or capabilities developed for lunar exploration.
- Develop innovative tools, means and methods to enable the public to engage interactively in human exploration.
- Inspire the next generation to embrace the tools of exploration: science, technology, engineering, mathematics and a sense of curiosity.
- Engage the public on the broader rationale and benefits of exploration.
- Achieve early, frequent and inspiring milestones relevant to the partnership, and to the public.

The IOWG also developed "reference utilization activities" to provide increased confidence that goals could be achieved, and campaign satisfaction criteria as a means of measuring the effectiveness of the ISECG Reference Architecture for Human Lunar Exploration.

1.2.4 Mapping the Barriers to Human Exploration Working Group

In 2008, in recognition of widespread support of an eventual human mission to Mars, a proposal was made for ISECG to further elaborate the perspectives described in Chapter 3 of the Framework Document, "Mapping the Space Exploration Journey." Thus, an ISECG effort referred to as Mapping the Barriers to Human Exploration has begun with the goal of identifying the significant, known technological and operational challenges associated with extending human presence to various destinations in the Solar System.

This activity was progressed with the publication of an International Astronautical Congress (IAC) paper co-authored by several ISECG members entitled "From LEO, to the Moon and then Mars: Developing a Global Strategy for Exploration Risk Reduction"[2] The paper examined Mars mission scenarios developed by NASA and ESA, and discussed conclusions regarding key challenges,

[2] K. Laurini, NASA; B. Hufenbach, ESA; B. Schade and P. Weber, DLR; A. Lorenzoni, ASI; October 2009

needed technologies and associated mission risks. The paper discussed both the importance of using the International Space Station as a platform for space exploration risk reduction and how the global exploration community could develop lunar exploration elements and architectures that enable the long term goal of human missions to Mars. The paper also discussed the logic and strategy for addressing technological, operational and programmatic challenges by using Low Earth Orbit and lunar missions to enable the long term goal of exploration of Mars and other destinations within our Solar System.

The IAC paper provided a solid basis for future ISECG discussions on this important topic.

Part 2: Global Exploration Activities

2.1 International Space Station (ISS) Lessons Learned

On August 7, 2009, William H. Gerstenmaier (NASA), Chair of the International Space Station Multilateral Coordination Board, transmitted to ISECG Chair Simonetta Di Pippo (ESA) a set of *International Space Station (ISS) Multilateral Coordination Board (MCB) ISS Lessons Learned* as they relate to exploration. The ISS Lessons Learned bore the signatures of the MCB members of NASA, ESA, CSA, JAXA and Roscosmos.

These were prepared by the MCB in recognition that, as the ISS approached completion, it would be valuable to future exploration programs to document lessons learned over the ISS phases of design, development, assembly, and operation.

The results contained in the ISS Lessons Learned are organized in seven categories

- Category 1 - Mission Objectives
- Category 2 - Architecture
- Category 3 - International Partner Structure and Coordination
- Category 4 - External Communications
- Category 5 - Operations
- Category 6 - Utilization
- Category 7 - Commercial Involvement

ISECG participating agencies welcomed receipt of this important input and are applying due consideration of these lessons learned in their work.

2.2 Status of National Space Exploration Reviews

The year 2009 was pivotal in terms of space policy reviews around the world. A status summary of key reviews follows.

2.2.1 United States: Review of United States Human Space Flight Plans (the "Augustine Committee")

In connection with the public release of NASA's FY2010 budget request, the White House announced the initiation of an independent review of NASA's human spaceflight activities. This "Review of United States Human Space Flight Plans" chaired by Norm Augustine was tasked to, among other things: examine current NASA development programs, including missions to the Moon and other destinations, and possible alternatives; consider options to extend the International Space Station beyond 2016, and; examine opportunities for international participation, including seeking input from our international partners as options are developed.

The Committee's final report was released on October 22, 2009, culminating over four months of fact-finding activities, public input and analysis. The report argued that future space programs must be matched with the resources needed for their execution. The report also noted that space exploration has become a global enterprise and that if the United States is willing to lead a global program of exploration, sharing both the burden and benefit of space exploration in a meaningful way, significant accomplishments could follow. Further, actively engaging international partners in a manner adapted to today's multi-polar world could strengthen geopolitical relationships, leverage global financial and technical resources, and enhance the exploration enterprise. The report also took note of the burgeoning commercial space industry.

The Committee concluded that the ultimate goal of human exploration is to chart a path for human expansion into the solar system -- an ambitious goal, but one worthy of U.S. leadership in concert with a broad range of international partners. Finally, the Committee developed five integrated alternatives for the U.S. human spaceflight program. NASA is currently working with the Office of Science and Technology Policy and the Office of Management and Budget to develop recommendations for the President.

2.2.2 Japan

In 2008, a "Basic Space Plan" was approved by the Japanese Diet which entered into force in August 2008. The new law created a new Minister for Space Development with responsibility for coordinating the various space activities spread across 11 governmental departments along with a Space Policy Bureau in the Prime Minister's Cabinet, to develop a strategy for Japan's space development efforts. In June 2008, a new Cabinet Office for Space Strategy (SSHQ) was tasked with recommending changes in Japanese space policy and organization.

On May 27, 2009, the SSHQ released a space policy for the Government of Japan. The policy, which is broad in scope, proposes a five-year initiative for the development of a variety of capabilities, and has as its centerpiece the importance of future lunar exploration in order to utilize the Moon's resources. The legislation also called for a more detailed one-year review of human space

flight and exploration. Members of the review committee were named in late July 2009, and the first of nine planned meetings was held on August 4, 2009. The committee is tasked with 1) defining the meaning and goals of lunar exploration; 2) developing a concrete vision for robotic exploration by 2020; and 3) recommending a basic policy for future human exploration of the Moon, including international cooperation.

2.2.3 European Commission/ESA

The outgoing Commissioner for Enterprise and Industry, and European Commission Vice-President, Günther Verheugen, along with the ESA Director General Jean-Jacques Dordain, co- hosted the "First EU-ESA International Conference on Human Space Exploration" on October 23, 2009, in Prague. Several non-European space agency representatives were invited as observers. The "Conclusions of the 23 October 2009 Prague Conference" report produced by the Conference Chairs read in part that *"the European Space policy and the European Space Programme framework, the EU, ESA and their respective Member States … should":*

- *Continue to work on the development of common objectives at EU/ESA level, in particular through refining complementarities among the EU, ESA and national initiatives;*
- *Improve communication with international partners, based where appropriate on existing mechanisms;*
- *Elaborate a roadmap, a set of robotic and human scenarios and a set of priorities for a visible and significant role for EU/ESA in an international exploration initiative, based on technical and financial data provided by ESA using consultation results within EU/ESA Member States and with international partners, and enabling regular concrete achievements at interim programmatic milestones;*
- *Explore an implementation mechanism that includes adequate EU instruments and funding schemes;*
- *Report on the progress of these actions during the second high-level conference in 2010.*

The follow-up conference will be held in Belgium on October 22, 2010.

2.2.4 Canada

In 2008-2009, the Canadian Space Agency carried out a series of consultations with its stakeholders and partners to define the future direction of Canada's space programs. As a result, the CSA is in the

final stage of preparing a Long Term Space Plan with clear principles and criteria that will guide the Canadian government's investments in space for the years ahead.

2.2.5 Germany

The new Government, empowered since October 28, 2009, gave instructions to review the German space activities. A strategy with a clear mission and technology goals shall be further developed within the coming year.

The basis for the development of the space strategy is the report of the Coordinator for Aeronautics and Space, Secretary of State Peter Hintze, published in August 2009. According to this report, space is emphasised in the German high technology strategy as an essential element aiming at increasing Germany's competitive position in space research and technology. Special attention is given in the report to space robotics and automation as the capabilities to be developed and which will be directly useful for terrestrial applications.

2.2.6 United Kingdom

The United Kingdom's British National Space Centre (BNSC) has published on 10 December 2009 a detailed review of the opportunities presented by space exploration for the UK. It examines the costs and the benefits of several example scenarios, including both robotic and human activities. It also includes a detailed economic analysis of the commercial opportunities, carried out by an independent economics team.

The report does not make recommendations, but provides a sound basis for future policy decisions in this area by setting out both the tangible and the intangible benefits for the UK for a variety of investment strategies.

It builds on the work done by the Space Exploration Working Group, whose report was published in September 2007.

Part 3: Summary and Way Forward

During the 4th ISECG meeting held in Noordwijk, The Netherlands on December 2-3, 2009, NASA agreed to assume the ISECG Chairmanship from ESA in 2010. Tentative plans were made to hold the 5th ISECG meeting in the latter half of June 2010 in Washington DC. Work will continue in earnest among all the ISECG Working Groups to prepare for the June 2010 meeting, including plans to complete the ISECG Reference Architecture for Human Lunar Exploration discussed in Section 1.2.3.

ANNEX

Highlights of Space Agency Exploration Activities

INTERNATIONAL SPACE EXPLORATION COORDINATION GROUP

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Italian Space Agency (ASI)
Exploration Highlights

1. Introduction

The year 2009 has been characterized, by the implementation of the decision taken during the last Ministerial Council, held in 2009, mainly in the robotic mission ExoMars, for wich Italy confirms its leadership, and in the contribution to the European Exploitation with International Space Station, through the bilateral agreement between ESA and NASA and the MoU between NASA and ASI

2. Past significant events and missions

Hereafter are reported the significant events related to exploration during the past year:

- *Human exploration*
  - On May 2009 ESA selected two Italians as part of the European Astronaut Corps: Samantha Cristoforetti and Luca Parmitano.
  - Shuttle mission STS-128/ 17 A carried the Leonardo Multi-Purpose Logistics Module containing life support racks and science racks. Leonardo carries onboard, among other facilities, the Mice Drawer System (MDS), the seventh biomedical payload developed by the Italian Space Agency for the ISS. The payload is a multifunctional and multiuser system for conducting experiments in various biomedical fields. For the first time, a mouse-research facility reaches the ISS. MDS enables medical research activities through the analysis of the effect of micro-gravity on the bone tissue, cardiovascular system, muscles of six mice.
  - On November 2009, the Shuttle mission STS-129 returned to Earth the MDS facility after a period on the ISS of 90 days; the twenty-one scientific experiments related to MDS, selected both by Italy and by other Space Agencies (ESA, NASA, JAXA, CSA and DLR) will provide results within a period of six months.
  - A series of call for proposals and funding opportunities have been carried out throughout the 2009:
    - support to the Italian proposals selected by ESA in the field of life science and human physiology in space,
    - support to the development of an Italian payload on the Russian mission RIBES-Bion M1,
    - funding of research proposals for the human spaceflight (mainly focused on the presence of Italian astronauts on the ISS in 2010),
    - call for interest for the ISS exploitation, mainly using the Italian payloads and opportunities.

- Industrial activities for the enhancement of the Multi-Purpose Logistics Module that will become a Permanent Multi-Purpose Module (PMM) on the ISS.

- *Robotic exploration*
  - Together with European partners, PDR activities of ExoMars (Prime Contractor TAS-I) on the subsystems (e.g.: the Drill & SPDS) and on the P/Ls, and participation with the Italian delegation to the negotiations with ESA and NASA for the new ExoMars mission architecture.
  - Operations, data acquisition and analysis of Italian instruments on-board Mars Express (MARSIS and PFS) and NASA MRO mission (SHARAD).
  - Activities for the development of 2 P/Ls for the Russian Phobos Grunt mission plus contribution to another one.

- *Earth based activities*
  - Life Support System activities (CAB Controllo Ambientale Biorigenerativo) and participation to the Mars500 with two Italian experiments.
  - Exploitation of a field infrastructure in Morocco for test campaigns for robotic exploration technologies (rovers mobility, drilling, navigation, remote control, instruments operations, landing systems); in particular, sites characterization and classification activities are on-going.
  - The development of a GIS (Geographical Information System) for Mars called PAGIS (Planetary Geosciences Information System) has been concluded and thematic maps have been produced.
  - Participation to the GES activities, to the IMEWG activities, in particular the MSR WG activities for the definition of the architecture of the MSR mission, and to the ILN activities.

3. Upcoming events

Italy foresees to follow both the human and robotic exploration. Attendance and active partecipation to the major events like IAF, COSPAR, etc.. is confirmed. Involvement in ISECG activities will be mostly focus on the robotic support activities including scientific aspects and in situ resource utilization.

In this context Italy will focus its attention on the following programmes:

- The Cosmic Vision phase A activities will be concluded and down selection will be fixed at the beginning of 2010

- COSMIC (COmbustion Synthesis under MIcrogravity Conditions) experiment will be tested on parabolic flights to verify the behaviour in Moon and Mars enviroments

The 2010 will be characterized by a relevant involvement of Italy in the exploitation of the ISS, thus confirming its relevant role in this endeavour:

- The Shuttle mission STS-130, foreseen in February 2010, will deliver the final connecting node, Tranquillity Node 3, and the Cupola, the robotic control station with seven windows that provides a 360-degrees view around the ISS, both mainly built in Italy.
- In the STS-134, scheduled for the end of July, the Alpha Magnetic Spectrometer (AMS) experiment will be put on orbit, and the Italian astronaut Roberto Vittori will be part of the crew as a mission specialist.
- Paolo Nespoli is involved in the 6 months Expeditions 26 and 27 on the ISS (launch in November 2010 and return in May 2011 on Soyuz 25).
- With the STS-133 mission, scheduled for September, there will be the delivery of the Permanent Multi-Purpose Module (PMM) on the ISS.

The industrial activities that will allow the qualification of the VEGA launch vehicle will be carried on through the whole 2010.

Conclusion

Italy is strongly involved in Exploration, both human and robotic. Currently our main objective is the Mars Robotic Exploration. At the same time, we are still aiming at enhancing our expertise in the following fields: robotics systems, pressurized modules and life support systems, to acquire new technologies for space transportation with a particular interest for re-entry technologies and to develop infrastructural capabilities such as the 64 m Sardinia antenna for Deep Space Communications able to operate in Ka band and the analogue facility for testing and training for planetary in situ missions in open field.

BNSC/United Kingdom
Exploration Highlights

ESA announced on 22 July 2009 that it would be creating a new centre in the UK. It will carry out activities related to climate change, integrated applications, and exploration. Plans include the involvement of international teams working on robotics and novel power technologies for space, as well as a planetary protection facility.

During 2009 the UK selected a Prime Contractor for the proposed MoonLITE mission, but financial restrictions have meant that this programme is currently on hold.

A penetrator system design study for the proposed Jupiter Ganymede Orbiter is underway through the ESA Science Programme. If successful, this may be followed by a technology development phase. The technology will also have application on missions to the Moon and Mars.

Instruments are being developed for use on penetrators for future planetary exploration missions and a technology development programme is in place. Work has continued on instruments for ExoMars and in particular significant progress has been made on the Life Marker Chip. EU funding has been used to continue development of autonomous rover operations.

The UK's Space Exploration Review was published on 10 December 2009 (for further detail see section 2.4.5). The analysis provided by this review has been included in the work of the Space Innovation and Growth Team, an industry-led working group which is charged with creating a vision for UK space activities over the next 20 years. The report is due in early 2010 and will be used by the UK government to inform future policy decisions and to increase the impact of the UK space sector.

One of the problems highlighted in the Space Exploration Review is the diversity of goals of any integrated space exploration programme which makes it hard to identify a government department as the 'customer' for such activities. This should be considerably simplified by the announcement, also on 10 December, that the UK would be creating a space agency to bring the various funders of space together. This should have the benefit for space exploration of creating a clear owner for this area of policy.

Also during 2009, ESA completed selection of six new members for its astronaut corps, which includes for the first time a Briton, Tim Peake.

CNES/Centre National d'Etudes Spatiales
Exploration Highlights

The recent seminar of scientific prospective organized by CNES in March 2009 has confirmed the outcomes of the October 2007 workshop about exploration. The priority of the French scientific community is the exploration of Mars. If it is acknowledged that science is not the only (or even the primary) motivation of space exploration, we believe that a strong support from the widest scientific community is essential. Human and robotic exploration are complementary to each other, so as to optimize the return to investment ratio.

With the support provided by CNES, the French research labs prepare instrument contributions for MSL 2011, Phobos Grunt, Maven, ExoMars 2016 and 2018, and a possible network mission foreseen in 2020, with the perspective of a first return sample mission in the 2020's. They also participate to the scientific payload of the solar system missions of ESA's Cosmic Vision programme. In addition, we have initiated several phase 0/A level studies of robotic missions to asteroids (Mascot lander on ESA's Marco Polo or JAXA's Hayabusa 2, Apophis rendez-vous, Trojan fly-by).

At the technical level, CNES will provide the vision & navigation algorithms of the ExoMars rover and implements with ONERA a R&T programme on autonomous navigation for future planetary rovers. A prospective work has been done on nuclear potential for space exploration. In addition, in the perspective of future exploration missions launched from the Kourou bas in French Guyana, a working group will propose a regulation in order to ensure the consistency between the French law on space operations and the existing regulations about the transportation and stowage of radio-isotopic materials.

CNES has contributed together with its Italian, British and German conterparts to the re-definition of the ExoMars mission, and it has been deeply involved in the French participation to the Prague workshop on exploration jointly organized by ESA and EU.

Regarding the ISS utilization, the priority for physical sciences has been given to fluid physics, with perspective of applications in the field of fluid management in space systems; the DECLIC hardware dedicated to the study of critical fluids has been installed in the US lab in September (co-operation with NASA). For life sciences, the priority goes to physiology, with perspectives of applications in the field of medical monitoring of the crews for long duration spaceflights; the CARDIOMED device dedicated to cardio-vascular monitoring will be installed in the Russian module next February (co-operation with IBMP).

The ISS utilization up to 2020 is likely. However, taking into account the development time of new systems and the available resources, one has to prepare now the post ISS era, i.e. beyond low Earth

orbit. That perspective has to be seen as an international venture in which every partner brings in its own competences and resources.

CSA/Canadian Space Agency
Exploration Program Highlights 2009[3]

Introduction and Overview

Work continued on Canada's contributions to the NASA 2011 Mars Science Laboratory Mission and the ESA ExoMars mission. 2009 was a busy year for Canada's human space flight program. Canada's Mobile Servicing System on the International Space Station continued to perform essential ISS assembly and servicing operations including the historic berthing of the maiden mission of Japan's HTV. The CSA's ISS Life and Physical Sciences program, that also includes operational space medicine, continues to extensively utilize the ISS, with some eleven experiments either already on-board or soon to be launched. After a one-year competition Canada selected two new astronauts for its corps, and two Canadian astronauts had missions to the ISS including a six-months expedition crew-member mission. During the Shuttle STS-128 mission in August Canada's new TriDAR, a laser triangulation and lidar based proximity operations visualization and tracking system, successfully completed a DTO (Development Test Objective). At the beginning of 2009 the Canadian Federal Government's budget included C$110m (over three-years) of stimulus funding for various space robotics terrestrial prototyping, and good progress has been made in implementing this initiative within CSA's Exploration Core program (see later). When Steve MacLean became CSA President in September 2008 he was given a mandate to develop Canada's next Long Term Space Plan (a ten-year plan with a twenty-year vision). Excellent progress has been made with the plan now in its final Ministerial-level consultation phase. The Plan is organized around three strategic directions: Space Services (Earth orbiting satellites to serve diverse needs of Canadians), Space Exploration and Capacity Building (with a focus on the Canadian science, industry and educational sectors). The CSA is to be re-organized around these strategic directions.

Canada's Long-Term Exploration Goals are:

- Full Utilization of the ISS
- On-Orbit Servicing
- Participation in Lunar Exploration (Canadian astronauts on the Moon through infrastructure contributions)
- Scientific Exploration of Mars with the ultimate goal of participation in the eventual Mars Sample Return Mission
- Space Astronomy

[3] This summary follows the more detailed presentation made during the 4th meeting of the ISECG held in Noordvijk, The Netherlands, December 2-3, 2009. The presentation is available upon request to: jean-claude.piedboeuf@asc-csa.gc.ca or graham.gibbs@asc-csa.gc.ca

To better prepare Canada for the next and international era in space exploration an Exploration Core program is underway at the CSA. The Exploration Core is funding prioritized technologies and systems, Phase 0 studies and terrestrial prototyping. The results of this broad effort will allow Canada to make more informed decisions concerning its contributions to and participation in the implementation of the Global Exploration Strategy. Phase 0 studies cover activities such as surface mobility systems, next generation Canadarm (for on-orbit servicing), in-situ resource utilization technologies, concepts of a Canadian contribution to the International Lunar (nodes) Network, navigation, communications technologies and more.

The CSA is also supporting a robust Analogue Sites program with field work being performed at locations in Canada, the United States and elsewhere.

DLR/ Federal Republic of Germany
Exploration Highlights

Early 2009, Professor Gregor Morfill and his colleagues conducted their 10th experiment series with the Plasma-Kristall-Experiment-Units since 2001.

The Plasma-Kristall-Experiment research is conducted in close collaboration with the Moscow Colleagues from the "Institute for High Temperatures" of the Russian Academy of Science. It was the first scientific payload on the International Space Station.

A special Anniversary had been recorded in February 2009. For 10 years now, DLR organizes parabolic flights for scientists from various disciplines. With the 13th campaign in ten years, 1425 parabolas have been flown, a true merit for science. Meanwhile the flights are a valuable tool in order to gain research results under reduced gravity conditions and are a proven means to prepare devices and instruments for ballistic rocket campaigns, experiments on orbital spacecrafts and the ISS.
In May 2009, two important national events took place, the "Symposium Lunar Base", was held in Kaiserslautern, primarily devoted to infrastructures on the Moon. The topic and the challenge to live and work under the extreme conditions of free space and mitigate the various risks for humans in space brought together national experts from various disciplines and created a fruitful interdisciplinary discussion.

The first "National Conference on Space Robotics" was held in Berlin in order to stimulate the cooperation between various disciplines in Technology and Science. The Conference, initiated under the patronage of the Federal Ministry for Economics and Technology, gave a good survey on the current status of robotic activities and developments invented German Space Community.
In August 2009, the Material Science Lab (MSL) was transported to the ISS with the Space Shuttle Discovery (STS 128). This Lab will be operated & managed by the German User Centre (MUSC) in DLR, Cologne. MSL is a joint project between ESA and NASA. The MSL is accommodated in the Material Science Rack-1 of the NASA-Destiny –Laboratory. Various material science experiments will use MSL in the reduced gravity environment of ISS for research purposes. In October 2009, MSL has been activated and checked for its functionality. In November 2009, first experiments were carried out successfully. In December 2009, the STS-129-Mission will bring back to Earth these first samples for further investigation.

In September, 2009, DLR held its public Space Day on "Aviation & Space Science" at the Cologne premises. Several research airplanes were shown on the Cologne Airport, various Space Research Institutes and the ESA European Astronaut Centre were open for the public and attracted 120.000 visitors with exhibitions and performances.

In the course of the event, the construction work for the "**Envihab**" facility has been inaugurated. "**Envihab**", a new Research Center of DLR, is oriented towards the research on the complex

interplay of humans in space from a medical- , psychological- and biological point of view. In future **Envihab** will allow the development and verification of Life Support Systems.

In October, 2009, the festivities for the 300th anniversary of the Berlin Charite´ took place. On that occasion, the first experiment with a device, developed by the Charite´, dubbed "Thermolab", took place. Thermolab looks into the body´s changing heat balance under microgravity. The heat-sensor is a joint development between Charite, DLR and Drägerwerk AG, Lübeck.

DLR organized the ISECG workshop on Enhancement of public Engagement", which was held in November, in Oberhausen. About 20 participants from 5 Agencies followed the invitation by DLR, to discuss strategies and activities, dealing with "Public engagement."

The participants of the Workshop used their stay at Oberhausen to visit the: "Out of this world"-Exhibition in the Oberhausen-Gasometer, which is remarkably successful with already more than 400.000 visitors. The largest attraction is a unique 25m wide illuminated Moon Globe hanging from the ceiling of the 110m tall and 68m wide building.

ESA/European Space Agency
Exploration Highlights

Following a successful, 3rd ISECG meeting held in March in Yokohama, Japan, ESA formally took over the Chairmanship of the International Space Exploration Coordination Group. In the frame of the International Architecture Working Group of the ISECG, two Lunar Architecture Workshops took place in June and November respectively hosted by ESA.

The ESA-JAXA Comparative Architecture Assessment (CAA) Phase 1 was completed in the summer and Phase 2 has been initiated supported by an ESA liaison engineer collocated at JAXA, Sagimihara. The exercise has the objective to identify cooperation scenarios relevant to human lunar exploration. A similar assessment between ESA and NASA started in 2008 is now in the process of consolidating the objectives and the work plan for Phase 2.

Ministers from the 29 European Space Agency and European Union Member States met in Prague on 23 October for the 1st EU-ESA International Conference on Human Space Exploration, to prepare a roadmap within 2010 leading to the definition of a common vision and strategic planning for space exploration.

Following a stringent selection process which began in May 2008, ESA Director General, Jean-Jacques Dordain, and ESA Director of Human Spaceflight, Simonetta Di Pippo presented the final selection of new European astronauts on 20 May: Samantha Cristoforetti (Italian), Alexander Gerst (German), Andreas Mogensen (Danish), Luca Parmitano (Italian), Timothy Peake (British) and Thomas Pesquet (French). They have started their Basic Training in September.

The Soyuz TMA-15 (19S) was successfully launched from Baikonour (Kazakhstan) on 27 May with ESA astronaut Frank De Winne on board. The launch marks the start of ESA's six-month OasISS mission to the International Space Station (ISS). Docking with the Station took place on 29 May. The arrival of the Soyuz TMA-15 crew marked the first ever six-member Expedition crew on board the ISS. For the first time each IP had a representing astronaut, at the same time on board ISS. Frank De Winne took charge of the ISS as the first European Commander on 11 October.

Following a successful lift-off from NASA's KSC on 29 August, Space Shuttle STS-128 Discovery, with ESA astronaut Christer Fuglesang on board, docked with the ISS on 31 August. Fuglesang performed 2 out of the 3 STS-128 EVAs. Discovery undocked from the ISS on 8 September, landing in California on 12 September. Christer Fuglesang mission dubbed 'Alissé', covered operations conducted both inside and outside the orbital complex. He was in charge of the payload transfer, and in particular of an important piece of ESA-supplied equipment: the second Minus Eighty Laboratory Freezer for ISS (MELFI-2).

Next in line to fly to the International Space Station is Roberto Vittori of Italy who will participate in the STS-134 mission in July or September 2010 to deliver the Alpha Magnetic Spectrometer (AMS). Paolo Nespoli also of Italy and André Kuipers of the Netherlands will follow for a six-month flight

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each as European crewmembers on Expedition 26/27 in 2010/11 and Expedition 30/31 in 2011/12 respectively.

In July, the first Mars500 crew, including two ESA participants, completed its simulated Mars mission after living in a special isolation facility at the Institute for Biomedical Problems (IBMP) in Moscow, Russia, for 105 days. The preparations for the full 520-day mission study have commenced, this study is planned to take place in 2010-2011.

The formal handover of Node 3 from ESA to NASA took place on 20 November in the Space Station Processing Facility at NASA's Kennedy Space Center, Florida, USA. Node 3, one of the three ISS interconnecting modules, will now undergo final preparations for a February 2010 launch on Space Shuttle Endeavour together with the attached European-built Cupola observation module. The handover completed the final major element of the barter agreement between ESA and NASA signed in Turin on 8 October 1997 under which ESA provided Nodes 2 and 3 plus additional equipment and knowhow in return for transportation of the European Columbus Laboratory to the ISS by Space Shuttle. After the flawless mission of the Automated Transfer Vehicle (ATV) *Jules Verne* last year, activities on the second ATV are on-going with a launch scheduled to the ISS in November 2010. ATV-2 has been named *Johannes Kepler* after the German astronomer and mathematician.

Columbus Systems are operating nominally despite a few minor technical anomalies and the life and physical sciences experiments are proceeding successfully. Two parabolic flights campaign were carried out in May and in October and a drop tower campaign was also performed in May. Worth to mention the European Technology Exposure Facility (EuTEF) – a suite of nine scientific experiments exposed to the harsh environment of space outside the International Space Station – who completed its 18-month mission after returning to Earth with Space Shuttle *Discovery* STS-128 mission.

Another important programme that received funding at last year's Ministerial Council was in the area of Space Transportation and Human Exploration. The key elements of this programme are the Advanced Re-entry Vehicle and the Lunar Lander. ESA's Director General, Jean-Jacques Dordain, and NASA's Administrator, Charles Bolden, signed a Memorandum of Understanding (MoU) on space transportation which provides the grounds for further close cooperation of the two agencies in human spaceflight. ESA has recently started the Phase A study of the Advanced Reentry Vehicle (ARV). For human spaceflight, the MoU will first of all help to define interoperable docking systems, allowing a better exploitation of the ISS, future joint exploration missions and finally mutual support in case of crew rescue missions. The ARV benefits from the highly successful Automated Transfer Vehicle (ATV) programme and will make use of the avionics and propulsion system of ATV. ARV will allow the delivery of cargo to the ISS and its safe return to Earth, which is important not only for scientific samples from the ISS but also for future exploration missions. In a second step, ARV could also be developed into a crew transportation system.

The other element of the Space Transportation and Human Exploration Programme is the Lunar Cargo Lander. The strategy to develop this key element of the International Lunar Architecture follows a stepped approach consisting in a first mission to be launched not later than 2018 with Soyuz or with an Ariane 5 shared launch to demonstrate the soft and precision landing capacity. Then it will be followed by the development of a full Ariane 5 capacity Cargo Lander. The Soyuz option

phase A study has been completed in May, the Ariane 5 shared will be completed early next year. Phase B1 will start immediately after the selection of one of the two options in February 2010.

Still looking at preparatory activities for future human exploration, in the field of life support systems, a pilot plant was inaugurated in June in Spain which tests regenerative life support system technologies that could one day recycle waste products and supply essential food, water and oxygen to humans living on the surface of the Moon or Mars. MELiSSA, short for Micro-Ecological Life Support System Alternative, is an artificial ecosystem to recover food, water and oxygen from waste (faeces and urine), carbon dioxide and minerals.

Looking at Mars exploration,following the invitation made by the Member States at the Ministerial Council in November 2008, intense discussions between ESA and NASA have led to an agreement between the two agencies to collaborate for a long-term Mars Exploration Programme. The first steps of this collaboration include the provision by ESA in 2016 of an Entry, Descent, and semi-soft Landing System (EDLS) technology demonstrator and a science/relay orbiter and, in 2018 the ExoMars rover equipped with drilling capability. NASA's contribution in 2016 includes a trace gas mapping and imaging scientific payload for the orbiter and the launch and, in 2018 a rover, the EDLS, and the launch.

Japan Aerospace Exploration Agency (JAXA)
Exploration Highlights

In 2009, there were many achievements on space exploration activities in relation to JAXA.

- HTV launched to the ISS by the H-2B launch vehicle

  The H-II Transfer Vehicle (HTV), developed and built in Japan, is an unmanned cargo transfer spacecraft that will deliver supplies to the International Space Station (ISS). The HTV has lifted off on September 11. The H-IIB launch vehicle with the HTV has blasted off from the Launch Pad 2 (LP2) of Tanegashima Space Center (TNSC) lighting up the night sky.The HTV-1 was attached to the CBM on the nadir side of the Harmony on September 18. The HTV-1, positioned at 12 m below the ISS called "release point," was released by the station's robotic arm (SSRMS). On October 31, while passing over the Pacific Ocean, the HTV-1 began its planned maneuvers to leave the ISS proximity. The HTV-1 gradually departed from the ISS orbit by performing several thruster burns. Following the third de-orbit maneuver, the HTV-1 has reentered the atmosphere in November 2, from 120 km above New Zealand, and it concluded the HTV-1 Mission, the maiden flight of Japan's unmanned cargo transfer vehicle to the ISS. Most of the vehicle components are expected to be destroyed and burned out encountering the aerodynamic heating during the reentry, but some of the debris is estimated to survive and fall into the South Pacific Ocean.

- KAGUYA impact and data relaease

  JAXA launched "KAGUYA (SELENE)" by the H-IIA Launch Vehicle on September 14, 2007, (JST) from Tanegashima Space Center (TNSC). The major objectives of the "KAGUYA" mission are to obtain scientific data of the lunar origin and evolution and to develop the technology for the future lunar exploration. JAXA maneuvered the KAGUYA main orbiter to drop it onto the following location on the Moon surface to complete its Moon observation mission.

  The KAGUYA conducted nominal operations for about 10 months then an extended operational phase for about seven and a half months after being launched.

  The KAGUYA's impact location was in the shaded area of the Moon, thus we expect a slight possibility of witnessing the impact flash generated when the KAGUYA hit the Moon. We are now asking people all over the world to provide us with images of the impact flash if someone successfully captured this feat.

  Concerning the sub satellite of the KAGUYA, the VRAD (Ouna) satellite, its observation

operation has already been completed. We will further carry out necessary observations for calibration, then will terminate operations.

JAXA released data from the lunar explorer "KAGUYA" (SELENE) (L2 products) during the nominal operation phase (from December 21, 2007, to October 31, 2008) to the public through the Internet on November 1.

L2 products are calibrated/validated processed data from KAGUYA science mission instruments. By using the L2 products, researchers all over the world are expected to advance the scientific analysis and applicability investigation of the moon.

- HAYABUSA, IKAROS, Selene-2, Hayabusa-2 and Marco Polo

  HAYABUSA is the world's first sample return explorer for asteroid. It visited,a near earth type-S asteroid which is called as ITOKAWA in 2005, HYABUSA did touch-down landing two times on ITOKAWA, as the world first success, and has the possibility of asteroid sample collection . Overcoming some serious technical anomaly, HAYABUS is expected to return to the earth with the collected asteroid sample. The final re-entry of HAYABUSA capsule is scheduled on 2010 June.

  IKAROS (Interplanetary Kite-craft Accelerated by Radiation Of the Sun) is a solar sail which gathers sunlight as propulsion by a large sail. This spacecraft will be launched in 2010 together with the Venus Climate Orbiter, "AKATSUKI"(PLANET-C), using an H-IIA launch vehicle. This will be the world's first solar power sail craft employing both photon propulsion and thin film solar power generation during its interplanetary cruise.

  SELENE-2, aiming to acquire the lunar soft landing and rover technology and in-situ scientific data is under phase-A study. JAXA/JSPEC hopes its launch around mid of 2010s. Hayabusa-2 is robotic sample return mission, succeeding Hayabusa project, toward elucidation of the origin and evolution of our solar system and life. Hayabusa-2 is in the phase-A study. Marco Polo is also robotic sample return mission which is expected to be implemented by Japan and Europe jointly. Its current status is under selection of ESA's Cosmic Vision Program.

- Panel on Lunar Exploration

  Panel on Lunar Exploration was established in July 2009 which consists of 20 experts who has variety backgrounds which are not limited to the space activity. The purpose of this panel is to study the lunar exploration by 2020 and objectives of robotic exploration, research roadmap, technical issue, spin-off effect to business market, lunar exploration in the long term, the objectives of robot and human exploration, issue we will face (not only technical but also

administrative) and international cooperation. 6 meetings will be held and final report is expected to be reported to the Minister of Space development in June 2010.

KARI/Republic of Korea
Exploration Highlights

In June 2009, KARI completed the construction of Korea's first space center, the Naro Space Center. The center is the first space port of Korea where future satellites will be launched through the development of Korean launch vehicles.

The construction of the Naro Space Center, which is located in Goheung, 485 km south of Seoul, covering an area of 5km^2, began in mid 2003. This vast complex, located on the southern coast of Korea, includes a launch pad, launch and flight safety control facilities, a mission director center, a meteorological observatory, and radar and optical tracking systems, etc.

In August 2009, Korea's first launch vehicle 'Naro (Korea Space Launch Vehicle-1)' carrying a scientific satellite, Science & Technology Satellite-2, was launched from the Naro Space Center. The launch was unable to place the satellite into its planned orbit due to an incomplete separation of the payload fairing. Korea has been analyzing the cause of the failure and has plans to launch again in May 2010.

After the success of the KSLV-1 program, KARI will be focusing on its second-generation space launch vehicle, KSLV-II, which is expected to support Korea's future lunar missions. KARI expects that the KSLV program will be a stepping stone for Korea's space development.

Meanwhile, in October 2009, KARI and Daejeon city co-held the 60th International Astronautical Congress (IAC) in Daejeon, Korea for 5 days. Thousands of experts and related people attended the conference which promoted international collaboration in space research and development. Also the President of Korea presented a welcoming address at the opening ceremony referring to the "the importance of space technology" in his speech.

Since the beginning of the 1990s, Korea's R&D in space mostly focused on the development of satellite systems, launch vehicles, etc. Recently though, through the Korean Astronaut Program and the KSLV-1 Program, interest in space programs has peaked in Korea and as a result of this increased interest, the Korean government has revised its 'Strategy Plan for Space Development', a part of the 'National Space Development Plan' which was first published in 2007.

NASA/United States of America
Exploration Highlights

During 2009, a year in which the U.S. celebrated the 40th anniversary of the first human landing on the moon, NASA achieved a number of important milestones aimed at furthering human and robotic exploration of the Solar System.

NASA completed five **Space Shuttle** missions to the **International Space Station (ISS)** in 2009. The ISS reached an important, international milestone, as Expedition 20 inaugurated the station's first six-person crew, and also marked the first time a mission's crew represented all five International Space Station partners.

The transfer of the NASA Kennedy Space Center's **Launch Pad 39B** from the Space Shuttle Program to the **Constellation Program** in June was followed five months later with the successful, two minute powered flight of the **Ares I-X test rocket** in October. Ares I-X was conducted as a development flight test for NASA's new Ares I crew launch vehicle. The flight test was preceded by the initial full-scale, full-duration test firing of the Ares I first stage motor in September. Also in September, NASA took a major step toward building the next crew exploration vehicle by completing the **Orion Project's** Preliminary Design Review. Next up will be a flight test of the Orion Launch Abort System from the White Sands Missile Range in early 2010.

NASA also conducted two weeks of technology development tests on two of the agency's prototype lunar rovers as part of the **Desert RATS** (Research and Technology Studies) – at the Black Point Lava Flow in the Arizona desert. The tests provide critical information about how cutting edge vehicles perform in field situations approximating the moon, including an intensive, simulated 14-day mission with two crew members, NASA's prototype **Lunar Electric Rover**. NASA's **K10 scout robot** identified areas of interest for the crew to explore. NASA's heavy-lift rover **Tri-ATHLETE** – or All-Terrain Hex-Legged Extra-Terrestrial Explorer -- carried a habitat mockup to which the rover docked.

The **Lunar Reconnaissance Orbiter** (LRO) launched June 18 on an Atlas V rocket. LRO is now midway through its first year, dedicated to scouting out potential human mission landing sites in a polar orbit of about 31 miles above the lunar surface, the closest any spacecraft has orbited the moon. LRO will produce a complete map of the lunar surface in unprecedented detail, search for resources and safe landing sites for human explorers, and measure lunar temperatures and radiation levels. First results from LRO's **Lunar Exploration Neutron Detector** (**LEND)**, contributed by the Institute for Space Research in Moscow, are indicating that permanently shadowed and nearby regions may harbor water.

On October 9, NASA's **Lunar Crater Observation and Sensing Satellite (LCROSS)**, created twin impacts on the Moon's Cabeus crater, a permanently shadowed region near the moon's South Pole. LCROSS and its spent Centaur upper stage rocket impacted at a speed of more than 1.5 miles per second. Working closely with scientists from LRO and other observatories that viewed the impact,

the LCROSS team is working to understand the full scope of the LCROSS results, but preliminary data indicates that the mission successfully detected water during the impact.

Meanwhile on Mars, the **Mars Reconnaissance Orbiter (MRO)** continued to produce valuable science and stunning images with its advanced set of instruments. Since its arrival at Mars in 2006, MRO has returned more data about the red planet than all other previous spacecraft combined. The twin **Mars Exploration Rovers**, Spirit and Opportunity continued to produce scientific results while operating far beyond their design life. The mission, designed to last 90 days, celebrated its fifth anniversary in January 2009. Spirit has been lodged in a "sandtrap" since April, and both rovers show signs of aging, but each are still capable of exploration and scientific discovery. The **Mars Science Lab**, recently named "Curiosity," continued with development that will lead to the 2011 launch and the first red planet rover since Spirit and Opportunity. Curiosity will have a much greater range, more instruments, and a bigger, stronger robotic arm.