Annual Report 2012

of the

International Space Exploration Coordination Group

INTERNATIONAL SPACE EXPLORATION COORDINATION GROUP

ISECG Secretariat

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

+31 (0) 71 565 3325

ISECG@esa.int

ISECG publications can be found on:

http://www.globalspaceexploration.org/

Table of Contents

1 Introduction

The 2012 Annual Report of the International Space Exploration Coordination Group (ISECG) provides an overview of ISECG activities, products and accomplishments in the past year. In the annex many of the ISECG participating agencies report on national space exploration highlights in 2012.

2 Executive Summary

ISECG was established in response to the "The Global Exploration Strategy: The Framework for Coordination" (GES) developed by 14 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.
The purpose of ISECG is to provide a coordination forum for agencies investing in space exploration to discuss their interests, objectives and plans and to promote interest and engagement in space exploration activities throughout society.
The work of the ISECG is focused on products, findings and recommendations that are critical in informing individual agency decision-making.

Activities in 2012 were mainly driven by the work on the second iteration of the Global Exploration Roadmap (GER) and the development of the space exploration benefits white paper. The GER work was informed through a dialogue with exploration stakeholder communities on global exploration planning initiated by several ISECG participating agencies.
In particular the Global Space Exploration Conference held in May 2012 in Washington, D.C., organized by the American Institute of Aeronautics and Astronautics (AIAA), the International Astronautical Federation (IAF) and co-chaired by ISECG provided an effective platform for ISECG participating agencies to collectively introduce the first iteration of the GER and seek feedback from the stakeholder community.
In parallel, recognizing the importance of delivering value to people on Earth, participating agencies conducted a dialogue to share their views and lessons learned on the nature and significance of the benefits resulting from space exploration. Following a detailed analysis of past benefits and relevant examples generated by space exploration, a logic model capturing systematically the outputs and expected outcomes of investment in space exploration was elaborated and supported further analysis and discussions before starting the drafting phase of the paper itself.

By serving as the international forum where interested agencies continued to share their objectives and plans for human and robotic space exploration, ISECG products and activities continued to contribute to the individual agency decision-making process towards an internationally coordinated approach to space exploration.

3 ISECG Background

In May 2007, 14 space agencies[1] 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 the **International Space Exploration Coordination Group** (ISECG) by the participating agencies. The Terms of Reference (ToR) for ISECG were formally adopted at the first meeting of the group in November 2007.

ISECG serves as the forum where space agencies work together on means of strengthening individual exploration programmes, facilitating collaborations and advancing space exploration through the coordination of participating agencies' mutual efforts. ISECG also supports promoting interest and engagement in space exploration activities throughout society.

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 encourages participating agencies to accept the role of the coordination process
  - ISECG encourages participating agencies to act upon the anticipated results of the coordination mechanism

[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), SSAU (Ukraine), Roscosmos (Russia), UKSA (United Kingdom),. "Space Agencies" refers to government organizations responsible for space activities.

- 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.

4 Activities

4.1 Overview

ISECG products are developed by working groups partly supported by dedicated teams that are initiated as required to work on special subjects. The work is guided by regular plenary meetings and monthly plenary ISECG teleconferences. The degree of participation in ISECG working groups varies by agency and by product. As ISECG work is based on consensus among the members, all products developed at the working group level need approval by the ISECG plenary.

ISECG members participating in the production of specific ISECG products (referred to as "participating agencies" of that product) demonstrate the flexible and evolutionary nature of ISECG to serve as a forum for interested agencies to advance a variety of initiatives of interest to their respective programmes and plans. Overall, ISECG continues to focus on the development of products that are both effective and of mutual interest to address the needs of the participating agencies.

ISECG and supporting working groups are supported by a permanent secretariat, provided by ESA. In addition, the ISECG secretariat provides generic information about ISECG and its products, hosts and manages the ISECG website and supports space agencies that request ISECG membership.

4.2 Activities on ISECG Level

ISECG chairmanship rotates and JAXA assumed chairmanship from NASA on August 30, 2011.

ISECG meetings at the Senior Agency Management (SAM) level were continued in 2012 to ensure timely and effective alignment between strategic considerations of ISECG members and ISECG activities. Senior agency managers reviewed the progress of ISECG work and provided guidance for the development of the second iteration of the Global Exploration Roadmap and the drafting of the space exploration benefits white paper.

In order to increase the visibility of ISECG products and to feed the dialogue with exploration stakeholder communities, papers were presented at the Global Space Exploration Conference, May 2012 in Washington, D.C., USA, the 63rd International Astronautical Congress, October 2012 in Naples, Italy, the First International Space Exploration Symposium, October 2012 in Tokyo, Japan and the ASTech International Space Exploration Conference, December 2012 in Paris, France.

4.3 Working Group Activities

4.3.1 Exploration Roadmap Working Group (ERWG)

Following the release of the first iteration of the Global Exploration Roadmap (GER) in September 2011, ISECG participating agencies engaged stakeholder communities in a dialogue on global exploration planning for seeking inputs on innovative ideas and concepts for meeting common exploration goals.
In particular, the Global Space Exploration Conference held in May 2012 in Washington and jointly organised by AIAA, IAF and ISECG provided an effective platform for ISECG participating agencies to collectively introduce the GER and seek feedback from the stakeholder community.

During 2012, the ERWG continued the human space exploration roadmapping activity and initiated work on the second iteration of the GER. Considering key observations from the first iteration as well as the desire to better link the long-term planning efforts with preparatory activities for exploration currently funded by many space agencies, ERWG focused its work on:

- Further defining strategies for near-term human mission scenarios beyond LEO and understanding how these near-term missions prepare for future human missions to the Moon, deep space and ultimately to Mars.
- Refining the important role ISS plays in preparing future exploration missions by acting as a test-bed for critical technologies and new operations techniques as well as by providing a unique platform for advancing research on human health and performance risks associated with future human exploration missions.
- Share lessons learned from analogue campaigns ranging from technology development, exploration mission operations simulations, simulations of human factors and performance, analogue tests of science operations and techniques.
- Assessing the synergies between robotic missions to the exploration destinations and future human missions: significant work has been devoted to defining and mapping strategic knowledge gaps which, if closed through robotic missions, reduce the risks and enhance the return of future human mission scenarios.
- Reviewing plans for technology development and identifying opportunities for cooperation and /or areas which are possibly under-funded today in view of envisaged near-term mission scenario.

Significant work has been in particular performed on the last two elements, as described below:

A dedicated team was formed to identify the Strategic Knowledge Gaps (SKGs) related to the GER destinations i.e. the Moon, near Earth asteroids, and Mars and its moons. Team members assembled multiple sets of SKGs developed by a number of key independent Analysis/Assessment Groups from NASA (LEAG (Lunar Exploration Analysis Group), MEPAG (Mars Exploration Program Analysis Group), P-SAG (Precursor Strategy Analysis Group), SBAG (Small Bodies Analysis Group)), ESA Topical Teams and mission scientists, and JAXA experts for each destination. As next step, an assessment of the priority level of these SKGs with respect to the ISECG GER Design Reference Missions (DRMs) has been started.

Another dedicated team collected, integrated and discussed a comprehensive data repository of technology development activities of participating agencies and integrated these data-set into the so-called GER Technology Development Map (GTDM). The GTDM categorizes these inputs by technology areas and maps them to the elements and capabilities identified in the GER mission scenarios. As a result, the GTDM becomes a unique product combining in a systematic fashion technology development entries of several participating ISECG space agencies and allowing the analysis of this data set from many different angles.

Work on updating of the GER will continue with the goal to publish the second iteration of the GER expected in the summer of 2013.

4.3.2 International Architecture Working Group (IAWG)

For the second release of the GER, the International Architecture Working Group (IAWG) has focused on work related to the Early Design Reference Missions (DRMs) for the two conceptual mission scenarios: Moon Next and Asteroid Next. In the development of the Early DRMs, the IAWG has taken into account analysis and information provided by ISECG agencies in these key areas:

- The availability of planned exploration capabilities;
- Several subjects related to the mission scenarios which were provided as inputs through various stakeholder engagement activities;
- The identification of agencies' plans for technology developments enabling the implementation of the ISECG DRMs and opportunities for inserting new technology into the mission concepts;
- The definition and prioritization of strategic knowledge gaps which reflect information helpful for the preparation of the ISECG DRMs; and opportunities for step-wise demonstration of capabilities needed for future Mars missions.

The IAWG will go into greater detail in describing early DRMs in each mission scenario. In the mission scenarios the IAWG has considered a combined set of both human and robotic missions depicting scientifically relevant and interesting robotic activities, technology and capability demonstration missions facilitated by robotics, and tele-operation of robotic lunar surface assets from cis-lunar space. The updated mission scenarios reflect a consideration of the capabilities required for furthering human exploration of the solar system and how early DRMs could contribute to risk reduction required for future exploration of asteroids, the Moon, and Mars.

4.3.3 International Objectives Working Group (IOWG)

The International Objective Working Group (IOWG) focused on the discussion of the contents of the ISECG white paper describing an international view of the benefits derived from space exploration. This work was initiated at the Kyoto meeting of senior agency managers in September of 2011. To support the discussion, the IOWG developed a theoretical model of how activities performed by space agencies translate into benefits received by people on Earth. Based on the benefits delivery model, the IOWG members shared their results and experience related to the delivery of benefits. After discussing this information, IOWG members were able to identify an outline for their white paper.

Several stakeholder engagement opportunities, listed below, informed this work:

- In April 2012, ESA invited IOWG to ESA's Stakeholder workshop on space exploration. The major findings are summarized into two recommendations to the Benefit model and the Stakeholder engagement.
- At the GLEX in Washington, DC in May 2012, the benefits logic model was simplified into two layers of Direct and In-Direct to make the benefits concept a more clear and concise one. Drafting of the benefits white paper (BWP) had begun to target the interim version in September.
- In October 2012, JAXA hosted the International Space Exploration Symposium to consult with space exploration stakeholders from Japan and also from international partners.
- In December 2012, a dedicated session on ISECG took place at the International Space Exploration Conference (co-organized by CNES) in Paris. This was in particular the opportunity for stakeholders to discuss the benefits of space exploration.

The IOWG will finalize the paper within 2013. For the BWP, the contents and structure will capture the support of space exploration stakeholders. The BWP should be suitable to respond to the interest of the stakeholders and public, to reach the public consensus for space exploration, and to be able to support the Global Exploration Roadmap from the societal benefits viewpoints.

4.3.4 Strategic Communications Working Group (SCWG)

The SCWG continued to work on supporting communication between ISECG members and other exploration stakeholders in science, industry, politics and society.
As strategic communications is considered a cross-cutting topic, SCWG again contributed to the product development process in ISECG working groups.
Coordinated actions further increased the visibility of ISECG and ensured that stakeholder communities and relevant existing multilateral working groups were informed regarding the existence of ISECG, its mandate and products.
The group continued discussions on the renewal of the public part of the ISECG website to ensure effective communication towards stakeholder communities. In a first step the design of the website shall be modified followed by content changes.
Future work priorities include planning and implementation of the public website relaunch.

Annex I

Space Exploration Highlights of ISECG Member Agencies

(in alphabetical order)

1. Agenzia Spaziale Italiana (ASI), Italy

Introduction

The year 2012 has been characterized, by the continuation of the programmes approved during the last ESA Ministerial Council, held in 2008, mainly the robotic mission ExoMars, for which Italy confirms its leadership, and the participation to the Exploitation of the International Space Station ISS, through the Intergovernmental Agreement, IGA, and the MPLM, Multipurpose Logistics Modules, MOU between NASA and ASI.
In November 2012 the ESA ministerial Council has been held in Naples, Italy. The cooperation between ESA and Roscosmos in ExoMars 2016 and 2018 missions has been confirmed and the participation to ISS went a step forward, with the approval of the MPCV Service Module as the European barter element to NASA. Plan for new Exploration activities have been also set up.

Past significant events and missions

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

- Human exploration
  - The Elite-S2 activities continued nominally through 2012.
  - The activities within the Permanent Multipurpose Module, PMM, derived from the MPLM FM1 Leonardo, developed by the Italian Space Agency, through Thales Alenia Space Italia, for NASA, and docked in 2011 to the ISS, are on-going as planned.
  - The ESA astronaut of Italian nationality Luca Parmitano is being trained for his long term mission to ISS planned for May-November 2013 period (ISS Increment 36/37).
  - The other ESA astronaut of Italian nationality Samantha Cristoforetti is also performing training activities for a long term mission to ISS in 2014-2015 (ISS Increment 42/43).
- Robotics for exploration
  - Together with European partners, the activities of ExoMars (Italian Prime Contractorship) are on-going.
  - Continuation of the operations, data acquisition and analysis of Italian instruments on-board Mars Express (MARSIS and PFS) and NASA MRO mission (SHARAD).

Upcoming events

Italy foresees to follow both the human and robotic exploration. Attendance and active participation 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.
The 2013 will be characterized by:

- a relevant involvement of Italy in the exploitation of the ISS, thus confirming its relevant role in this endeavour.
- Continuation of the activities nationally and within ESA in preparation for the ExoMars 2016 and 2018 mission. The ESA-Roscosmos cooperation in confirmed and consolidated.

- An ASI-led Combustion Experiment for Green Air, ICE-GA, is being planned in cooperation with NASA, and will use the NASA Combustion Integrated Rack on the ISS. Another combustion experiment to be flowed on ISS, the DIAPASON Particle Detection unit, is also being planned in cooperation with NASA.

Conclusion

Italy is still strongly involved in Exploration, both robotics and with the astronauts. Currently the main objective is the Mars Robotic Exploration, mainly ExoMars, and the utilisation of ISS. At the same time, Italy is also aiming at enhancing the Italian expertise in exploration related fields like robotics systems, pressurized modules and the relevant life support systems, aiming to acquire new technologies for the future space exploration.

2. Centre National d'Etudes Spatiales (CNES), France

In 2012 CNES has continued to implement the Contract between the ministry and CNES for the 2011-2015 period signed in October 2010. In this document, it is stated that CNES shall 'make proposals to promote an international exploration program of the Solar System in a renewed governance'. In particular, an increased role for the European Union in exploration matters is foreseen.
Furthermore, CNES took an active part in the preparation of the second version of the ISECG Global Exploration Roadmap and of the Benefits White Paper. CNES was also the key sponsor of the ASTECH International Space Exploration Conference which took place in Paris on December 2012 and is also involved in the European discussions aimed at preparing the European participation in the 2nd high-level international platform on exploration which is scheduled to take place in Washington DC in January 2014.

For France, recent significant exploration-related activities are:

Mars robotic exploration

- Participation to EXOMARS (ESA/ROSCOSMOS cooperation):

    * Contribution to the payload

    * Rover vision/navigation expertise

    * Support on EDLS

- Payload elements (CHEMCAM, SAM) and scientific operations on CURIOSITY (NASA)

- Contribution to MAVEN (NASA)

- Instrument (SEIS) on the NASA INSIGHT mission

There have also been CNES activities on robotic missions to other destinations:

ROSETTA (comet - ESA), BEPI-COLOMBO (Mercury – ESA/JAXA), HAYABUSA-2 (asteroid - JAXA; in particular the MASCOT lander with DLR) and JUICE (icy moons of Jupiter - ESA)

Human spaceflight

- Exploitation and utilisation of the ISS:

    * ATV Control Center in CNES premises in Toulouse

    * French participation in the ESA ELIPS program

    * CADMOS: French part of the ISS scientific ground segment

* Physiology/space medicine: CARDIOLAB with DLR, CARDIOMED with ROSCOSMOS

- Cooperation with China on cardiovascular monitoring (CARDIOSPACE)

- Start of a joint CNES/ESA bed rest campaign at MEDES (CNES subsidiary)

- Joint CNES/DLR/ESA partial-g (Moon, Mars) parabolic flight campaign in December 2012

3. Canadian Space Agency (CSA), Canada

Summary

Space exploration missions have a unique capacity to capture our imagination, stimulate our curiosity, and answer fundamental questions about the Universe. Space exploration contributes to the Government of Canada's Science and Technology Strategy and paves the way for the utilization and commercialization of space. The Canadian Space Exploration Program can be a key driver for our future through the creation of jobs, growth and prosperity. It can help maintain our space industry's ranking in the world as a knowledge-based, technically innovative and responsible global partner, and further develop exciting, forward-looking opportunities for young Canadians. Investments made in science and technology will define the strength of economics in the twenty-first century.

CSA Structure

Under a Director General, the CSA's Space Exploration branch is organized in directorates that are responsible for the following program areas:

- Space Exploration Operations & Infrastructure
- Astronauts, Life Science and Space Medicine
- Space Exploration Development

Space Exploration Operations & Infrastructure

In 2012, the CSA continued to operate the Mobile Servicing System (MSS) to carry out robotic maintenance and resupply operations on the International Space Station (ISS). The CSA's Canadarm2 captured and berthed three visiting vehicle resupply mission: SpaceX's demonstration flight; JAXA's HTV-3 and SpaceX-1. The MSS also supported Russian and US spacewalks, and accomplished the transfer of cargo from HTV-3.

To support maintenance activities the Canadian robotics system successfully replaced a Remote Power Control Module (RPCM) on the ISS via ground control, thus freeing up the crew's time to perform valuable science experiments.

Canadarm2 and Dextre also performed flawlessly during the joint CSA-NASA Robotic Refueling Mission (RRM). These activities resulted in the development and certification of new flight products and procedures to support MSS operations and expand the boundaries of robotic operations.

Astronauts, Life Sciences and Space Medicine

Veteran CSA astronaut Chris Hadfield continued his training and preparation for ISS Expedition 34/35 mission, which launched on December 19, 2012. This is Hadfield's third space mission and second trip to the ISS. He will be on orbit for about five months. After three months working as a Flight Engineer during Expedition 34, Hadfield will assume command of the ISS and its crew in March 2013—a significant first for Canada. Landing is scheduled for mid-May 2013.

Canada's two newest astronauts, Major Jeremy Hansen and Dr. David Saint-Jacques, have successfully completed their Basic Training course requirements and are now eligible for long-duration flight assignment on the ISS. They will continue to receive pre-assignment training and assume collateral duties within the crew office at NASA's Johnson Space Center.

The Advanced Astronaut Medical Support group continued work on a physician web interface, a medical ultrasound remote-control interface and an astronaut health-monitoring system, and initiated a study on an Advanced Crew Medical System Concept Study. The group also began validating the Performance Readiness Evaluation Tool (PRET).

The mandate of the CSA's Space Health and Life Sciences group is to identify, characterize and mitigate risks to humans during extended space travel. Three subjects are completing the VASCULAR protocol on the ISS to examine the effects of long-duration exposure to weightlessness on the structure and function of the cardiovascular system. Hypersole, completed on the last two shuttle missions, examined the effects of weightlessness on the function of cells in the sole of the foot that detect contact with surfaces. Finally, three life-science activities began development for execution on the ISS:

- Microflow, a technology demonstration of a flow cytometer for space,
- See Jitter, an experiment determining the effects of a vibrating field of view on perception, and
- BP Reg, a cardiovascular experiment aiming to validate techniques for monitoring cardiovascular.

Radi-N2, a collaborative study with Russia characterizing the ISS neutron radiation environment, will continue during the Increments 34, 35/36, 37/38 and 39/40.

Space Exploration Development

Planetary Exploration

Canada's chief planetary science goals are to understand the origin and evolution of the solar system, to investigate habitability and detect life elsewhere in the solar system. The CSA's focus in planetary exploration is the robotic exploration of Mars, and the robotic and human exploration of the Moon and cislunar space.
The CSA continues to be a strong supporter of a future international Mars sample return mission, and is keen to contribute scientific investigations and enabling technologies to missions that advance this goal.
In 2012, the CSA's planetary exploration activities included support for the Canadian Alpha Particle X-ray Spectrometer (APXS) investigation on NASA's Mars Science Laboratory mission, which landed in August 2012. APXS provides data on the chemical composition of Martian rocks and soils. The instrument has had an important role in the mission to date as a decision-making tool for scooping and drilling activities and in the selection of samples for analysis by MSL laboratory instruments. A study for an advanced version APXS was also completed in 2012 by the APXS team at University of Guelph and MacDonald Dettwiler and Associates (MDA).
The OSIRIS-REx Laser Altimeter (OLA) investigation for NASA's OSIRIS-REx New Frontier mission remained in development through 2012 for the planned launch in 2016. The instrument has heritage from the CSA's lidar on the Phoenix Mars Lander's meteorological station, and it is planned that a portion of returned sample will be curated in Canada. This will be Canada's first involvement in a sample-return mission.

A Phase-A study for the Mars Atmospheric Trace Molecule Occultation Spectrometer (MATMOS) planned as a payload on the ESA ExoMars Trace Gas Orbiter was completed in partnership with NASA JPL, and it may be considered for future missions. The CSA also continues to participate in the ESA ExoMars program.
In 2012, the CSA started to work with NASA HEOMD investigating a potential collaboration.

Astronomy

In the summer of 2012, the CSA delivered the Fine Guidance Sensor (FGS) and Near-Infrared Imager and Slitless Spectrograph (NIRISS) instruments to NASA for the James Webb Space Telescope (JWST), slated for launch in 2018. The CSA is contributing read-out electronics for the UV detectors on board ISRO's ASTROSAT space observatory, which were delivered to India in 2010. Canada also contributed to ESA's Herschel and Planck missions, which continue to provide excellent science since their launch in 2009.

Since its launch in 2003, Canada's micro-satellite space telescope, the Microvariability and Oscillation of STars (MOST) continues to make valuable contributions to the field of stellar astronomy. Based on similar micro-satellite technology, our Near-Earth Object Surveillance Satellite (NEOSSat) is ready for launch in early 2013. Scanning the sky near the Sun, this micro-satellite will help find new near-Earth asteroids.

The CSA will be providing a laser metrology system for JAXA's next large X-ray observatory ASTRO-H to be launched in 2014. The CSA has also supported the development of nano-satellites BRight Target Explorer (BRITE) to perform photometry of the brighter stars from orbit (scheduled for launch in 2013 and 2014).

Advanced Exploration Technology Development

Created in 2007, the CSA's Exploration Core program funds advanced exploration technology development. The Exploration Core program continues at an impressive pace, due to additional funding through Canada's Economic Action Plan (stimulus budget). The program's goal is to ensure Canada's readiness to participate in future human and robotic exploration missions. Signature technologies include: optics; radiation mitigation; robotic servicing; spectrometers; advanced crew medical systems; drilling and sample extraction; and rovers.

In 2012-2013, the CSA continued to work with its industrial contractors to deliver a series of space robotics projects as part of Canada's Economic Action Plan. This included the completion of terrestrial prototypes for the Next-Generation Canadarm project, which was delivered in 2012, as well as prototypes of a series of rovers and their associated technologies for future Moon and Mars exploration. Moreover, four contracts to support analogue mission deployments were completed and resulted in a total of three deployments in 2012.

Space exploration missions and programmes also generated technologies that found their way into terrestrial applications and commercial markets. For example, investments to develop rovers under the stimulus budget helped to commercialize an electric version of an all-terrain vehicle from Bombardier Recreational Product (BRP). Another example is an innovative fuel cell built by Hydrogenics for the rover program that is now available for other terrestrial applications.

Analogue Activities

In 2012, the CSA completed its third In-Situ Resource Utilization (ISRU) analogue mission in Mauna Kea Hawaii (known as RESOLVE). The CSA contributed the Artemis Jr rover, a drill and an avionics suite for operating the payload assembly, as well as a Juno rover for the parallel MMAMA experiments.

In addition, a series of four analogue missions took place in Canada. Two sets of analogue missions investigating the presence of methane were conducted at a total of 4 sites: Asbestos, Thetford Mines, Axel Heiberg Island and at the CSA's analogue terrain in St-Hubert, Quebec. A mission searching for signs of life was also performed at Pavilion Lake and Kelly Lake in British Columbia. Finally, analogue activities investigated human-robotic interaction in planetary exploration missions in the context of impacts and sample return from the South Pole Aitken Basin on the Moon at the Mistastin impact structure in Labrador and at the Sudbury impact structure in Ontario.

These deployments and analogue activities utilized the CSA's Exploration Ground Infrastructure facilities, such as the Exploration Development and Operations centre (ExDOC), for remote command and control. Additionally, engineering test activities were completed on the CSA's Analogue Terrain involving operations of assorted prototype Mars and Lunar Rovers and associated instruments. These activities included use of the ExDOC and the newly commissioned Portable Command & Control Shelter (PCCS) i.e. a "mobile ExDOC."

Space Exploration Plan

The CSA has finalized the first version of the Canadian Space Exploration Plan. The plan provides an overview of the international context and rationale for space exploration, Canada's strengths, and proposes directions for its space exploration program. The document outlines the program goals, priorities and a roadmap to provide the context in which Canadian space exploration initiatives are identified and pursued. It consolidates the results of several consultations over the past two years among Canadian and international stakeholders interested in space exploration. It is intended as a reference for the Canadian space exploration community to engage in further consultations and consensus-building dialogue defining the future of space exploration in Canada.

4. Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), Germany

Highlights of the 2012 Exploration and Manned Space Events.

Together with its international partners, DLR continues to discuss the shaping of exploration activities at all levels. Examples of the ongoing activities include the construction of the DLR life sciences research facility :envihab in Cologne and the development of the asteroid lander package MASCOT for the Japanese Hayabusa-2 mission. The following paragraphs will provide a few more highlights of events throughout the year 2012 with relation to exploration and human spaceflight.

March 2012
The second national Conference on Space Robotics was held in the premises of the Ministry for Economics and Technology in Berlin. The Conference reported about the progress in the field since 2009. On-going and future projects have been presented. The potential for technology-transfer has been outlined. Prof. Hirzinger gave a presentation about 25 years of Space Robotics Research in Germany. Concomitantly an exhibition took place in the Deutsche Museum, Bonn which gave an overview of recent projects, results and achievements in the field of Space Robotics.

April 2012
In Berlin, a European Lunar Symposium took place in collaboration with the NASA Lunar Science Institute. Preceding this event, on April 18, was a Lunar Lander Day. The symposium had 170 international attendees, a very good response. The necessity for future lunar missions has been strengthened by the participants. The ESA Lunar Lander mission scenario was introduced and found great interest in the audience.

May 2012
In Berlin, three days were devoted to research benefits of the International Space Station (ISS) and its future. The international event was jointly organized by ESA and DLR. Many impressive results were communicated. The symposium covered many research results gained in 10 years of ISS operations. Results of fundamental science, as well as industrial, medical and consumer applications were reported.

June 2012
SHEFEX (Sharp Edge Flight Experiment) II, a space vehicle of DLR, carried out a successful flight. The sharp edged vehicle is a means to test innovative ceramic tiles which resist temperatures up to 2000 degrees Celsius. Shefex helps to enable a promising technology for future spacecrafts.

July 2012
TET-1, a small satellite for technologies and on orbit H/W Verification has been launched. TET is suitable for testing new solar cells, electronic devices, batteries, small engines, etc.

August 2012
The MSL rover Curiosity of NASA landed successfully on the surface of Mars. With the RAD experiment, it carries a radiation monitoring instrument whose sensor element was developed and provided by DLR and the University of Kiel in Germany. Already throughout the cruise phase, the

instrument recorded measurements of the deep space radiation environment including two solar particle events. Together with the continuing measurements on the surface, the instrument provides for the first time a full characterization of the radiation loads throughout a Mars mission.
Also in August, NASA selected the Discovery-class mission “Insight”, which will launch to Mars in 2016. DLR will provide one of four major instruments on this mission with the Heat Flow and Physical Properties Package (HP3). This mole instrument will drill up to about 5 meters into the Martian soil to provide in-situ temperature and heat flux measurements for the characterization of the Mars interior.

September 2012
ILA, the Berlin Air Show was a great success. 230.000 visitors came to Berlin, including about 125.000 experts and professionals. Space had its own pavilion organized by DLR and ESA with an exhibition named “Space for Earth”. A total of 24 attractive space-related topics were presented, among them also biological elements for future closed loop ecological systems in space.

November 2012
The European space activities were governed by the ESA Ministerial Council in Naples, November 20-21, 2012. Germany once again underlined its international commitment and shaping role as the major overall contributor to ESA with a new commitment of 2.4 billion Euro. Highlights of the decisions for Human Spaceflight and Exploration were the confirmation of the ISS exploitation until at least 2020 as well as the agreement to start the development of a European service module for the US crew vehicle MPCV. Unfortunately, the Lunar Lander Project had to be deferred due to a lack of financial backing by other ESA member states.

December 2012
Further results from the MARS 500 mission in 2011, a simulated Mission to Mars, were published. A university research team had prescribed a rigid diet plan for the Mars 500 travelers. Mars 500 is, among other studies, the longest study ever on Sodium consumption, uptake and metabolism in humans. One spectacular result is that the sodium metabolism follows a biorhythm of several days. It became obvious that a usual 24 hour monitoring is by far not good enough to make assumptions about the salt uptake, body stowage and excretion. These results are crucial for future long duration human space missions.
December also saw the kick-off of a large scale Helmholtz research alliance of DLR institutes and German research institutions called ROBEX. Over the course of five years, ROBEX will develop robotic capabilities for the exploration of extreme environments by particularly exploring the synergies between the challenges of lunar robotic infrastructures and deep sea exploration.

5. European Space Agency (ESA)

Main Event

ESA main event for 2012 has been the Council meeting at Ministerial level held in Naples (Italy) on 20-21 November. An excerpt of a press release summarizing the outcome is reported in Annex.

Exploration Highlights

Two important decisions have been taken in 2012 in the field of exploration allowing Europe to make progress for exploitation of the low Earth orbit (LEO) and exploration of destinations beyond LEO:

- the first one concerns the decision to pursue the implementation of the two ExoMars missions, i.e. the 2016 Trace Gas Orbiter (TGO) and Entry descent and landing Demonstrator Module (EDM) and the 2018 Rover, in collaboration with Roscosmos after NASA withdrawal of the programme.

- the second one is the green light given by Ministers for Europe to provide the service module of NASA's new Multi-Purpose Crew Vehicle (MPCV) for the test flight scheduled in 2017 as a barter for ISS operations for 2017–2020. Besides allowing Europe to continue to exploit the Columbus laboratory until 2020, this decision also enables a cooperation between ESA and NASA on the future human space transportation system and potentially the participation in exploration missions beyond LEO.

International Collaborations

Discussions were held with the ISS partners to further explore collaboration on human exploration beyond ISS. In addition, separate exchange of views were conducted with the Russian and Chinese space agencies regarding potential collaboration opportunities addressing future manned space programmes.

International Space Station (ISS)/ LEO

The third Automated Transfer Vehicle (ATV-3) "Edoardo Amaldi" was successfully launched from the Guiana Space Centre on 23 March and it docked flawlessly with the ISS on 29 March. After resupplying the ISS with oxygen, water, propellant, dry cargo and performing nine ISS re-boosts, the vehicle was loaded with dry cargo waste and waste liquid and undocking took place on 28 September. It burnt up as planned in the upper atmosphere over an uninhabited area of the southern Pacific on 3 October. ATV-4 "Albert Einstein" arrived in Kourou on 16 September. The European Robotic Arm (ERA) launch on Proton has been set in December 2013. The launch and integration campaign started in Russia during summer.

On 1 July ESA astronaut André Kuipers, together with his Russian Commander Oleg Kononenko and NASA astronaut Donald Pettit, landed safely on the steppes of Kazakhstan after more than 6 months spent on board of the ISS. Next European astronaut to visit the ISS, is Luca Parmitano scheduled to fly on 29 May 2013, based on an ASI (Agenzia Spaziale Italiana) long-duration flight opportunity.

A. Kuipers's PromISSe mission was carried out successfully, with a large suite of biomedical experiments, fluid physics experiments and a number of experiments part of the Spaceship Earth educational programme for primary and secondary schools.

Mainly human research and biological experiments, in the cardio-respiratory/-pulmonary, immunology, bones and muscles, and neurophysiology domains, have been performed. They are of scientific significance for human exploration preparation as they elaborate on the adverse effects of space on the human well-being and performance during long-duration missions. In addition a suite of integrated cosmic radiation measurements and shielding experiments have been performed and further continue. Most of these life science experiments on ISS are closely linked to preparatory ground-based studies.

During the ISS Symposium held in Berlin from 2-4 May, 280 participants from over 25 countries including Heads of Agency, politicians and members from the international science community discussed the ISS research results and concluded that they were of great significance to industrial applications and acknowledged that they were yielding tangible benefits for society.

Moon Exploration

Despite the very good progress all over the year of the various activities to support the ESA Lunar Lander definition, spacecraft design and model payload as shown during the Preliminary System Requirements Review (Pre-SRR) held in the October-November timeframe, the mission has been put on hold after the Council meeting at ministerial level due to the lack of funds to pursue its development.

In parallel to the Lunar Lander activities, ESA and Roscosmos have been assessing possibilities for ESA participation in the Luna-Resurs Lander mission (launch >2017) and the Lunar Polar Sample Return (LPSR) mission (launch > 2020). Following a bilateral meeting on 25 October, a protocol was signed by Dr.-Ing. Reiter e. h. (ESA, Director of Human Spaceflight and Operations) and Prof. Raikunov (TSNIIMash, Central Research Institute of Machine Building, Russian Space Agency) outlining a possible way forward for the ESA-Russia cooperation on lunar exploration.

Mars Exploration

The ExoMars Programme underwent a major reformation in 2012. After it became evident that NASA could no longer support the bilateral cooperation on the ExoMars mission, a joint ESA-Roscosmos working group reported on a technically feasible solution for a bilateral cooperation on ExoMars in February 2012. This bilateral cooperation scenario consists of two missions to be launched in 2016 and 2018, respectively. The 2016 mission will carry the ESA-provided TGO and EDM, and will be launched by a Russian Proton launcher. The TGO will accommodate ESA- and Roscosmos provided scientific instruments. The 2018 mission will consist of an ESA-provided Carrier Module, bringing the Russian Descent Module and Surface Platform and the ESA Rover to Mars. The Rover and Surface Platform will accommodate both ESA- and Roscosmos provided scientific instruments. In April 2012, a Declaration of Intent for Joint Robotic Mars Missions was signed by ESA and Roscosmos, and a formal Agreement on the cooperation that was negotiated between ESA and Roscosmos during the second half of 2012 is planned to be signed in March 2013. In parallel to these negotiations, industrial implementation of the ExoMars missions proceeded according to the new cooperation scenario with Roscosmos. The 2016 mission is now in its full

development phase, and the 2018 mission is undergoing a joint ESA-Roscosmos definition study with pre-development activities on-going on the Rover.

In the context of the Mars Robotic Exploration Preparation (MREP) Programme, a number of candidate missions have been identified for post-ExoMars launch opportunities to Mars in 2022/2024, with the PHOOTPRINT Mars moon sample return mission and the INSPIRE network mission as the most promising candidates. In MREP, several technologies are developed which are relevant to these candidate missions, and at the same time prepare for a future potential European participation to Mars Sample Return (MSR). Moreover, long-term technology developments, which are defined as strategic and enabling technology developments for European robotic exploration, are also developed (e.g. Novel Power Sources using radioisotope heat generation). As the MREP Programme (2008-2012) was nearing its end, the ESA Council at Ministerial level in November 2012 approved the MREP-2 Programme (2013-2017). MREP-2 will further define and prepare the first post-ExoMars mission, and will further develop MSR-related and long-term technologies.

The Mars Express spacecraft provided technical support (data relay) to NASA Mars Science Laboratory (MSL) Curiosity landing on the Red Planet on 6 August.

Preparatory Activities

As ESA astronauts were working on the ISS, on the ground, preparations for destinations beyond were proceeding. ESA organized the CAVES (Cooperative Adventure for Valuing and Exercising human behavior and performance Skills) training session with astronauts from all the International Space Station partner nations living underground for a week. This training was meant to prepare them to work under real exploration conditions in multi-cultural teams under extreme conditions. During their six-night stay in caves in Sardinia (Italy), the ‘cavenauts’ lived and cooperated in a pitch-black cave isolated from the outside world. In addition to exploring the underground cavern, the astronauts performed a scientific programme including search for life as they would do on a mission to another planet.

Significant achievements have been gained with a variety of human research performed in ground-based facilities (Concordia isolation studies, bedrest studies with focus on nutrition effects, IBER (Investigations into Biological Effects of Radiation) studies with exposure of biological materials).

ESA carried out three parabolic flights campaigns with the A300 and performed several physical science and life science experiments (including some from Mars500 with the entire international crew of six). The third campaign was `the second Joint European Partial-g Parabolic Flight (JEPPF) campaign in collaboration with CNES and DLR where 13 experiments in life and physical sciences and exploration technologies have been performed under variable gravity conditions (Earth – Mars – Moon – Weightlessness).

Looking at other preparatory activities for future human exploration, the Micro-Ecological Life Support System Alternative (MELiSSA) and the industrial activities for the Advanced Closed-Loop System (ACLS) service, which is a regenerative air revitalization system designed to remove CO_2 from the ISS atmosphere and then to produce O_2 from this CO_2, continued to progress as planned. The detailed design of the Engineering and Flight models for the ACLS have been finalized. The first Operations & Communications Test (OPSCOM-1) in preparation of the Multi-Purpose End-To-End Robotic Operation Network (METERON) was successfully performed on ISS on 23 October 2012.

NASA Astronaut Sunita Williams commanded a small rover at ESOC in near real time from the ISS using the new communication technique DTN (Disruption Tolerant Network).

The study and development of future exploration capabilities continued including the Advanced Re-entry Vehicle (ARV), EXPErimental Re-entry Testbed (EXPERT) and the International Berthing/Docking Mechanism (IBDM). The ARV Phase A study has been concluded and even if the programme will not continue, the results from the ARV crew version of this study have beeen used for the MPCV Service Module definition. Following continued difficulties in obtaining permission from the Russian government for the launch of the Re-entry Test-bed (EXPERT) on the baseline Volna missile from a submarine, studies have been initiated to identify alternative launchers. Interest has been expressed by several NASA centers in scientific cooperation with ESA in EXPERT reentry activities. Important progress have been achieved on the IBDM which is a system capable of docking various vehicles with very different masses in the same mission, as required for future exploration undertakings. A fully representative development model is under development, featuring the critical mechanical elements and the associated control and power avionics. The mechanism shall be compatible with the most recent International Docking Standard, as agreed among the ISS International Partners, and the new International Docking Adapters at the ISS.

Recently ESA promoted a road mapping activity on Exploration Technologies, coordinating inputs from all concerned ESA Directorates and European Industry. Such a work is being used in support to the procurement plans of the different R&D programmes in this field.

Following the roadmap indications, the required resources for the technology procurement will be coordinated and optimised among all the different programmes and destinations, taking into account also major users outside space exploration and significant spin-in from other sectors. The technology roadmaps prepared by ESA and the related procurement work plans shall be maintained and updated in the coming years and shall be used also as the basis for the planning of possible international collaborations for future missions.

The Exploration Scenario Studies awarded to European industries in 2010 to inform the development of a Strategic Plan for Human Spaceflight and Exploration have been concluded by an ESA internal review which took place in September. Options for roadmaps for future human spaceflight and exploration have been presented and will inform future decisions.

ESA is supporting the activities of ISECG through its participation in its working groups and continues to host the secretariat and the website.

Annex

Council meeting at ministerial level

On 20 and 21 November, the Ministers in charge of space activities within the 20 ESA Member States and Canada met in Naples (Italy) to decide on the future space programmes with the objective of pushing the frontiers of knowledge, supporting an innovative and competitive Europe and enabling new space-based services. During the two-day Council meeting at ministerial level, they have allocated €10 billion for ESA's space activities and programmes for the years to come.

Apart from the 20 ESA Member States and Canada, several observers were also present at the Ministerial Council: Eight out of the 9 EU Member States that are not yet Member States of ESA (Bulgaria, Estonia, Hungary, Cyprus, Latvia, Lithuania, the Slovak Republic and Malta); the European Commission, the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT), the European Science Foundation, the European Defence Agency (EDA), the European Maritime Safety Agency (EMSA), the European GNSS Agency (GSA) and the Organisation for Economic Co-operation and Development (OECD).

European Ministers and representatives at Ministerial Council 2012 focused the investments on fields with high growth potential or with a direct and immediate impact on the economy such as telecommunications and meteorology. They approved ESA's level of resources for 2013-17, the proposals for the domain of Earth Observation and confirmed Europe's commitment to the exploitation of the International Space Station (ISS).

Ministers secured investments for the detailed definition studies of the new launcher Ariane 6 and the continuation of the development of Ariane 5 ME adapted, with the goal to develop as many commonalities as possible between the two launchers. These activities are funded for two years with a decision on the continuation of both launchers to be taken in 2014.

Ministers gave the green light for Europe to provide the service module of NASA's new Orion Multipurpose Crew Vehicle (MPCV) as an in-kind contribution for ISS operations for 2017–20. This decision is strategically important for Europe as it will enable a cooperation between ESA and NASA on the future human space transportation system.

Ministers of ESA Member States approved a Political Declaration towards the European Space Agency that best serves Europe. In doing so, Ministers have initiated a process able to define how ESA can adapt its operations to take benefit of both, its intergovernmental framework and the EU competence in space. They have also stated their willingness to ensure coordination and coherence between the process initiated on the ESA side and the one initiated on the EU side. This Political Declaration was also supported by Ministers from 7 of the EU member States not yet members of ESA present at the meeting.

Ministers decided to hold the next Council at Ministerial level in spring 2014.

6. Japan Aerospace Exploration Agency (JAXA), Japan

First International Space Exploration Symposium

The Japan Aerospace Exploration Agency (JAXA) successfully held "The First International Space Exploration Symposium in Japan - Space Exploration for Humanity and the Future-" in Tokyo, Japan, on October 30 and October 31, 2012.

The purpose of this symposium was to discuss the significance of space exploration and what targets would be suitable for future human space exploration and to provide the audience with an opportunity to deepen their understanding of future human space exploration through panel discussions, presentations, and interactive question-and-answer sessions.

Some 20 experts from all over the world, including the United States, Russia, and Europe, attended as speakers, and there were around 400 people in the audience.

Analysis of samples brought back by HAYABUSA

HAYABUSA (MUSES-C) is an explorer developed to demonstrate the technologies required for two-way exploration of an asteroid. The explorer was launched on May 9, 2003; reached the Itokawa asteroid on September 12, 2005; performed scientific observation around it; and landed on it to collect samples from its surface layer. On June 13, 2010, HAYABUSA returned to Earth, thus completing its mission to bring back samples from a celestial body for the first time in the world.

The samples were recovered from the capsule and are being analyzed. Although the retrieved samples are very small, having a particle size of 0.3 mm or less, their composition and mineralogical structure have been identified to verify for the first time in history that the asteroid is a primitive body of the solar system and constitutes a parent body of a meteor.

JAXA issued the first International Announcement of Opportunity (AO) for Hayabusa sample investigation in January 2012. The JAXA AO committee received 31 proposals and selected 17 proposals for sample allocation. Sixty-two samples were distributed to the investigators. The second International AO was released in January 2013. It is expected that the samples will contribute to the further development of planetary physics globally.

HAYABUSA2

JAXA is preparing the next sample-return mission named “Hayabusa2” to be launched in 2014 to another type of asteroid with an expected arrival at the target asteroid in 2018 and an expected return to the earth in 2020.

Learning from the experience gained in the original HAYABUSA, the asteroid explorer HAYABUSA2 will facilitate and secure two-way exploration to astral bodies within the solar system.

HAYABUSA2 faces challenges in new fields of science. Like the original HAYABUSA, it will be a sample-return mission to bring back substances from asteroids of a different kind. The Itokawa

asteroid that the original HAYABUSA explored was an S-type asteroid consisting of rocky substances, but the asteroid called 1999JU3 to which HAYABUSA2 is destined is a C-type that is thought to contain much more organic matter and water.

The organic matter constituting the Earth's oceans and life is assumed to have been present in the interstellar gas that formed the solar system some 4.6 billion years ago. The mission assigned to HAYABUSA2 is to examine the water and organic matter that were present when the solar system was created.

HAYABUSA2's destination asteroid 1999JU3 is, like the Itokawa asteroid, on an orbit that comes close to the Earth's orbit and is roughly globular in shape with a diameter of about 900 meters.

The substances on the surface of the asteroid may have been degraded by solar rays and other factors, so HAYABUSA2 will also try to collect subsurface substances by exposing and gathering them with the collision device in an attempt to obtain substances with the least possible degradation.

ISS (KIBO and KOUNOTORI)

Japanese Astronaut, Akihiko Hoshide stayed onboard ISS from July to November 2012. During the stay, he conducted several medical research on biological effects on astronauts by the long zero gravity flight in space toward the future human space exploration.

H-II Transfer Vehicle (HTV)-3 was launched on July 21, 2012 and docked to the ISS on Jul. 28, 2012 with ISS logistics such as foods, water, and space experiment equipments. Inbound, the HTV-3 loaded by the waste from ISS re-entried into the atmosphere successfully on Sep. 14, 2012. During the re-entry, the i-Ball installed in the HTV-3 measured acceleration and temperature of the re-entrying HTV-3 and took pictures of destructing HTV-3 after released from the HTV-3.

7. Korea Aerospace Research Institute (KARI), Republic of Korea

President-elect Geun-hye Park will be inaugurated as the 18th President of the Republic of Korea on February 25, 2012. President-elect Geun-hye Park has emphasized the importance of science and technology, especially the need to support the early development and completion of the KSLV-II (Korea Space Launch Vehicle II) program as well as the implementation of the following and lunar exploration projects by the 2020 timeframe.

The third attempt to launch the Korean Space Launch Vehicle 'Naro' (KSLV-I) was successfully conducted from the Naro Space Center in Korea on January 30, 2013. KSLV-I inserted the STSAT-2C (Science and Technology Satellite) satellite into a low Earth elliptical orbit. Earlier attempts to launch KSLV-I in 2009 and 2010 subsequently ended in failure and the third attempt had been postponed twice in 2012 due to technical issues.

KARI's next step for its plans for space exploration is the independent development of the KSLV-II launch vehicle, a three-stage rocket with a liquid-fuel 300-ton thrust engine capable of lifting a 1.5 ton satellite into space. The self-developed KSLV-II is tentatively scheduled to be completed by 2021, but the Korea Aerospace Research Institute (KARI) could pull this forward to 2018-2019.

In order to prepare for future space exploration missions, KARI has carried out basic research in various related areas, such as orbiter/lander systems for lunar exploration, science payload systems for planetary exploration, as well as microgravity experiments for ISS utilization.

With respect to satellite programmes, the KOMPSAT-3 (Korea Multi-Purpose Satellite III) satellite, also known as the Arirang-3, was launched from the Tanegashima Space Center of Japan in May 2012. Arirang-3, with its four-year mission lifetime, is providing geographical information of the Earth using a sub-meter resolution camera.

Toward ISS utilization, KARI has been closely working with JAXA to implement a joint space experiment onboard the Japanese Experiment Module (JEM) around 2015. Upon completion of the feasibility evaluation (which was finalized in 2012), KARI has fabricated the prototype experiment payload for ground testing. Based on the results obtained from a series of ground tests, KARI has been updating the prototype experiment payload to comply with the mission requirements.

KARI continues to expand its space programmes further into outer space and strives to become a major player in the future global exploration of space continuously seeking for appropriate partners for international collaboration, in particular through ISECG and GER activities.

8. National Aeronautics and Space Administration (NASA), USA

Exploration Highlights

In 2012, NASA achieved several significant milestones in its ambitious space exploration program, landing the most sophisticated rover on the surface of Mars, welcoming its first commercial cargo mission to the International Space Station, and advancing the systems needed to send humans deeper into space.

NASA successfully placed its most advanced robotic rover yet on Mars. The Mars Science Laboratory mission, carrying the one-ton rover named Curiosity, touched down in August. Curiosity has sent back detailed photos of its landing site at Gale Crater and weather observations, as well as data about the Martian soil. Curiosity included significant international contributions from CNES, CSA, DLR, the Russian Federal Space Agency, and the Spanish government.

Entering into its fourth year of scientific and exploration data gathering, the Lunar Reconnaissance Orbiter (LRO) continues to send back the highest resolution images ever taken of the surface of the Moon from lunar orbit. Lighting and thermal conditions, space radiation measurements, hydrogen mapping, and topography of unprecedented resolution are now being catalogued and used globally to inform future robotic and eventual human missions.

NASA and its international partners celebrated 12 years of permanent human habitation on the International Space Station. To date, more than 1,500 research and technology development experiments have been conducted on this unique orbiting lab, with more than 200 of them conducted in 2012 alone. These experiments are producing advances in medicine, environmental systems, and our understanding of the universe. For example, human research studies have produced results that help astronauts lose less bone density during their long stays in space, which may have profound impacts on health care for the aging population on Earth.

Research on the International Space Station will progress at an even greater pace with NASA's commercial cargo flights which began in 2012. A Space Exploration Technologies Corp. (SpaceX) Dragon spacecraft successfully resupplied the International Space Station with 882 pounds of cargo and returned almost twice that amount back to Earth in October; included were frozen research samples collected on the space station. SpaceX is contracted to fly at least 12 cargo missions to the space station through 2016 that will provide NASA and its international partners with the means to return considerable amounts of research and samples for analysis.

In July, NASA's Kennedy Space Center in Florida welcomed the arrival of the agency's first space-bound Orion capsule, marking a major milestone in the construction of the spacecraft that will carry astronauts farther into space than ever before. In the fall, NASA reached agreement with ESA to use an ESA designed service module for the first Orion test flight around the Moon. NASA and its industry partners around the country also made swift progress on the development of Space Launch System (SLS), the launch vehicle for the Orion spacecraft. The Orion, SLS, and Ground Systems Development and Operations programmes also reached their critical milestones this year, allowing these programmes to move from concept into its preliminary design phase and all remain on target for its first flight in 2017.

Over the course of the year, NASA's science missions continued to explore our universe and beyond and yielded significant and valuable scientific results. Using NASA's Hubble Space Telescope, astronomers announced in December that they had seen further back in time than ever before and have uncovered a previously unseen population of seven primitive galaxies that formed more than 13 billion years ago. In addition, NASA's Mercury Surface, Space Environment, Geochemistry, and Ranging (MESSENGER) spacecraft provided compelling support for the hypothesis that the planet harbors abundant water ice and other frozen volatile materials within its permanently shadowed polar craters.

Finally, in 2012, NASA and the world lost two pioneering explorers - Neil Armstrong, the first man to walk on the moon, and Sally Ride, the first American woman in space. They blazed the trail for many brave men and women who would follow in their footsteps, and they will remain an inspiration for generations of current and future space explorers.

9. State Space Agency of Ukraine (SSAU), Ukraine

Cyclone-4 and Sea Launch Space Projects

Development and manufacturing of the ground complex support equipment in cooperation of the Ukrainian enterprises is currently in progress within Cyclone-4 project. In June, 2012 the first batch of support equipment for Cyclone-4 ground complex was shipped to Brazil. Construction of the major structures of the ground complex and preparation to assembly works continues at Alcantara Launch Site.

In 2012, Sea Launch international consortium in the framework of Sea Launch program performed three successful launches of Zenit-3SL space rocket from Odysseus floating platform, which injected the following spacecrafts into geostationary calculated orbits:

01.06.2012 – SC «Intelsat-19»;

19.08.2012 – SC «Intelsat-21»;

03.12.2012 – SC «Eutelsat-W5A».

Zenit-3SL LV is being developed by Ukrainian Yuzhnoye State Design Office and manufactured by Yuzhny Machine-Building Plant in cooperation with Russian and Ukrainian enterprises.

Radio Astronomy

International RadioAstron Project, initiated by Astro Space Center of Lebedev Physics Institute of Russian Academy of Sciences is, at the moment, one of the most challenging projects in modern radioastronomy and involves 20 countries.

On July 18, 2011 Russian space radio telescope with a 10-m-diameter antenna, which compiles a unified system of ground- and space-based interferometer jointly with on-ground radiotelescopes, was launched into high-apogee (up to 400 000 km) orbit. This system's operation allowed achieving a revolutionary quality in astrophysics exploration of astronomical objects.

Ukrainian RT-70 Radio Telescope (Yevpatoriya, Crimea) with the unique characteristics of 70 m antenna and highly sensitive receiving systems of cryogenic cooling level and operating frequency of 327 MHz, 1,6 GHz, 4,8 GHz and 18-26 GHz is an integral part of the project.

In 2012, implementation of the project's scientific part was commenced. Particularly, in the framework of RadioAstron project 167 sessions have been held using the facilities of RT-70 radio telescope with a total duration of 180 hours, which presents one of the best results among ground-based radio telescopes, applied within the project.

International Space Station

On January 24th, 2012 implementation of an experiment for «Chibis Microsatellite», released from ISS board, started. The set of scientific equipment includes wave-magnetic complex, developed and manufactured in Ukraine.

Scientific information, received from Chibis microsatellite is both to give insight on the principal task – studying of the lightning's nature, and to make an important step towards solving one more issue – examining of the opportunities of earthquakes' forecasting from space. It appears to continue an exploration process, previously conducted by French DEMETER microsatellite. All the data received from microsatellite may be included into «Space weather» forecasting system.

Conferences

The Regional meeting of the International Academy of Astronautics (IAA) in cooperation with the National Academy of Sciences of Ukraine (NASU) and the State Space Agency of Ukraine was held in Kyiv on May 30, 2012, dedicated to priority areas of cooperation in the field of space.

In course of the Regional IAA Meeting in Kyiv attendants discussed the ways of strengthening cooperation between the Academies, identified the directions of practical contribution of Ukraine to the solution of global space issues and signed a Memorandum of Understanding on Prospects and Priorities of Cooperation between the International Academy of Astronautics and the NASU in the Field of Space.

Currently the IAA addresses subsequent attention to the establishment of joint exploration of the Moon and Mars, space settlements on solar system planets, asteroid hazards and others. Ukrainian scientists have made a significant contribution to the space projects. These include: space monitoring and prediction of seismic activity of Earth; disposal of radioactive waste outside the Earth's biosphere; anti-asteroid protection of the Earth; preventing man-made pollution of the near-Earth space etc.

In September, 2012 the National Space Facilities Control and Test Center in Yevpatoriya hosted the 12th Ukrainian Conference on Space Research. It has been attended by participants from the USA, France, Russian Federation, Belarus and Kazakhstan. In the framework of the Conference, opportunities and prospects of Ukraine in astrophysical and cosmological research in current and future space missions have been discussed.

10. UK Space Agency (UKSA), United Kingdom

During 2012, the UK has initiated the following new activities:

- Nuclear isotope production for radioisotope power systems - developing a method of extracting americium-241 from plutonium.
- Developing with ESA a robotics and autonomy facility at Harwell, which when completed will use simulation models combined with field trials to validate autonomous systems for planetary surfaces.
- Developing with ESA an analogue sample curation facility at Harwell, which will provide standard samples to assist in the development of planetary surface instrumentation.
- Membership of the ELIPS (European Life and Physical Sciences) microgravity programme and contribution to the ISS utilisation programme.

In addition the UK continues to strongly support the ESA Mars Robotic Exploration Preparatory programme and is an active member of the ExoMars programme, developing the rover vehicle and science instruments.

The UK is also contributing to the NASA InSight mission to Mars by providing the micro-seismometer.


ISECG
ROSCOSMOS
UK SPACE AGENCY
cnes
CENTRE NATIONAL D'ÉTUDES SPATIALES
NASA
CNSA
CSA ASC
CSIRO
JAXA
isro
esa
DLR