International Space Exploration Coordination Group

Annual Report 2013

INTERNATIONAL SPACE EXPLORATION COORDINATION GROUP

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1 Introduction

The 2013 Annual Report of the International Space Exploration Coordination Group (ISECG) provides an overview of ISECG activities, products and accomplishments in the past year. It also highlights the national exploration activities of many of the ISECG participating agencies in 2013.

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 forum to discuss interests, objectives and plans in space exploration and to support promotion of interest and engagement in space exploration activities throughout society. The work of ISECG results in documents, papers, findings and recommendations that are critical in informing individual agency decision-making. In 2013, ISECG remained focused on working collectively towards the further development and implementation of the GES to facilitate collaborations.
The past year is marked by important milestones in the process of implementing the GES.
In August, the updated Global Exploration Roadmap (GER) was released. It reflects a coordinated international effort to prepare for collaborative space exploration missions. The updated roadmap contains a single reference mission scenario that reflects the step wise evolution of critical capabilities which are necessary for increasingly challenging human space exploration missions, while delivering a wide range of benefits to citizens on Earth.
In September, the document Benefits Stemming from Space Exploration was released reflecting a strong commitment by space agencies to deliver benefits to society. It articulates a shared perspective on the nature and significance of the benefits of space exploration programmes, and on the potential for the future delivery of benefits. The paper describes the fundamental benefits that are expected to flow from investment in the missions and activities described in the GER.
Both documents will aid ISECG participating agencies in engaging relevant stakeholder communities in discussions on how the flow of benefits to society can be further improved.
In November, the ISECG public website was relaunched to enhance communication with stakeholders.
ISECG activities in 2013 continued to facilitate the ability of participating agencies to engage in productive bilateral or multilateral discussions. This will contribute to strengthening the sustainability of an internationally coordinated approach to global 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 the GES through the coordination of participating agencies' mutual efforts in space exploration. ISECG also supports promoting interest and engagement in space exploration activities throughout society.
The scope of ISECG is broad and strategic. Its activities are based on the following principles:
- Open and inclusive
  - ISECG receives inputs from all interested agencies that invest in and perform space exploration activities
  - ISECG provides for consultations among all agencies with a vested interest in space exploration
- Flexible and evolutionary
  - Existing consultation and coordination mechanisms are taken into account
- Effective
  - ISECG workshops and products provide value to individual participating agencies
- Of mutual interest
  - ISECG activities benefit all participants and respect national prerogatives
  - ISECG activities allow for optional participation based on the level of interest

[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.

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. The work is performed through a periodically updated workplan as required by the evolving needs of the participating agencies and the status of the products.

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 CSA assumed chairmanship from JAXA on April 10, 2013.

In order to increase the visibility of ISECG products and to feed the dialogue with exploration stakeholder communities, papers were presented at the AIAA Space 2013 Conference and Exposition, 2013 in San Diego, USA and at the 64th International Astronautical Congress 2013 in Beijing, China.

ISECG meetings at the Senior Agency Management (SAM) level were continued in the past year to ensure timely and effective alignment between strategic considerations of ISECG members and ISECG activities. Senior agency managers reviewed the updated Global Exploration Roadmap and the white paper "Benefits stemming from Space Exploration". They also provided guidance for future work.

The following press release was issued, on April 10, 2013 after the SAM meeting in Longueuil, Quebec:

Senior Space Agency Managers Meet to Discuss Global Space Exploration

Today, the Canadian Space Agency hosted senior representatives from 11 space agencies(*) from around the world for a meeting of the International Space Exploration Coordination Group (ISECG) to exchange information regarding interests, plans and activities in space exploration.

During the meeting, the group discussed the status of exploration planning, how space exploration can generate benefits for life on Earth and continued work to be reflected in the next edition of the Global Exploration Roadmap. The Global Exploration Roadmap reflects the international effort to define, through continued discussion among space agencies, feasible and sustainable exploration approaches to the Moon, near-Earth asteroids, and Mars. It also takes into account innovative ideas and concepts from external stakeholders since the roadmap was first issued in September 2011. The roadmap demonstrates the importance of the International Space Station (ISS) as a first step and a bridge to exploration of destinations beyond low-Earth orbit. The updated version will illustrate planned and conceptual near-term missions, which advance human and robotic exploration starting in the Earth-Moon-system. It is expected to be published in the middle of 2013.

The meeting also marked a change in the rotating chair of ISECG, with the Canadian Space Agency assuming the lead for the coming year.

ISECG is a voluntary, non-binding international coordination forum of the partner agencies who contributed to the Global Exploration Strategy. Member nations share a vision for concerted human and robotic space exploration missions focused on solar system destinations where humans may one day live and work. The partners also work together on strengthening both individual exploration programmes and collective efforts.

(*) In alphabetical order: ASI (Italy), CNES (France), CNSA (China), CSA (Canada), DLR (Germany), ESA (European Space Agency), JAXA (Japan), KARI (Republic of Korea), NASA (United States of America), Roscosmos (Russia) and UKSA (United Kingdom).

4.3 Activities on Working Group Level

4.3.1 Exploration Roadmap Working Group (ERWG)

The Exploration Roadmap Working Group (ERWG) work in 2013 culminated with the release of an update to the Global Exploration Roadmap in August. The updated roadmap reflects an international vision of the next steps in implementing the common human exploration strategy which begins with the International Space Station and extends human presence into the solar system with human missions to the surface of Mars as the driving goal. The updated roadmap contains a single reference mission scenario that reflects the step-wise evolution of critical capabilities which are necessary for increasingly challenging human space exploration missions, while delivering a wide range of benefits to citizens on Earth.

ERWG findings include:
- Near-term human missions in the lunar vicinity and the lunar surface are extremely useful to prepare for future human missions to deep space and Mars. They represent the opportunity for interested agencies to advance capabilities in a way that is consistent with their objectives and long-term interests.
- The ISS plays a key role in preparing for 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.
- Robotic missions provide an important opportunity for obtaining data needed to prepare human exploration beyond low-Earth orbit, while advancing priority science objectives.
- Conceptual missions, such as human assisted sample return, provide a good opportunity to foster integration between human and robotic missions. They show promise for enhancing the return on investment to both the science and human exploration communities.
- The potential for using resources available at the lunar poles should be investigated in order to determine whether they can be used cost-effectively and safely in future human exploration activities.
- Several technology development gaps exist which represent good opportunities for increased investment in order to advance global space exploration goals.

With the release of the updated Global Exploration Roadmap, agencies have discussed opportunities for collaborative stakeholder engagement events. Several workshop or conference events are planned in 2014, including events in the United States (spring), Japan (summer) and Europe (autumn).

Agencies will continue the human space exploration road-mapping work. Planned activities include sharing information on their evolving policies and plans for space exploration as well as receiving feedback from the stakeholder communities on the released version of the GER and reviewing potential impacts on future GER releases. Key objectives for the forward work are to advance the definition of the near-term mission scenario in the 2020 to 2030 time period and to integrate additional agencies in the discussion on the international vision for the next steps in implementing the common human exploration strategy.

4.3.2 International Architecture Working Group (IAWG)

The second release of the GER presents the description of a single mission scenario. In the 2013 calendar year the IAWG was responsible for developing and coordinating inputs relative to this mission scenario. The updates compiled by the IAWG were the result of analyses conducted by multiple agencies and reflected adjustments to current and expected capabilities.

The transportation elements under development, namely the Russian Piloted System, Orion and SLS, are key elements in enabling the ability to conduct desired exploration missions. Evaluating potential missions with these capabilities leads to the emergence of the three mission themes articulated in the GER. The primary mission capabilities to follow the planned transportation elements are:

- Solar Electric Propulsion (SEP) spacecraft and bus
- An Evolvable Deep Space Habitat (eDSH)
- In-space cargo delivery
- Lunar landers (including crew and cargo)

The lunar vicinity is characterized as a reachable destination for Orion and SLS in the near term. The addition of an exploration class SEP system was identified by NASA's proposed mission to robotically redirect a small near-Earth asteroid to cis-lunar space, then send astronauts aboard Orion and SLS to explore and sample. Further expanding capabilities are reflected in the addition of an eDSH as a key part of several mission strategies and are present in the mission themes. The human lunar lander was reassessed to reflect the presence of an eDSH in the lunar vicinity as a staging post which enables surface access. Various agency partner contributions to these elements could take a variety of forms as specifics of the elements continue to be conceptualized in the ISECG.

In portraying the mission scenario, the IAWG has included both human and robotic missions and evaluated multi-destination transportation capabilities, in a framework that has been coordinated by all members of the ISECG.

4.3.3 International Objectives Working Group (IOWG)

The IOWG conducted regular telecons and multiple workshops to complete development of a document on the societal benefits of space exploration. The paper, entitled "Benefits Stemming from Space Exploration", was endorsed by ISECG and released publicly in September, 2013. It articulates a shared perspective on the nature and significance of the benefits of space exploration programmes, and on the potential for the future delivery of benefits. The paper describes the fundamental benefits that are expected to flow from continued investment in the missions and activities described in the Global Exploration Roadmap.

While not intended as the final word on exploration's societal relevance, the paper reflects a strong commitment by space agencies to deliver benefits to society, and will aid agencies in engaging relevant stakeholder communities in discussions on how the flow of benefits to society can be further improved.

The IOWG also reviewed stakeholder feedback regarding the common space exploration goals and objectives that were first developed in 2011 and documented in the initial version of the GER. As a result of this review, the IOWG made some minor adjustments to the goals and objectives, and these were incorporated in the updated version of the GER, released in August, 2013.

4.3.4 Strategic Communications Working Group (SCWG)

In 2013, the SCWG continued support of internal and external communication processes and activities of ISECG.
The ISECG web presence is a key instrument in enabling communication by providing an information platform for all target groups and individuals who are interested in international space exploration efforts. Website enhancements in 2013 started with the relaunch of the ISECG public website in November. In addition to presenting ISECG news and background information, it features a section with frequently asked questions and links to ISECG participating agencies and the ISECG secretariat. It also provides downloads of ISECG publications such as documents and published papers.

Future work priorities include regular webnews and identifying outreach opportunities for consideration by the ISECG plenary.

Annex I

Space Exploration Highlights of ISECG Member Agencies

(In alphabetical order)

1. Agenzia Spaziale Italiana (ASI), Italy

Introduction

The year 2013 has been characterized, by the continuation of the programmes approved during the last ESA Ministerial Council held in 2012 (C/M12, mainly the ExoMars Programme with its two robotic missions to Mars foreseen in 2016 and 2018, 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 PMM, Permanent Multipurpose Module, MoU between NASA and ASI. The MPCV Service Module programme, approved as the European barter element to NASA during ESA C/M12, is another initiative with a major Italian contribution.

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 2013.
- The activities within the Permanent Multipurpose Module, PMM, derived from the MPLM FM1 Leonardo, developed by ASI, through Thales Alenia Space - Italy contract, for NASA, and docked in 2011 to the ISS, are on-going as planned.
- The ESA Astronaut of Italian nationality, Luca Parmitano, has ended his long term mission to ISS (May-November 2013, ISS Increment 36/37).
- The other ESA Astronaut of Italian nationality, Samantha Cristoforetti, is performing training activities for a long term mission to ISS in 2014-2015 (ISS Increment 42/43).
- Two ASI-led Experiments for Green Air, ICE-GA (on innovative fuels having low environmental impact) and DIAPASON (on nano-particles detection), are currently being performed inside NASA Combustion Integrated Rack (CIR) on the ISS in cooperation with NASA.
- Two national scientific programmes, focusing on Space environment effects on life, ended in 2013: GPM (aimed to investigate the effects of micro-g and hypoxia at cellular scale) and LIGRA (aimed to study in depth the theoretical foundations of interactions between gravity and human life and to analyse the effects of micro-g in terms of dosimetry and temporal reversibility)

- Robotics for exploration

- Together with European partners, the activities on ExoMars Programme (Italian Prime Contractorship) are on-going.
- Continuation of the activities on DREAMS, the Italian experiment on board the ExoMars 2016 EDM, Entry, Descent and Landing Demonstrator Module. DREAMS has positively passed all the Project Reviews so far and is respecting the schedule for the integration on board.
- Continuation of the operations, data acquisition and analysis of the Italian instruments on-board Mars Express (MARSIS and PFS) and NASA MRO mission (SHARAD).

It is worthwhile mentioning the successful maiden flight of OSC Cygnus, whose pressurized module was manufactured by Thales Alenia Space – Italy, based on the heritage of MPLMs, Columbus and Nodes pressurized modules.

Upcoming events

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

The 2014 will be characterized by:

- A relevant involvement of Italy in the exploitation of the ISS, thus confirming its relevant role in this endeavour, especially in the scope of Life Sciences, whose importance for Human exploration is evident.
- Continuation of the activities, nationally and within ESA, in preparation for the ExoMars 2016 and 2018 missions. The ESA-Roscosmos cooperation is confirmed and consolidated.
- An ASI Announcement of Opportunity focused on the study of possible Space Exploration scenarios is foreseen.

Conclusion

Italy is still strongly involved in Exploration, both robotics and with the astronauts. Currently the major objectives are 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 2013 CNES has continued to implement the Contract between the French government 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 programme of the Solar System in a renewed governance'. In particular, an increased role for the European Union in exploration matters is foreseen. France has therefore actively contributed to defining the contents of the technological programme Horizons 2020 of the European Union, and notably its part on exploration.

Furthermore, CNES took an active part in the preparation of the second version of the ISECG Global Exploration Roadmap and of the White Paper "Benefits stemming from Space Exploration" which were released in the summer of 2013. CNES is also the key sponsor of the upcoming ASTECH International Space Exploration Conference scheduled to take place in France on October 2014. Furthermore, CNES is involved in the discussions preparing the International Space Exploration Forum to take place in Washington DC in January 2014.

For France, recent significant exploration-related activities are:

<u>Mars robotic exploration</u>

- Participation to EXOMARS (ESA/ROSCOSMOS cooperation):

    * Contribution to the payload of the ExoMars2018 rover

    * Rover vision/navigation expertise

    * Support on EDLS for ExoMars 2016

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

- Contribution to MAVEN (NASA)

- Contribution to the DLR-led MASCOT lander on HAYABUSA-2 (asteroid - JAXA)

- Instrument (SEIS) on the NASA INSIGHT mission

There have also been CNES activities on robotic missions to other destinations: ROSETTA (comet - ESA) - and in particular the Philae lander, BEPI-COLOMBO (Mercury – ESA/JAXA), and JUICE (icy moons of Jupiter - ESA)

Human spaceflight

- Exploitation and utilisation of the ISS:

  * ATV Control Center in CNES premises in Toulouse (notably the docking and re-entry operations of ATV-4)

  * French participation in the ESA ELIPS programme

  * CADMOS: French part of the ISS scientific ground segment

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

  * Material sciences: DECLIC (cooperation with NASA)

- Cardiovascular monitoring of mice: MTB (Mice Telemetry in BION), an experiment on a BION capsule

- Cooperation with China on cardiovascular monitoring (CARDIOSPACE)

- Joint CNES/ESA bed rest campaign at MEDES (CNES subsidiary) to simulate the effects of weightlessness

- Parabolic flights (zero gravity), in particular for astronaut training

3. China National Space Administration (CNSA), China

Introduction

In 2013, China made monumental achievements on the manned space programme and the lunar exploration programme, successfully completed rendezvous and docking between Shenzhou-10 and Tiangong-1, Chang'e 3 safely soft-landed on the lunar surface and Chang'e 3 separated with Rover Yutu on the moon which had started cruising exploration. China is also actively promoting the feasibility study of Mars exploration simultaneously.

Manned Space Programme

According to the "Three step" strategy of China manned space programme approved by the Chinese government, China Manned Space Engineering Office (CMSEO) successfully organized and conducted Shenzhou-10 Manned Space flight mission from 11 June to 25 June, 2013. During the mission, twice rendezvous and docking tests were completed between Shenzhou-10 manned spaceship and Tiangong-1, in particular, once was automatically conducted and the other was manually controlled by the astronaut crew. Besides the R&D, the test of Shenzhou-10's circle flight to Tiangong-1 was also verified. Chinese astronaut crew carried out an amount of space science experiments and technological tests, meanwhile, made an on-orbit space scientific lecture to the students. At the same of the Shenzhou-10 mission, CMSEO also organized the research and construction for the Tiangong-2 space lab mission and Chinese manned space station mission.

In Sep 2013, CMSEO and UNOOSA co-organized the "United Nations/China Workshop on Human Space Technology", in which more than 150 participants from 30 countries participated. The workshop was focused on the following aspects: Human spaceflight and space exploration in the past and future; Research activities in microgravity science and technology; Educational activities in microgravity science and technology; National, regional and international space programmes. The workshop effectively facilitated Human Space Technology Initiative (HSTI) which was initiated by UNOOSA.

In 2013, CMSEO took an active role in seeking international cooperation opportunities, and organized several Chinese-European workshops in the fields of astronaut selection and training, R&D technology, and space science experiments. The discussions during these workshops laid a sound foundation for future cooperation.

The proceeding international projects include:

- Cooperation with ESA on the study of gamma-ray bursts in space (POLAR)
- Cooperation with CNES on Astronaut Cardiovascular monitoring (CARDIOSPACE)

Lunar Exploration

Chang'e 3 lunar orbiter, blasted off on 2 December, 2013, entered the 100km- high lunar circular orbit on 6 December and safely soft-landed in Sinus Iridum on the lunar surface on 14 December. The lunar rover "Yutu" left the lander for mobile exploration which is the first Chinese lunar lander detector for cruising mission. The exploration missions on the moon lander will last for one year regarding the lander and three months regarding the rover.

Up to 24 May, 2013, Chang'e 2 orbiter, launched in 2010, had a record of accumulation flight more than 40 million kilometers, which further validated Chinese deep space exploration technology. Chang'e 2 orbiter carried out the earth-moon Lagrange 2 space environment detection from August 2011 to April 2012 and the asteroid Toutatis No. 4179 flybys probing on 13 December, 2012 after fulfilling its lunar exploration mission.

Development of the lunar sample return mission, Chang'e 5, is also running smoothly based on the schedule.

Mars Exploration

CNSA organized the first feasibility study of the Mars exploration mission and raised the technical proposal for the launching of the first Mars exploration mission in 2018. The proposal includes one orbiter and one rover to develop a comprehensive Martian exploration and regional precision detection. At the 64th International Astronaut Congress 2013 in Beijing, CNSA held a discussion with ESA and ROSCOSMOS for promoting the cooperation on Mars exploration.

4. 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. Space exploration can be a key driver for Canada's future through the creation of jobs, growth and prosperity. It can help maintain our domestic 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 programme areas:

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

Space Exploration Operations & Infrastructure

In 2013, 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 missions: SpaceX-2; JAXA's HTV-4 and Orbital Demo. The MSS also supported Russian and US spacewalks, and accomplished the transfer of cargo from SpaceX-2 and HTV-4.

Canadarm2 and Dextre also performed flawlessly and completed the last session of Phase 1 of the joint CSA-NASA Robotic Refueling Mission (RRM). A second phase is planned for the next year. Working via ground control, the Canadian robotics system relocated several On-orbit Replaceable Units (ORUs) stowed on the ISS external storage platforms, thus freeing up the crew's time to perform valuable science experiments.

Astronauts, Life Sciences and Space Medicine

Veteran CSA astronaut Chris Hadfield landed on May 13, 2013, after a 5-month stay on ISS (Expedition 34/35) and has since completed his post-flight rehabilitation. He retired from the CSA in early July 2013. Canada's two active astronauts, Dr. David Saint-Jacques and Maj. Jeremy Hansen are pursuing their pre-assignment training activities and have been assigned to the Capcom/Training branch at NASA's Johnson Space Center (collateral duties). Both are ready to be assigned to ISS missions and medically certified for ISS duties. They are scheduled to complete MSS robotics training at the CSA in the spring 2014.

The Advanced Astronaut Medical Support group continued work on a medical ultrasound remote-control interface, as well as an astronaut health-monitoring system. Work on the validation of the Performance Readiness Evaluation Tool (PRET) also continued.

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. The CSA currently has three ongoing research activities on the ISS to support this objective:

1. VASCULAR examines the effects of long-duration exposure to weightlessness on the structure and function of the cardiovascular system. The final on-orbit subject session has been successfully completed.
2. BP Reg is a cardiovascular experiment that aims to validate techniques for monitoring cardiovascular health. Three of the eight planned on-orbit sessions have been completed.
3. Radi-N2, a collaborative study with Russia characterizing the ISS neutron radiation environment, will continue on the ISS through Expeditions 37/38 and 39/40.

Microflow, a technology demonstration of a flow cytometer for space, was also successfully completed during ISS Expedition 34/35.

The CSA and the Institute of Aging of the Canadian Institutes of Health Research (IA-CIHR) are developing a formal agreement to support a long-term relationship between space health and aging health research. A National SHARE (Space Health and Aging Research) workshop in 2012 brought together researchers and partners from both fields to identify common challenges and mutually beneficial outcomes. Space induces health changes similar to those of aging: cardiovascular and balance changes, weakened bones and muscles, disturbed sleep, and depressed immune response. Working together, the two organizations will leverage their expertise and facilities (in space and on Earth) to find solutions to common problems faced by astronauts and an aging population. A series of international webinars are being organized in 2013 to prepare for an international SHARE workshop in the future.

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 to 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.

In 2013, the CSA continued to support 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 played 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.

The CSA's OSIRIS-REx Laser Altimeter (OLA) investigation for NASA's OSIRIS-REx New Frontiers mission remained in development through 2013 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.
In 2013 the CSA issued several concept studies to assess potential contributions to future international missions

Astronomy

In 2012-2013, the CSA supported the integration of the Fine Guidance Sensor (FGS) and Near-Infrared Imager and Slitless Spectrograph (NIRISS) instruments to the Integrated Science Instruments Module (ISIM) and the first cryogenic vacuum test campaign of the ISIM of NASA's James Webb Space Telescope, slated for launch in 2018.

The CSA is contributing read-out electronics for the UV detectors on board ISRO's ASTROSAT space observatory (delivered to India in 2010) and is continuing to support testing of the UVIT detectors during the AI&T phase.

Canada also contributed to ESA's Herschel and Planck missions, which continue to provide excellent science since their launch in 2009 and past the end of operations for both satellites earlier this year.
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) was launched in February 2013 and is undergoing commissioning. Scanning the sky near the Sun, NEOSSat will help detect new near-Earth asteroids.

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

Advanced Exploration Technology Development

The CSA's Exploration Core Programme funds advanced exploration technology development. Its 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.

2013-2014 marked the first year of operations for the prototypes developed using accelerated funding from Canada's Economic Action Plan. The CSA focused on the utilization of these new systems in analogue missions and the enhancement of Technology Readiness Level (TRL) for potential future space missions.

To date, five analogue deployments have been completed with the new prototypes to assess concepts of operation for lunar rover missions in unknown natural terrain under realistic communication constraints. In some cases, operations have even been conducted from as far as halfway across the globe. Deployments included: Mars Dome in support of NSERC Canadian Field Robotics Network; the CSA Analogue Terrain in support of NSERC's CREATE Programme; a second deployment at the CSA Analog Terrain controlled remotely from Hi-SEAS (Hawaii Space Exploration Analog and Simulation); tests at a sand quarry in Mercier, Quebec; and a deployment at the Rougemont sand quarry near the CSA's headquarters in Quebec.

In addition, prototypes are being developed to increase the TRL as far as TRL-5 to TRL-6 for some selected applications, including a Rendezvous Navigation Lidar System for Earth orbit maneuvers, a rover Lidar Navigation and Imaging System to enhance future Mars/Lunar rover missions, and a drill for lunar ISRU applications. A rover-compatible TRL-4 Laser-induced Breakdown Spectroscopy instrument is being finalized, and the CSA is investigating a Direct-to-Earth Communication system prototype to enable continuous tele-operation of a lunar rover from Earth.

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

Summary

In 2013, DLR has continued to develop and implement the German Space Programme, based on the National Space Strategy published in 2010. This strategy clearly highlights the focus for human spaceflight on the exploitation of the International Space Station in Low Earth Orbit as well as the argument for scientifically-driven robotic missions beyond LEO. Consequently, DLR together with German research institutions and industry remain strongly involved in the ISS, ExoMars and lunar preparatory activities at ESA level, while complementing this with excellent scientific instrumentation, robotics contributions and data analysis in the National Programme and in cooperation for international exploration missions. In February 2013, DLR opened its new office in Tokio that will facilitate even closer partnership and exchange with JAXA. The following sections provide an update on German exploration involvement, the recent findings and ongoing preparatory work on mission contributions and technologies in Germany.

Human Spaceflight Activities

Through DLR's Space Administration, Germany has reconfirmed its support in the European programmes for ISS exploitation and utilization and continues to define their implementation with ESA and the national institutions. This also includes the expertise and prime role of German industry in the definition of the European Service Module for NASA's Orion Crew Vehicle. The DLR Space Administration, together with ESA, continues to prepare the flight of the European astronaut Alexander Gerst to ISS in May 2014, which will be supported by a strong national research and outreach programme.

In April/May 2013, the DLR Space Administration provided the Omegahab payload on the BION-M1 mission. This is a mini-ecosystem designed to function as a bioregenerative life support system in microgravity, with its own nutrient and gas exchange. In parallel, breadboard activities progressed for physico-chemical and bioregenerative life support systems in German academia and industry.

In July 2013, the annual meeting of the Association of Space Explorers (ASE) assembled more than 50 international astronauts in Cologne, accompanied by an intensive outreach programme that involved media, schools, universities and other institutions throughout the country. This event also framed the inauguration of DLR's :envihab research facility in Cologne which will provide unprecedented capabilities in the fields of life sciences and habitat technology development. Coincidentally, the IAA Humans in Space Symposium was held in Cologne as well, which allowed an intense week of sharing results and discussing future prospects of life sciences research with an international audience.

Robotic Exploration Activities

Concerning robotic exploration, contributions funded through the DLR Space Administration are currently onboard and operating successfully on multiple international missions collecting excellent scientific data:

- The High Resolution Stereo Camera (HRSC) celebrated its 10th anniversary of successfully mapping Mars in 3D on ESA's Mars Express in June 2013.

- The APXS and MIMOS instruments on NASA's Mars Exploration Rover "Opportunity" feature contributions from Germany and continue to work flawlessly.
- Germany has contributed significantly to the development of the radiation detector RAD on NASA's "Curiosity" rover, whose team has published first results from the measurement the radiation levels during cruise and on the surface of the red planet in Science in May 2013.
- German scientists have completed an atlas of the asteroid Vesta in September 2013 based on the imagery from the German Framing Camera on NASA's Dawn mission.

For ESA's ExoMars mission in 2018, the DLR Space Administration is managing the development of the Mars Organic Molecule Analyzer (MOMA) together with teams from NASA and CNES as well as the high resolution camera for the PanCam together with the UK. These important instruments have been tested and demonstrated in field tests like AMASE and SAFER in summer 2013 and successfully passed their PDR in October/November.

In November 2013, the DLR Space Administration also held the first SpaceBot Cup, a national team competition to develop and build a robotic system to handle tasks in a planetary exploration scenario. Ten teams from academia and industry participated with their robotic systems to master a difficult planetary environment parcours with selected manipulation tasks. The innovative concepts will feed into refining German robotics development for planetary exploration.

The DLR research institutes are readying the Mobile Asteroid Surface Scout (MASCOT) lander package for its flight on JAXA's Hayabusa-2 asteroid sample return mission in 2014. After the signature of the MoU between DLR and JAXA in 2012, DLR and CNES confirmed their partnership on MASCOT with a MoU at Paris in June 2013. CNES will contribute one of the scientific instruments on the asteroid lander. Throughout 2013, the technical teams advanced the hardware for the mission and delivered initial test models to JAXA. The flight model integration has started and will be delivered for integration on the spacecraft in early 2014.

At the same time, DLR's Institute of Space Systems is testing and verifying various touchdown scenarios for the Philae lander of ESA's Rosetta mission in the LAMA test facility in Bremen to prepare the 2014 landing on asteroid Churyumov-Gerasimenko.

At the Institute of Space Systems and the Institute of Planetary Science of DLR, technical work for the Heat Flow and Physical Properties Package (HP3) for NASA's Insight Mars mission is progressing. Environmental tests are ongoing and the protoflight model is already being manufactured.

Leveraging synergies and interests from the two research communities of lunar and deep sea exploration, the German research alliance on Robotic Exploration of Extreme Environments (ROBEX) demonstrated how joint work can benefit both space and terrestrial robotics development. In its first year, the alliance that includes several of DLR's research institutes agreed on reference scenarios for both research areas, identified common technical solution concepts and initiated several interdisciplinary design teams for selected technologies or mission aspects.

Other Relevant Space Events

On 22 September 2013, DLR held the bi-annual German Space Day at the DLR site in Cologne. It provided insights into DLR's research facilities and topics, the fleet of research aircraft including the zero-g plane for parabolic flights, as well as the training and operational activities at ESA's European Astronaut Centre to more than 30.000 visitors.

DLR participated actively to the Paris Airshow in Le Bourget in June 2013 and to the Moscow Airshow MAKS in Moscow in August 2013 by showcasing German research and technology activities for partners, interested experts and public visitors.

6. European Space Agency (ESA)

International Collaborations

In January an ESA working group constituted of training and medical managers from the European Astronauts Center (EAC) visited the Astronaut Center of China (ACC) to discuss and exchange on their respective astronaut training approaches. Subsequently a meeting was held between the ESA WG and the China Manned Space Agency (CMSA) on potential cooperation on human spaceflight (Astronauts, Low Earth Orbit (LEO) infrastructure and utilisation).

As follow-up of the on-going development of the European Service Module for the NASA Orion/ Multi-Purpose Crew Vehicle (MPCV-ESM), preliminary joint discussions between ESA and NASA have been initiated to identify options for a possible extension of the cooperation on Transportation Systems for Exploration.

ESA and Roscosmos have signed a document on a joint ISS Utilisation Programme. ESA, Roscosmos and NASA are elaborating a joint utilisation programme of the Muscle Atrophy Research and Exercise System (MARES) facility on ISS.

International Space Station (ISS)/ LEO

The fourth Automated Transfer Vehicle (ATV-4) “Albert Einstein” was successfully launched from the Guiana Space Centre on 5 June with a record cargo of 6600 kg including more than 1400 individual items, water, fuel and gas. While docked with the ISS, it performed six ISS reboosts. Undocking took place on 28 October, ATV-4 and its waste burnt up harmlessly in the atmosphere on 2 November. ATV-5 “Georges LeMaître”, the last of the ATVs, left Bremen harbour on 5 October for a launch in June 2014.

The launch and integration campaign of the European Robotic Arm (ERA) started in Russia during Summer. Due to some issues with internal contamination of fuel transfer lines of the Multi-purpose Laboratory Module (MLM), the ERA launch has been delayed until not earlier than 25 April 2014.

Based on a long-duration flight opportunity provided by the Italian Space Agency, ESA astronaut Luca Parmitano and his two crewmates were launched aboard a Russian Soyuz rocket from the Baikonur Cosmodrome (Kazakhstan) on 28 May. They docked with the ISS six hours later. Together with NASA astronaut C. Cassidy, Luca performed two spacewalks. The second spacewalk on 16 July was terminated due to a water leak in his spacesuit. Together with his crewmates, he is expected to come back on Earth on 11 November. A. Gerst, who is scheduled for a launch in May 2014 and Samantha Cristoforetti, who is scheduled for a launch in November 2014 are completing their training. The European Field Medical Training (FMT), a course designed to provide ESA astronauts with additional training and experience in treating medical problems, has been successfully implemented.

ESA utilisation of the ISS continues with a large number of experimental activities (Human Research: Thermolab/EKE, Circadian Rhythms, Reversible Figures, Space Headaches, DOSIS-3D, Energy, IMMUNO; Physical Sciences: GeoFlow-2b, Materials Science Lab experiments. Radiation: DOSIS-3D, TriTel; Astrophysics: Solar; Technology Demo: Vessel-ID) successfully performed. Various of the human research experiment series in neurophysiology, cardiopulmonary,

thermoregulation have been completed and experiment samples retrieved successfully by the Soyuz and SpX-2 return capsules. Most of the human research and biological experiments 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. A new international Research Announcement for ISS Experiments in Life Sciences will be solicited at the end of 2013.

Lunar Exploration

Following the ESA Council meeting at Ministerial level held in Naples (Italy) in November 2012 where the ESA Lunar Lander mission was not funded, a new approach for lunar exploration has been elaborated, building on a common interest with Roscosmos to join efforts in this area.

Agencies, industries and institutes from both sides have been actively engaged in defining a progressive participation of Europe to the sequence of planned Russian lunar missions, based on the principle of mutual benefit and complementarity in technology and science. The focus is on the Luna-Resurs mission, with a view to Lunar Polar Sample Return. Possible ESA contributions are building on recent European developments, for instance in landing technologies (precise navigation, obstacle avoidance) and subsurface drilling and sampling technologies. The ESA Director General and the Head of Roscosmos signed a Protocol of Understanding on the definition of future ESA-Roscosmos cooperation for the exploration of the Moon, at the Paris-Le Bourget Air Show on 18 June.

Mars Exploration

The major reformation of the ExoMars Programme into an ESA-Roscosmos cooperation was finalised with the signature of the “Agreement between ESA and Roscosmos concerning Cooperation on Robotic Exploration of Mars and other Bodies in the Solar System” on 13 March 2013. The bilateral ExoMars Programme consists of two missions to be launched in 2016 and 2018, respectively. The 2016 mission will carry the ESA-provided Trace Gas Orbiter (TGO) and the Entry descent and Landing Demonstrator Module (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 parallel to the finalisation of the Agreement, 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 its System Requirements Review with pre-development activities on-going on the Rover.

Scientific cooperation between ESA and Roscosmos also started in 2013. At the first joint ExoMars Science Working Team meeting co-chaired by ESA and Russia (IKI), about 80 scientists (20 from Russia) discussed cross-participation in European and Russian instrument teams, and planned joint instrument testing campaigns.

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 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). The MREP Programme period 2 (2013-2017) started after subscription by Member States at the ESA Council at Ministerial level in November 2012.

In 2013, discussions were held with Roscosmos on cooperation on post-ExoMars missions, such as Phobos Sample Return. In addition, discussions re-started in the framework of the International Mars Exploration Working Group (IMEWG) on Mars Sample Return.

Space Transportation

Important progress have been achieved on the International Berthing Docking Mechanism (IBDM) which is a system capable of docking various vehicles with very different masses in the same mission, as required for future exploration undertakings. The design work for the Evolved Engineering Development Unit to bring the system design to System Requirements Review has been progressing, together with the trade-off for the selection of the avionics architecture. Dynamic simulations of various docking cases were completed in support of the International Docking Standard System (IDSS) discussions.

A joint press conference with NASA to announce the cooperation between ESA and NASA on the Service Module of the Multi-Purpose Crew Vehicle (MPCV-ESM) was held on 16 January. Design activities were initiated at the beginning of the year leading to the Preliminary Design Review in November.

Preparatory Activities

As ESA astronauts were working on the ISS, on the ground, ESA's unique training programme for astronauts, CAVES (Cooperative Adventure for Valuing and Exercising human behavior and performance Skills), took place in Sardinia's Supramonte, in September. Six participants spent two weeks deep in caves, in the dark and cold. They were separated from the outside world, doing scientific research and daily tasks together, just like in space.

Significant achievements have been gained with a variety of human research performed in ground-based facilities (Concordia isolation studies with 15 crew members, bed rest studies with the scope of testing nutritional supplements as a countermeasure for the effects of (simulated) weightlessness on the human body). Dedicated research announcements for Concordia and Bedrest research have been solicited on 1 October in the framework of the European Programme for Life and Physical Sciences (ELIPS). ESA also carried out two parabolic flight campaigns with the A300 to perform physical and life science experiments. A suite of Radiation experiments (IBER) have been performed at the synchrotron facility of GSI/Darmstadt within ELIPS.

The study and development of future exploration capabilities continued including the EXPErimental Re-entry Testbed (EXPERT). 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, analyses of alternative launch systems for the EXPERT mission have been performed with US companies and NASA. Different options have been examined and the related preliminary financial and technical data are under analysis.

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 revitalisation 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 Engineering model of the ACLS is under manufacturing and the PDR has been concluded successfully.

Within the framework of a joint ESA/EC project funded under FP7, the kick-off meeting on Additive Manufacturing Aiming Towards Zero Waste & Efficient Production of High-Tech Metal Products was performed with 70 participating industrialists and researchers from Europe and Australia. AMAZE is the biggest project in the world on Additive Manufacturing and is delivering very strategic technology for space and non-space firms.

Operations & Communications Test (OPSCOM) activities continue with the preparation of the second experiment from the ISS where the Eurobot located at ESTEC will be tele-operated. Additional flight experiments of the Network suite are planned for 2014 (stand-alone test of a single Exoskeleton joint, known as Haptic-1 + tele-operating of Eurobot at ESTEC from ISS).

Based on an extended road mapping activity carried out in 2012 in preparation of the Council meeting at Ministerial level, procurement plans of the different R&D programmes related to Exploration Technologies are 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.

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

7. Japan Aerospace Exploration Agency (JAXA), Japan

Asteroid Explorer HAYABUSA2

JAXA is preparing the sample-return mission named “Hayabusa2” to be launched in 2014 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.

Robotic Lunar Landing Missions

For future human Moon and Mars exploration, the development and demonstration of the required technologies are essential. JAXA thinks about lunar exploration as the test bed of those technologies and also obtaining scientific knowledge of Moon. JAXA has been working on the lunar landing explorer SELENE-2, as the lunar explorer programme succeeding the KAGUYA (SELENE) expedition.

SELENE-2 will land on Moon and use a robotic rover to investigate surrounding area, demonstrating accurate safe landing technologies and surface mobility. For long duration observation on lunar surface, night survival technologies are also developed. SELENE-2 will help to solve the mystery of the origin and revolution of Moon and Earth system. It will also contribute to know detailed lunar surface environment such as radiation, temperature, regolith dust, soil mechanics, and prospective lunar resources.

Following SELENE-2, Moon sample and return mission SELENE-3 is planned. Lunar sample from South Pole Aitken Basin, etc will step ahead lunar science.

ISS(KIBO and KOUNOTORI)

Japanese Astronaut, Koichi Wakata has started his 3rd stay on ISS from November 7, 2013. He will be the first Asian Commander of the ISS during the 39th expedition period. Also, during his stay he will conduct several medical researches about biological effects on astronauts by the long zero gravity flight in space toward the future human space exploration.

H-II Transfer Vehicle (HTV)-4 was launched on Aug 4, 2013 and docked to the ISS on Aug. 10, 2013 carrying ISS logistics such as foods, water, and space experiment equipments. Inbound, the HTV-4 loaded by the waste from ISS re-entried into the atmosphere successfully on Sep. 7, 2013.

H-X rocket and Orbit Transfer Vehicle

JAXA has studied concept of new launch system H-X until now. In 2013, this concept was discussed by space transportation system sub-committee in Space Policy Committee, it was decided to start development of H-X launch system since next fiscal year.

In addition, JAXA continued to advance the R&D activities of orbital transfer vehicles to contribute to the space exploration. These include both cryogenic propulsion and electric propulsion, based on the experiences of H2A launch vehicle and Hayabusa explore, respectively.

Investigation of human lunar vicinities missions

Prior to the human lunar landing mission, the mission to the lunar vicinities including Lagrangian point and lunar orbit are potential candidates for human exploration. The mission objectives, system architecture and conceptual system requirement are begun to investigate. The research activities are continue to pursue the required technologies to realize the human Lagrangian mission.

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

In January 2013, the third attempt to launch the Korean Space Launch Vehicle 'Naro' (KSLV-I) was successfully conducted from the Naro Space Center in Korea. KSLV-I inserted the STSAT-2C (Science and Technology Satellite) satellite into a low Earth elliptical orbit

KARI's next step in developing a launch vehicle for space exploration is the independent development of the KSLV-II launch vehicle, a three-stage rocket capable of lifting a 1.5 ton satellite into space. The development of KSLV-II is tentatively scheduled to be completed by 2022.

With respect to future space exploration missions, the feasibility study for the lunar exploration mission will be completed by the end of this year. Concurrently, KARI is carrying out basic research in various related areas such as orbiter/lander/rover systems for lunar exploration and science payload systems for planetary exploration. KARI is also expanding its international partnerships in relation to the lunar exploration mission.

Towards ISS utilization, KARI has been working with JAXA to implement a joint space experiment (cell culturing experiment) onboard the JEM and has completed the MDR/SDR for the experiment. KARI has thereafter been designing the instrument for the experiment.

With respect to satellite programmes, KOMPSAT-5 (Korea Multipurpose Satellite-5), Korea's fourth multipurpose satellite, was launched in August 2013 from the Yasny launch site. KOMPSAT-5 is Korea's first synthetic aperture radar satellite. In addition to the multipurpose satellite missions, a cubesat programme was conducted to provide an opportunity for university students to develop a satellite and to cultivate the interest of the younger generation in space activities.

KARI continues to make effort to expand its space programmes further in space exploration and strives to become an important player and partner in future global space exploration activities.

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

In 2013, NASA continued to make significant progress in space exploration that includes critical scientific and technical achievements from research on the International Space Station (ISS), the debut of a new NASA mission to capture and redirect a small asteroid, the successful launch of a second commercial resupply service provider to ISS, and the launch of new science missions, including the Lunar Atmosphere and Dust Environment Explorer (LADEE) and the Mars Atmosphere and Volatile EvolutioN (MAVEN) missions. LADEE will provide unprecedented information about the environment around the moon and give scientists a better understanding of other planetary bodies in our solar system and beyond. MAVEN is the second mission for NASA's Mars Scout Programme and will obtain critical measurements of the Martian upper atmosphere to help understand how the climate changed over the Red Planet's history.

Scientific accomplishments on ISS continue to increase, as does the quantity of data returned from automated research instruments, and the astronaut crew time dedicated to research. For example, in April, researchers announced exciting Alpha Magnetic Spectrometer (AMS) science results collected on ISS that possibly indicates the existence of either a dark matter particle, or a near-by spinning neutron star (pulsar). In addition, the Center for the Advancement of Science in Space (CASIS) continued to expand utilization of the ISS by the wider, non-NASA-sponsored research community. At the end of September, CASIS saw their first funded payloads successfully delivered to ISS.

In anticipation of future human missions beyond low Earth orbit, NASA continues to utilize ISS to perform human research and test new technologies. This includes studies that were initiated to better understand the causes for vision changes experienced by many astronauts on ISS. Initial studies have indicated that this change in vision could be linked to changes in the way the cardiovascular system handles fluid shifts to the brain from being in space. While critical to astronaut health, understanding the role of the cardiovascular system in these vision changes could also provide information for advanced treatments of cardiovascular disease in certain populations here on Earth. Also, to study the effects of prolonged spaceflight on human health and performance, a yearlong mission involving a U.S. astronaut and a Russian cosmonaut is planned for 2015. In addition, NASA signed a contract with Bigelow Aerospace to test an innovative inflatable module on ISS in 2015. Finally, a 3D printer to investigate the concept of in-orbit fabrication of replacement parts will be tested on ISS next year.

NASA unveiled plans for the Asteroid Redirect Mission that will robotically capture a small near-Earth asteroid, redirect it into a stable orbit around the Moon, and explore it with astronauts launched on Orion and the Space Launch System (SLS). A 40-kilowatt solar electric propulsion system will propel the robotic spacecraft that captures the asteroid. The astronauts will collect samples for return to Earth during Extravehicular Activities. This mission integrates NASA's space science, human exploration, and technology programmes, and it may enable the capabilities needed to extract valuable asteroid resources for use in human exploration scenarios and to defend our planet from potentially catastrophic asteroid collisions.

NASA continues to make steady progress on Orion and the SLS. SLS achieved a major milestone by completing its Preliminary Design Review in July. Equipment to fabricate key SLS elements has been installed and tested at the Michoud Assembly Facility. In preparation for Orion's first flight on a Delta IV rocket in 2014, the spacecraft assembly of the flight test vehicle has begun at the NASA Kennedy Space Center.

System testing is proceeding very well and all avionics have been checked out. In addition, pressure and structural tests of the capsule were conducted. Fabrication of the heat shield has been completed and is being readied for installation on the Orion spacecraft. The adapter ring between the spacecraft and the launch vehicle was also manufactured.

In August, NASA selected a new group of eight astronaut candidates who will help the agency push the boundaries of exploration and travel to new destinations in the solar system.

In October, Orbital Sciences Corporation successfully completed its Commercial Orbital Transportation System (COTS) demonstration mission to the ISS, signaling the end of NASA's successful COTS Programme under which NASA's partners, Orbital Sciences and Space Exploration Technologies Corporation (SpaceX), developed new U.S. rockets and spacecraft to transport cargo to low-Earth orbit and ISS. NASA now contracts space station cargo resupply missions with both companies.

NASA's current science missions are continuing to yield important scientific results. The Curiosity rover continues is successful mission on the surface of Mars as it makes its way to Mount Sharp. The Kepler Space Telescope discovered 833 new candidate planets; since the last update in January, the number of planet candidates identified by Kepler increased by 29 percent and now totals 3,538.

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

Projects

Cyclone-4: During a year Ukrainian enterprises continued works in the framework of Cyclone4 project in cooperation with Brazilian partners. Three shipments of technology hardware for on-ground infrastructure have been provided, and construction works on ground complex facilities and infrastructure continued. At the moment the manufacture and ground tests of launch vehicle units is performed.

Land Launch: On August 31, the Zenit-2SB launch vehicle has been launched within the Land Launch project from Baikonur Cosmodrome, delivering into intended orbit the telecommunication satellite Amos-4. Zenit-2SB LV was developed by Ukrainian Yuzhnoye State Design Office and manufactured by Yuzhmash Machine-Building Plant in cooperation with Russian and Ukrainian enterprises.

Dnipro: Two launches of Dnipro LV have been performed from Yasniy Launch Base (Russian Federation) within Ukraine-Russia-Kazakhstan conversion programme for providing launching services. On August 22, the ERS satellite KompSat-5 has been injected within the programme. On November 21, the launch of 24 payloads was successfully performed by Dnepr LV. All payloads have been inserted into their target orbits.Dnipro LV was developed on the basis of SS-18 ICBM, designed by Yuzhnoye SDO and manufactured by Yuzhmash PA.

Activities

The first Open-Ended consultations on the International Code of Conduct for Outer Space Activities held in Kyiv (Ukraine), May 16-17, 2013, attended by delegations from 61 states.

Ukrainian official delegations took part in and made statements and technical presentations at regular sessions of the United Nations Committee on Peaceful Use of Outer Space and its Scientific and Technical and Legal Subcommittees.

The representative of Ukraine was the member of the Group of Governmental Experts (GGE) on Transparency and Confidence-Building Measures in Outer Space Activities and took part in its three meetings. The result of the GGE's work is the consensus report, which will be presented at the 68th session of the United Nations General Assembly.

The expert of Ukraine took part as a speaker in the UNIDIR Regional seminar "Building Confidence for Eurasian Space Activities through Norms of Behavior", held in Astana (Kazakhstan) in October, 2013.

In July, the 4th Consultations of the representatives of executive authorities of CIS-states have been held in Yevpatoriya devoted to cooperation in the field of space. The goal of the consultations was to discuss further areas for multilateral cooperation extension in the field of space and in the framework of CIS.

In September the National Space Facilities Control and Test Center in Yevpatoriya hosted the 13th Ukrainian Conference on Space Research. In the framework of the Conference the parties discussed capabilities and prospects of Ukraine in astrophysical and cosmological research in current and future space missions.

11. UK Space Agency (UKSA), United Kingdom

A robotics and autonomy facility is being established at the new ESA centre in Harwell, the European Centre for Space Applications and Telecommunications (ECSAT). This facility will use simulation models combined with field trials to validate autonomous systems for planetary surfaces.

A Mars rover field trial – Sample Field Acquisition Experiment with a Rover, or 'SAFER' – was successfully completed in October, with a control team based in ECSAT overseeing a rover in the Mars-like Atacama desert. This demonstrated critical technologies and expertise for remote Mars exploration, using the 2018 ExoMars rover mission as a reference.

Studies continue for an analogue sample curation facility, also at Harwell, which will provide standard samples to assist in the development of planetary surface instrumentation and mission development. The Natural History Museum (NHM) is working closely with ESA to set up this analogue sample collection: initially located at NHM this is planned to be transferred to the Harwell campus in due course.

Work is also ongoing for the development of nuclear isotope production for radioisotope power systems – developing a method of extracting americium-241 from plutonium.

In 2013 the first UK ESA astronaut, Timothy Peake, was assigned a mission on the International Space Station, for launch in December 2015. This is a significant step for the UK and the mission will be used to promote science, technology, engineering and maths education in the UK, and to highlight science which utilises the unique environment of the ISS.

Since January 2013, the UK has been an active member of ESA's European Life and Physical Sciences (ELIPS) microgravity programme. Priority areas for the UK include materials research, biomedicine and astrobiology, and several projects are underway in these fields.

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, providing the micro-seismometer.


ISECG
International Space Exploration
Coordination Group