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Space Exploration: the future as seen in 2015

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Abstract. The space exploration improves our knowledge of the solar system, the origin of life and of the Earth itself. Europe has played a major role in this domain, both in terms of scientific results and industrial excellence.
The Space Exploration pushes on a wide range of technologies and brings innovation in a variety of areas, boosting highly qualified research and investments in high-tech domains. To maintain this high level performance the scientific and industrial actors in the field of Space Exploration must make the best use of the funding available from all sources, including ESA, EU, national and regional programs.

1. Introduction

The first part of this paper highlights the up to date roadmaps of future activities for Space Exploration, at short and medium terms with major impact on the Italian scientific and industrial communities.

The analysis includes roadmaps & programs:

- from ASI and ESA;
- possible cooperation with other Agencies (NASA, ISRO, CAST);
- the EU point of view (H2020).

ASI (Italian Space Agency) roadmap. At the time of writing, ASI had not yet officially published the three year work-plan. ASI holds an excellent heritage for contributing to ESA and NASA planetary missions; it is worth mentioning Cassini, Rosetta, Venus Express, Dawn, Juno, Mars Express, MRO just to quote some notewoth contributions.

Referring to the last ESA Ministerial Conference, ASI subscribed support to the ExoMars program, to Mars Robotic Exploration and to technologies (GSTP-6, TRP). ASI budget 2015 as a contributor to ESA is about 330 Meuro, of which about 80 Meuro for Exploration and Observation of Universe.

Summary of ASI activities for 2015 concerning Planetary Exploration (running):

- Contribution to ESA Cosmic Vision (science & P/L for Bepi Colombo, Solar Orbiter, CHEOPS);
- Contribution to ESA ExoMars 2016 and 2018 missions (science & P/L);
- Technologies for MREP-2;
- Space Debris.

Summary of ASI activities for 2015 concerning planetary exploration (future):

- Contribution to ESA Cosmic Vision (science & P/L for JUICE, preliminary activities for PLATO, possible scientific contribution to the M4 mission to be selected);
- At national level, on December 2014, ASI has issued an invitation to propose new ideas for scientific instrumentation to be used for future missions of observation and exploration of the Universe; the selected

scientific Institutions will start working by mid 2015.

In addition ASI is continuing talks with other major Agencies for Space Exploration, fostering possible cooperation on future programs. Cooperation is aimed with NASA, Russia and JAXA.

ESA (European Space Agency) roadmap. ESA budget for planetary exploration includes funding for:

- Robotic exploration;
- Science (a part of it);
- Technology support and Basic Activities (a small part of them);
- SSA.

The ESA scientific program is the Cosmic Vision. This is the field including the most attracting opportunities for planetary exploration which are:
CV-L (Large) opportunity:

- JUICE mission to has been selected as L1 for a launch in 2022. The payload composition has been frozen, and the mission has been endorsed by SPC; the SRR has been hold on October 2014.

CV-M (Medium) opportunity:

- Solar Orbiter has been selected as M1 .fast track. for a launch in 2017;
- PLATO has been selected as M3 mission, for a launch in 2024. Three parallel definition study contracts are being placed with ADS(UK), TAS(IT) and OHB(DE); the first contractual phase of the study will be completed by end of June 2015. Mission adoption is currently planned in June 2016. A kick-off meeting of the PLATO Consortium activities was held at DLR in Berlin on July 2014.
- M4 mission. The Call for the M4 mission has been issued in August 2014, with 31 Letters of Intent received; 7 LoI have been proposed by Italian scientists. The Call has been closed on January 16th 2015.

CV-S (Small) opportunity:

- CHEOPS has been selected as S1 for a launch in 2017. The PDR at both system and payload level have been hold on Q2/Q3 2014.

The Exploration program includes several missions / activities:

- ExoMars 2016: an ESA mission with an Orbiter named Trace Gas Orbiter (TGO) and an Entry, Descend and Landing (EDM) Mission launched with a Proton rocket. The mission is close to launch.
- ExoMars 2018: a joint ESA/ Roscosmos mission with the ESA ExoMars rover landed thanks to a Descent Module provided by Roscosmos. The Rover will carry a suite of instruments, including a 2-m Drill for subsurface sampling, a Sample Preparation and Distribution System (SPDS) aimed to deliver martian samples to the suite of geology and life seeking scientific instruments in the Rover.s Analytical Laboratory Drawer (ALD). The Russian Surface Platform (SP) will contain further instruments for environmental and geophysical investigations.
  The Italian scientific contribution to ExoMars 2018 is through:
  - the ExoMars Drill unit
  - Mars Multispectral Imager for Subsurface Studies (Ma-MISS), under INAF-IFSI PI-ship; Ma-MISS is deeply integrated in the Drill unit.
- the Mars Sample Return mission; limited contribution from most countries, including Italy, allowing studies and few critical technology assessment.
- next Mars mission; ESA is carrying out studies on a follow up mission to ExoMars 2018, to be flown before MSR. Two possible missions have already been investigated: Phootprint and Mars Precision Lander. Final decision on the roadmap for Mars will be taken at CMIN16.
- Technology development programs relevant to Space Exploration: MREP-2, GSTP and TRP. ESA announced early February that by April 2015 an update of the Technology roadmap for space exploration will be carried out.

ESA is discussing with NASA, Russia, JAXA and China for cooperation on space exploration programs. ESA General Director has highlighted that "the Moon is a key exploration destination of ESA, together with LEO and Mars"; the ESA program in cooperation with Roscosmos foresees the development of some technologies which are enabling for robotic missions, with a focus on the Luna-Resource Lander mission, potentially followed in the longer term by the Lunar Polar Sample Return (LPSR) mission. In addition, ESA vision for the Moon at present includes the development of the European Service Module of the Orion . Multi Purpose Crew Vehicle (MPCV-ESM).

Under the Space Situational Awareness (SSA) program, Europe is acquiring the capability to independently watch for objects and natural phenomena that could harm satellites in orbit or infrastructure – such as power grids – on the ground. To achieve this, ESA's SSA program is focusing on three main areas (segments):

- SST - Space surveillance and tracking of objects in Earth orbit (Watching for active and inactive satellites, discarded launch stages and fragmentation debris that orbit the Earth).
- SWE - Space weather (Monitoring conditions at the Sun and in the solar wind, and in Earth's magnetosphere, ionosphere and thermosphere, that can affect space-borne and ground-based infrastructure or endanger human life or health).
- NEO - Near-Earth objects (Detecting natural objects that can potentially impact Earth and cause damage).

At the C-MIN12, the SSA program received 76 M. for the timeframe 2013-2016; Italy contributes with 8% to the total, in particular for SST and NEO.

Linked to SSA, ESA is proposing the Clean Space initiative. Due to its far-reaching nature, Clean Space is being introduced as a cross-cutting theme within ESA's Technology programs as part of Agenda 2015.

EU and H2020 opportunities for Space Exploration. A review of EU budget, split into thematic area, shows that only few opportunities are relevant to Space Exploration; in details, within COMPET Technology and Science:

- Technologies for European non-dependence and competitiveness (partially);
- Bottom-up space technologies at low TRL;
- Scientific exploitation of astrophysics, planetary & comets data;
- International cooperation in space science.

Other national and regional opportunities for science and Space Exploration.

The MIUR has issued an Invitation To Tender (ITT) on May 30th 2012 with the aim to build up large network of public and private entities involved in thematic which could be strategic for the national industry, including aerospace activities. In replying to the above ITT, the CTNA (National Aerospace Technology Cluster) has issued a proposal (including four projects) which has been approved by MIUR (on December 2012) for funding; the projects are:

- Advanced helicoters (reference company AgustaWestland)
- Technologies for aviation and UAV platforms (reference company Alenia Aermacchi)
- Space projects for innovation (reference company Thales Alenia Space)
- Eco compatible propulsion systems (reference company Avio).

Each project is worth 10 to 12 Meuro. The four projects have been approved by MIUR and should start by mid 2015.

The space project is named **SAPERE** (Space Advanced Project Excellence in Research and Enterprise) and is made of two parts:

- SAFE (Space Asset For Emergency); Earth observation space systems for management support during crisis events;
- STRONG (Systems, Technologies and research for space exploration and access to space); increase the use of VEGA, with development of technologies for electric propulsion; use of IXV Evolution for returning to Earth some P/Ls from the ISS.

Other opportunities for Space Exploration programs could come from Regional funding. This budget, which is in addition to H2020, is provided by the EU to Regions to foster local activities.

The budget is used by each Region in support to the ”Key Enabling Technologies (KET)”. which have been declared by each Region in 2014. A Region which has declared ”space” as one of these KETs is allowed to issue an ITT on some space related thematic.

2. Review of future Selex ES programs for Space Exploration

The second part of the paper deals with the space activities of Selex ES (SES) and, in particular, to its contribution to planetary exploration, from past to future.

Remembering the excellent results gained by Selex ES on Rosetta, both for science and for equipment (attitude control and navigation, solar panels), this paper show the updates on the instruments under development for Bepi Colombo and Exomars 2018 missions.

Selex ES for **BepiColombo** mission. Under ASI contract and MoU between ASI and ESA (with a contribution from CNES), Selex ES is Prime contractor of SIMBIO-SYS (Spectrometer and Imagers for MPO BepiColombo . Integrated Observatory SYStem), (PI: E. Flamini, ASI), which is an Optical Instrument suite made by three instruments: HRIC (High Resolution Imaging Channel), STC (STereo imaging Channel), VIHI (Visual and Infrared Hyperspectral Imager).

SIMBIO-SYS for BepiColombo: **HRC** (Fig. 1)

The HRIC has been designed to perform imaging at very high spatial resolution (pixel scale of about 5 m at 400 km from planet surface) in the visible, thus improving key surface features identification with respect to previous instruments. The HRIC Co-PI is P. Palumbo (Parthenope University of Napoli).

The main tasks of the HRIC are to provide high resolution images of selected Mercury surface features like craters, scarps, lava flows and plains with a panchromatic filter and to help in geo-mineralogical characterization of local surface features by band-pass filters.

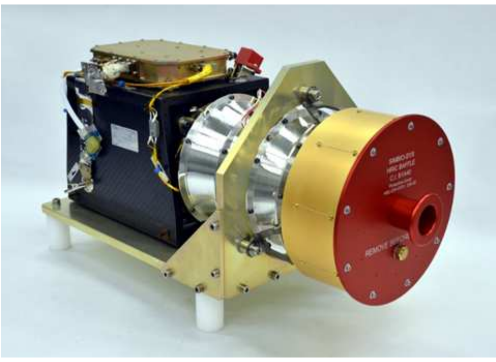

Fig. 1. SIMBIO-SYS HRIC

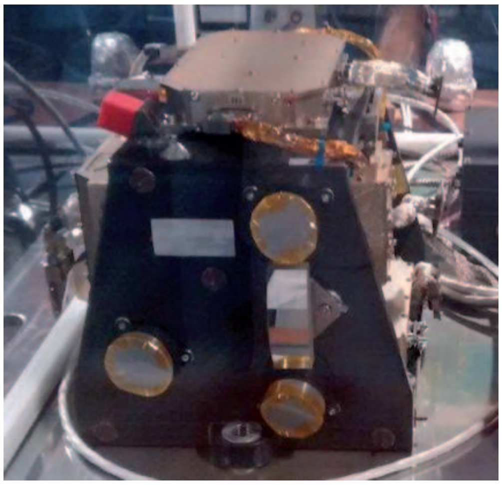

Fig. 2. SIMBIO-SYS VIHI (left) and STC (right)

SIMBIO-SYS for BepiColombo: **STC** (Fig. 2)

The STC is the stereo medium-resolution camera of the SIMBIO-SYS suite, and incorporates two symmetrical optical heads (”subchannels”), designed to obtain high optical quality and SNR performance over their total FOV’s. The STC Co-PI is G. Cremonese (INAF-OAPD).

The main scientific objectives of STC are:

– to map the entire surface of the planet and determine the location, size and height of the major structures. Global mapping pixel

Fig. 3. Ma-MISS OH in the Drill tip

scale shall be 50 m (across/ along track average) at periherm;

- to allow the generation of a global Digital Terrain Model to a vertical accuracy of 80 m (at the periherm on the equator);
- to provide the context for the HRIC investigation.

SIMBIO-SYS for BepiColombo: **VIHI** (Fig. 2)

VIHI is designed to investigate the Mercury surface from a polar orbit to map the physical, morphological, tectonic and compositional properties of the planet (surface geology and stratigraphy, surface composition, regolith properties, crustal differentiation, impact and volcanic processes). The channel is realized under CO-PI ship from INAF-IAPS (F. Capaccioni) with a contribution from LESIA (F).

VIHI is an advanced hyperspectral imager operating in the spectral range 400-2000 nm with 256 spectral channels and 100 m/pixel maximum ground sampling at periherm (400 km altitude over the planetary surface).

Selex ES for **ExoMars 2018** Mission

The contribution of Selex ES to the scientific package of ExoMars 2018 is made by:

- Drill System under ESA contract, for Mars drilling and sample collection up to 2 m depth;
- the spectrometer Ma-MISS (Mars Multispectral Imager for Sub-surface Studies) under ASI contract, PI: M.C. De Sanctis (INAF-IAPS) for in-situ geological and biological analyses of the martian soil (the spectrometer optical head is embedded in the Drill tip).

MA_MISS operates during Drill cutting, permitting soil investigations prior acquisition

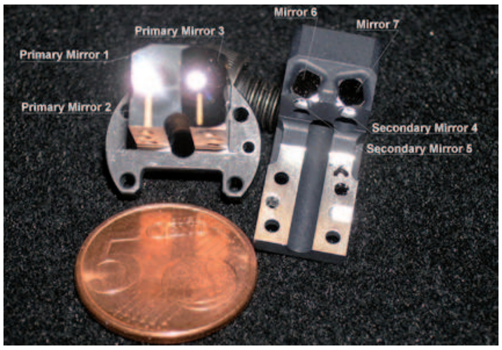

Fig. 4. Ma-MISS OH details

Fig. 5. Ma-MISS calibration lamp

of sample; Ma-MISS performs spectroscopy of the borehole wall in the 400-2200nm range with 20 nm spectral sampling.

The architecture of Ma-Miss requires the miniaturization of its elements for a close integration inside the Drill System, as shown in Fig. 3 to 5. The Optical Head, embedded in the Drill tip, captures the diffused light from the observed target and transfers it to a spectrometer for subsequent analysis.

3. Conclusions

New missions call for a high level scientific investigation, which can be obtained only with innovative instrumentation and adequate technical development. In the current time, with reduced budgets allocated, It becomes vital to secure the necessary funding by fostering all possible opportunities, from national Agencies, ESA, the EU, national and regional programs. The aim of this paper has been to present a wide angle view of possible financing sources for Space Exploration.

In the second part of this paper, Selex-ES has shown its achievements for Bepi Colombo and ExoMars missions, demonstrating its capability to develop new state-of-the-art Electro-optical Instruments, based on a continuous technological improvement in close cooperation with the scientific community following the ASI roadmaps.

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