52nd International Astronautical Congress
1-5 Oct 2001/Toulouse, France

PLANETARY EXPLORATION: RESULTS OF A EUROPEAN SCIENTIFIC CALL FOR IDEAS

Didier Schmitt[1], Marcello Coradini[2], Oliver Angerer[1]
European Space Agency
[1]ESTEC, MSM-GAL, P.O. Box 299, 2200 AG Noordwijk, The Netherlands
didier.schmitt@esa.int, oliver.angerer@esa.int
[2]ESA HQ, SCI-C, 8-10, rue Mario-Nikis, 75738 Paris Cedex 15, France
marcello.coradini@esa.int

Abstract

In preparation of a proposal for a European long-term programme for robotic and human exploration of the solar system bodies, an Exploration Scientific Experts Group (ESEG) has been appointed. ESEG was charged with the definition of the scientific rationale for the programme proposal. To give input to this experts group a call for ideas was issued in ESA member States. A total of 291 ideas (describing a long term vision and short term initiatives) were received. The scientific reasons for exploring the Solar System, which came out of the call for ideas, were analysed and further detailed by the ESEG members.
In order to translate the scientific goals into mission scenarios and to identify enabling technologies a workshop on "Robotic and Manned Exploration of the Solar System" was organised.

Background

The European Space Strategy developed by ESA together with the European Union includes as important mandates to "…explore the Solar System and the Universe…" and to prepare "… for the "next step" in human space exploration: the exploration of the Solar System.". Also the ESA Council's Long-term Space Policy Committee's recommendations and action plan include the exploration of the Solar System. To meet these mandates the development of a new programme proposal for planetary exploration, now designated "Aurora" began in the end of 2000. To prepare the scientific rationale an Exploration Scientific Experts Group (ESEG) was established. This group was composed of 15 experts from a variety of scientific fields, all of which are relevant to planetary exploration. To support this group a call for ideas was initiated in February 2001.

Call for Ideas- Statistics

Despite the fact that only one month was allowed from first issuing to deadline almost 300 ideas were received. About one third of the scientists who submitted an idea heard about the call for ideas from colleagues or through other channels. Thus one side goal, to try and also reach parts of the scientific community that has no prior space involvement, was achieved.
The scientists were asked to estimate the level of co-operation they would foresee in the realisation of their ideas, on the level of laboratories as well as

on the level of countries. On average five laboratories in three to four countries were predicted. This shows a very positive trend, which might be special to this multidisciplinary and challenging field of planetary exploration.
Table 1 shows the five countries in which most of the ideas originated.

Table 1: The five countries with the highest number of submission to the call for ideas

Country	Submissions
Germany	56
France	53
United Kingdom	50
Italy	34
Canada	23

The high number of submissions for Canada (as associated member of ESA) is due to the fact, that the call for ideas was co-ordinated with the Canadian Space Agency, who were conducting a similar exercise at the same time.

Call for Ideas- Content

As the call for ideas had been formulated in a very broad way, addressing every scientist from any field of research, the ideas that were submitted touched a lot of different subjects, often more than one topic was addressed in one submission. That is why numerical classification might be somewhat misleading. Some clear trends could be recognised though.
More than one third of all submitted ideas covered aspects related to human spaceflight. Those aspects would be physiological changes in long-term spaceflight and countermeasures, psychological considerations and (advanced) life support systems. This large share is a clear indication, that future planetary exploration is seen as, eventually, human exploration.
For the rest of the scientific ideas, the overall topic of the vast majority of submissions was Exo-/Astrobiology. This extremely interesting and currently very popular field encompasses many disciplines like microbiology, geology, biochemistry, comparative planetology and many more. All of the fields are linked together by the search for the origin, evolution and distribution of life.
About 150 ideas were related to the exploration of Mars. The fact that Mars experienced through a long time period conditions similar to Earth and the relatively good accessibility of Mars make it a prime target for exobiological research.
The second planetary target of interest was Jupiter's moon Europa, who is believed to have a liquid salt water ocean underneath its ice surface. As water is essential for life as we know it, this makes Europa another valuable target for Exobiology.
Also great interest was expressed in Near Earth Objects (NEOs). These asteroids hold only moderate promise for exobiology (especially compared to the two previously mentioned bodies). Here, the interest is based on the fact that the trajectories of NEOs often cross Earth's orbit, thus posing a potential threat to life on Earth. More knowledge is needed in order to assess this threat and develop strategies for protection.
Though the purpose of the call for ideas was to define the scientific interests in planetary exploration some ideas covered also more technical ideas. These were mainly related to In Situ

Resource Utilisation (ISRU) and Rovers/Robotics.
Using the information from the 'call for ideas' and taking into account already existing ESA programs to avoid duplication, the ESEG formulated a number of key scientific questions:

- **Search for extraterrestrial life forms**: To look for and hopefully find life (extant or extinct) in locations other than Earth would fundamentally change our understanding of life, its evolution and our place in the Universe.
- **Search for biomolecules**: Connected to the above question, the search for biomolecules can further our understanding of the distribution of the building blocks of life, as one of the prerequisites for the development of life forms.
- **Where is the water?**: As far as we know today water is essential for the development of life.
- **Identification of favourable conditions for life**: More general than the previous question this does not only improve our knowledge about influences on our own evolution, but also allows us to pick more promising planetary targets for further investigation of the first question.
- **Dynamically new comets**: Comets are still among the lesser known objects in our universe. They are valuable in providing clues to the formation of the solar system and might have played a role in the delivery of biomolecules to our planet.
- **Characterisation of minor bodies**: Though the planets of the solar system are certainly interesting, their various moons and other smaller objects are important to complete our understanding of the solar system and the origin and evolution of life. Some moons seem to offer better conditions for possible development of life, than many planets.
- **Role of the environment on life/living matter**: Various environmental influences (different gravity levels, radiation etc.) play a role in the development and evolution of life that is not yet well understood.
- **Scientific preparation for future supporting human missions**: Sooner or later humans will expand beyond Earth and the low earth orbit again, and at least in the beginning scientific objectives will be a key driver. Many difficult problems exist, though, with regard to life support, medical and psychological issues that have to be solved before sensible human exploration missions can be conducted.
- **Planetary protection**: This expression usually refers to measures to avoid contamination of other planets (or samples thereof) and also of the Earth. As a second meaning the protection from possible cometary or other impacts is included under this point.

Workshop

On the 3rd and 4th of April 2001 a workshop on Robotic and Human Exploration of the Solar System was held at ESTEC in the Netherlands, in order to bring together and harmonise the scientific considerations with the technological side of the programme proposal.

For the discussion the scientific objectives were condensed to two main points:

- Search for life outside Earth: Signs of prebiotic chemistry, and extinct or extant life in the solar system.
- Evolution of planetary environments conducive to life

The missions to study these two general scientific objectives would be very different in complexity depending on the target for each specific mission (e.g. Planets/minor bodies/dust). A synergetic philosophy between in situ analysis and sample return was highly recommended because it was argued as the most productive.

In the case of Mars a logical sequence of missions was elaborated, with the first phase aiming at the global mapping (from orbit) of the planet. This could give better information, for example, on geochemical composition (for ISRU) and would help identify suitable landing sites for follow-up missions. In-situ analysis missions on and below the surface were seen as the next step. Here the preference lay clearly on multi- site analysis with limited mobility in contrast to single-site missions with more mobility but less versatility. Multi-site in this discussion referred to tens of landers (30- 50). Thus even relatively simple instruments could provide great scientific returns. This would allow for sensible sample return missions, which would be well targeted into a scientifically promising geological/ geographical area (which was identified through the previously mentioned phases). Finally - as a side effect of the scientific research – enough data would be collected so that essential information needed for human missions (about hazards, survivability etc.) would be available and would help again to select landing site(s), help define mobility requirements, influence habitation module design and so on to make the best use of the human missions aimed at scientific research.

This self-contained approach may, in part, be applied to other planetary bodies.

A few other important issues were also discussed.

Planetary Protection was a topic of major interest and importance. A common European Planetary Protection Policy should be developed and planetary protection guidelines must be followed for every planetary exploration mission (even orbiters, so as to safeguard against adverse effects of crashes).

Connected to this issue was the call for a sample curation/ sample handling facility. Such a professional, dedicated facility would protect against contamination of the samples and of Earth and enhance the scientific value.

The very high interest in the general public with regard to planetary exploration was the basis for the recommendation to develop significant outreach and public awareness activities ('from kindergarten to universities').

Antarctica was mentioned several times as a very important analogue environment for exploration, with respect to human issues (e.g. psychology) as well as for certain technologies, like those needed for Europa missions. Altogether the use of ground-based simulations and analogue environments on Earth, but also specific robotic precursor missions will play a major role in the preparation of future human missions.

The Current Programme Proposal

The process described above lead to the main goals formulated in the programme proposal:

- To prepare the technologies for the expansion of human presence in the solar system
- Search for extraterrestrial life and its precursors
- To investigate threats to human life from space (NEO)

Mars is the primary target for future human missions. In preparation of those missions many issues of survivability have to be tackled, like radiation protection, psychological reactions to isolation and confinement in long-duration spaceflight, advanced life support systems etc. Earth based analogue environments, the International Space Station as well as robotic precursor missions will be employed to find solutions to those problems.

A matter of extreme importance for any exploration mission is planetary protection. Avoidance of forward contamination (terrestrial microorganisms to other planetary bodies), back contamination (possible alien microorganisms brought back to Earth) and sample contamination (in-situ or on Earth) must be assured before missions are planned and conducted.

Planetary exploration is a topic that motivates and excites a wide audience. A special effort in public awareness and outreach activities is foreseen to accompany the programme.

Technology development will at first focus on areas where Europe lacks experience or that play a key role in exploration and have a significant spin-off potential. Such technology areas are for example:

- Entry , descent and landing
- Micro- avionics
- Alternative power generation
- Propulsion
- Robotics

The Aurora programme proposal will be submitted for decision in November 2001 at the Ministerial Meeting of the ESA Member States. If approved the envelope programme will commence with a three-year definition phase where mainly studies will be conducted to further define the programme content and future missions. After this initial phase Aurora will start a programme with steady budgets for 5-year periods, to ensure planning stability with a maximum of flexibility. During the regular conduct of the programme the definition component will continue, to explore and define new projects/ missions. It will be supplemented by a development component, where actual hardware will be built and missions conducted. Two categories of missions are foreseen: 'Flagship' missions shall enhance the European capability toward human planetary missions while providing significant scientific return. They will be complemented by 'arrow' missions, smaller, cost-capped missions with a more flexible selection process and limited development time (for example technology demonstration missions).

If approved in November, Aurora will pave the way for Europe to play a major role in the exploration of our Solar System.