IAA Study Group Status Report

Responsible Commission: V

Study Number and Title: Study Group 5.12

Dynamics of space exploration activities and outlook

Short Study Description (repeat from Study Group Proposal):

The objective of the International Academy of Astronautics (IAA) Cosmic Study "Dynamics of Space Exploration" is to compile a comprehensive space policy report on the recent developments and trends of the domain of space exploration. A new vision for space exploration has to be bold, collective, holistic, paved with realistic milestones shared by the stakeholders and conceived in a sustainable manner. A new value proposition for space exploration should be pursued such as measuring the scientific, technological, economic and cultural benefits for humankind. The goal is to develop a common integrated space vision. This common space vision could be implemented in the future by an international Space Exploration Council that acts as an efficient planning and decision-making body and unites a number of stakeholders from governments, space agencies, space entrepreneurial entities, the aerospace industry, the scientific community, and civilian society from all spacefaring countries. It will present a synergistic approach with a top down structure supported by bottom up activities of science/technology analysis and space architecture working groups. In this IAA Cosmic Study we identify challenges and opportunities in order to align space stakeholders nationally and internationally and discuss how an international Space Exploration Council could reconcile the interests of "individual" countries and private pursuits.

Progress in past six months:

Prior to 26 September 2014, the following text material has been added for several chapters, particular Chapter 3:

- 3.2/3.3 Destinations: Moon, Mars (updates)
- 3.4 NEO research: additions of ARM project
- 3.5 Extension of chapter in the explorations activities on the International Space Station
- 3.6 Other destinations: Update
- Inclusion of the recommendations of the new NRC report on Human Spaceflight

Since early February 2015, the contributors have been asked to deliver by the second half of April updates to the following sections:

2. Changing space exploration context

2.1 *The History of space exploration*: Quantify when possible the total costs for the first steps in space exploration and compare them, for instance, to aggregated R&D budgets or to big science equipment's costs on the same period.

2.2 *Changing space exploration context: Geopolitics*: Need to expand much more on China, India and Japan with further quantitative information such as budgets, results, next missions. Since this is under a geopolitics heading, we have to evidence the role of space for these countries in supporting their geopolitical stance. An update on the upcoming high-level space exploration conference to be held in Japan in 2016 will be provided if already some details will be available in advance. S. Plattard, N. Peter and K. Suzuki will contribute.

3. Sciences drivers for exploration (per destination)

3.1 *The Moon*: sub section to be enriched and more detailed. It is perceived as being relevant to have also an additional table giving details on the 2015 missions and beyond, including estimated budgets. Page 9, § 1, 2, and 3 of the current version, "pursuant to the current developments", need to be detailed. For instance the Google X-Prize whose deadline has just been postponed to 2016 shall be developed further and updated.

3.2 *Mars*. Update will include results of Curiosity's investigations together with the first results of MOM and MAVEN. The presentation and expected results of the upcoming Mars missions planned until 2020 will be increased.

3.3 *The Martian Moons Phobos and Deimos:* Is a reflight of Phobos-Grunt scheduled?

3.4 Near *Earth Objects (NEOs)*. A detailed update on the NASA's ARM project is needed, and should cover a description of the maturity of the project, funding, launch date, etc. Even if no final decision is made at the completion time of the Study. Hayabusa 2 will also require some update. A summary of the first Rosetta-Philae results, including those recently published in Science, will be presented.

3.5 Low *Earth Orbit (LEO)*

Concerning the ISS we have to come with an appreciation on the 2024/2020 issue (2028?) and the announcement of the new Russian plans to split ISS in 2024. An outline of the planned experiments up to 2020 is required, refreshing on the rationale that lead to such a selection of experiments. Considerable expansion on the section devoted to Shenzou and Tiangong is expected, including future plans for Chinese human LEO activities until 2030. The possibility for European astronauts to fly on a Chinese space station should also be exposed.

3.6 Other *Destinations - Cis-lunar Space*

In the different listed areas of potential activities (human research, life science, planetary science, astrophysics, heliophysics, Earth science, and asteroid redirection), projects

under development will be identified and their expected completion date. Need to expand on concrete projects and associated time-lines.

4. Dynamics of Exploration

4.1 *Robotic Exploration*

Technological challenges to come that will be central to enhancing space exploration capabilities will be developed so that the reader has a sense of what those challenges really are. This does not show clearly in the current version.

4.2 *Human Spaceflight*

Developments and achievements obtained with the ISS will be detailed. In a similar manner the Chinese LEO human activities deserves a much longer development. The section on the private initiatives will be expanded with an evaluation of the maturity of their progress; for instance for Mars One.

P. Ehrenfreund, as member of the NRC Human Spaceflight Committee, will summarize the main findings of the report published in 2014.

4.3 *Technology Roadmaps*

Technological roadmaps and exploration scenarios have been presented by ISECG and other technical fora. Yet, for this report, it would be worthwhile to pick one of them and present it in some detail to the reader. In particular what is the approach followed in building up some technological bricks that can benefit to more than one programme.

4.4 *Access to space*

We will indicate, for a range of exploration missions, manned or robotic, the type of launch capacity needed, just to be more specific.

For USA, Europe, Russia, China, India and Japan, detailed updates are expected such as the Orbital Antares issues, Orion success, SLS progress, Space X developments. First success of the Russian Angara, Zenit upgrade for heavy launch. More on China since this country plans to play a leading role in space exploration. Expand as much as possible on the heavy lift Long March series. For Europe, the Ariane 6 decision and the termination of Ariane 5 ME undergoing project will be acknowledged. These decisions will remove Europe from the very heavy lift track for exploration, leaving it to the US, Russia and China only. The strategic consequences on the European stance on exploration will be presented. Success of Indian GSLV Mark III launch should also be recognized and more said on the Indian timetable for conducting its heavy launcher programme.

5. Legal and policy regime for exploration

5.1 *International Space Treaties*

Issues that will need some clarifications in the interpretation of the mentioned treaties will be presented.

5.2 *Multilateral non-binding initiatives in space sustainability*

The first and the second initiatives presented are still under development. An update about the draft on the code of conduct on outer space activities which is still open for comments and suggestions will be brought in. Furthermore, the LTSSA initiative within the UNCOPUOS is still under progress and should lead to a final report in 2016. A description of the ongoing process will be made. A more explicit presentation for the reader will be made as to how these non-binding recommendations may impact space exploration.

5.2 *Legal Issues: Planetary Protection and Stewardship*

A *modus operandi* will be outlined on the "need to begin to develop an international consensus on these issues in order to eventually have a set of coordinated national laws to carry out international guidelines and rules".

6. Emerging challenges and opportunities

6.1 United Nations support for space exploration

The Human Space Technology Initiative (HSTI) will be explained in more detail with a view on its planned activities.

6.2 *Support and cross-interaction of national and international bodies.* To be written

6.3 *Political decision makers.* To be written

7. Conclusion and recommendations

This section will be expanded presenting more concrete details about the different schemes under consideration. All contributors are welcome to enrich this section.

Website Study Information up to date? (Study Group Membership, Study Plan and Schedule):
No. See below regarding the updated list of contributors

Issues requiring resolution? (recommend approach)

s

Product Deliveries on Schedule? (If modified explain rationale):

Still need to clarify some issues, see this page. The study should be completed by the fall of 2015.

Study Team Member Changes? (List any Study Team Members that you wish to discontinue, and provide names plus contact coordinates of any Members you wish to add on the second page of this Study Update form.) Note: Complete contact information including email, tel. and fax must be provided for all additions. Only Members with complete contact information will be listed and receive formal appointment letters from the IAA Secretariat.)

Name of person providing Study Group Status (Study Group Chair or Co-Chair):

Please note that as of 23 January 2015, Serge Plattard is now the Chair of this Study, Pascale Ehrenfreund the Co-Chair, and Nicolas Peter the Secretary. Although Nicolas Peter was the initial Study lead, being still not a correspondent member/member of the IAA, he was not entitled to ensure formally this position.

Status Report Date: March 9, 2015

Study Team Membership Changes

Effectivity Date:

Discontinue:

Name: Grimard, Max

Name: Rummel, John D.

Updated list of contributors (18):

Name: Ehrenfreund, Pascale

Name: Hertzfeld, Henry

Name: Horneck, Gerda

Name: Logsdon, John

Name: Lupisella, Mark

Name: Mackwell, Steve

Name: Masson, Jacques

Name: Masson-Zwaan, Tanja

Name: Patrick, Michel

Name: Peter, Nicolas

Name: Othman, Mazlan

Name: Plattard, Serge

Name: Reed, Cheryl

Name: Saccoccia, Giorgio

Name: Suzuki, Kazuto

Name: Ulamec, Stephan

Name: Ventskowsky, Oleg

Name: Westall, Frances