Space Strategic Research Clusters in Horizon 2020

ESSC-ESF Recommendations

European Science Foundation (ESF)

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The European Science Foundation hosts six Expert Boards and Committees:

- The European Space Sciences Committee (ESSC)
- The Nuclear Physics European Collaboration Committee (NuPECC)
- The European Marine Board (EMB)
- The European Polar Board (EPB)
- The Committee on Radio Astronomy Frequencies (CRAF)
- The Materials Science and Engineering Expert Committee (MatSEEC)

In the statutory review of the Expert Boards and Committees conducted in 2011, the Review Panel concluded unanimously that all Boards and Committees provide multidisciplinary scientific services in the European and in some cases global framework that are indispensable for Europe's scientific landscape, and therefore confirmed the need for their continuation.

The largely autonomous Expert Boards and Committees are vitally important to provide in-depth and focused scientific expertise, targeted scientific and policy advice, and to initiate strategic developments in areas of research, infrastructure, environment and society in Europe.

European Space Sciences Committee (ESSC)

The European Space Sciences Committee (ESSC), established in 1975, grew from the need to give European space scientists a voice in the space arena at a time when successive US space science missions and NASA's Apollo missions dominated space research. More than 35 years later, the ESSC actively collaborates with the European Space Agency (ESA), the European Commission, national space agencies and the ESF Member Organisations. This has made ESSC a reference name in space sciences within Europe.

The mission of the ESSC today is to provide an independent forum for scientists to debate space sciences issues. The ESSC is represented ex officio in all ESA's scientific advisory bodies, in ESA's High-level Science Policy Advisory Committee advising its Director General, it has members in the EC's FP7 space advisory group, and it has observer status in ESA's Ministerial Council. At the international level, ESSC maintains strong relationships with the National Research Council's (NRC) Space Studies Board in the US.

The ESSC is the European Science Foundation's (ESF) Expert Committee on space sciences and the ESF's interface with the European space community.

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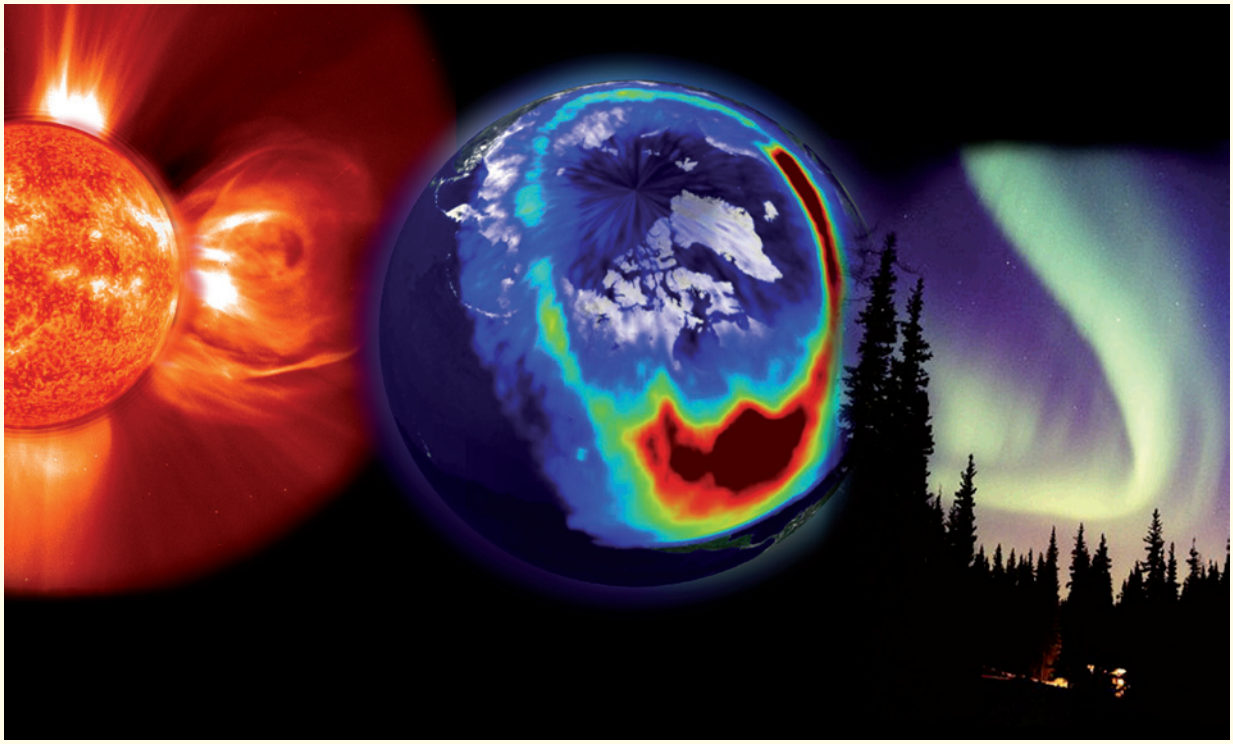

Figure 1. The three most visible elements of space weather: a storm from the Sun, aurora as seen from space, and aurora as seen from the Earth. Left: a coronal mass ejection as seen from SOHO. Middle: charged particles as they spread down across the atmosphere during a large solar storm event on 14 July 2000. Right: Aurora display in Alaska. Credit: NASA

1. Space Situational Awareness – Space Weather:
An integrated approach to space weather data and systems. Goal: understanding solar activity impact on the Earth and its environment to a level allowing prediction

2. Scientific Research Enabling Human Space Exploration:
- To further study the effects of long duration space flight and simulations on crew health and performance
- To further develop efficient countermeasures and to facilitate post-flight re-adaptation to the terrestrial environment

3. Astrobiology and Planetary Protection:
An integrated approach to space analogue sites that encompasses life in extreme environments, planetary protection aspects and 'Search for Life' research

4. Space Data for Climate Models:
To develop well-calibrated space data with quantified uncertainties to be used to initialise, constrain and validate climate models

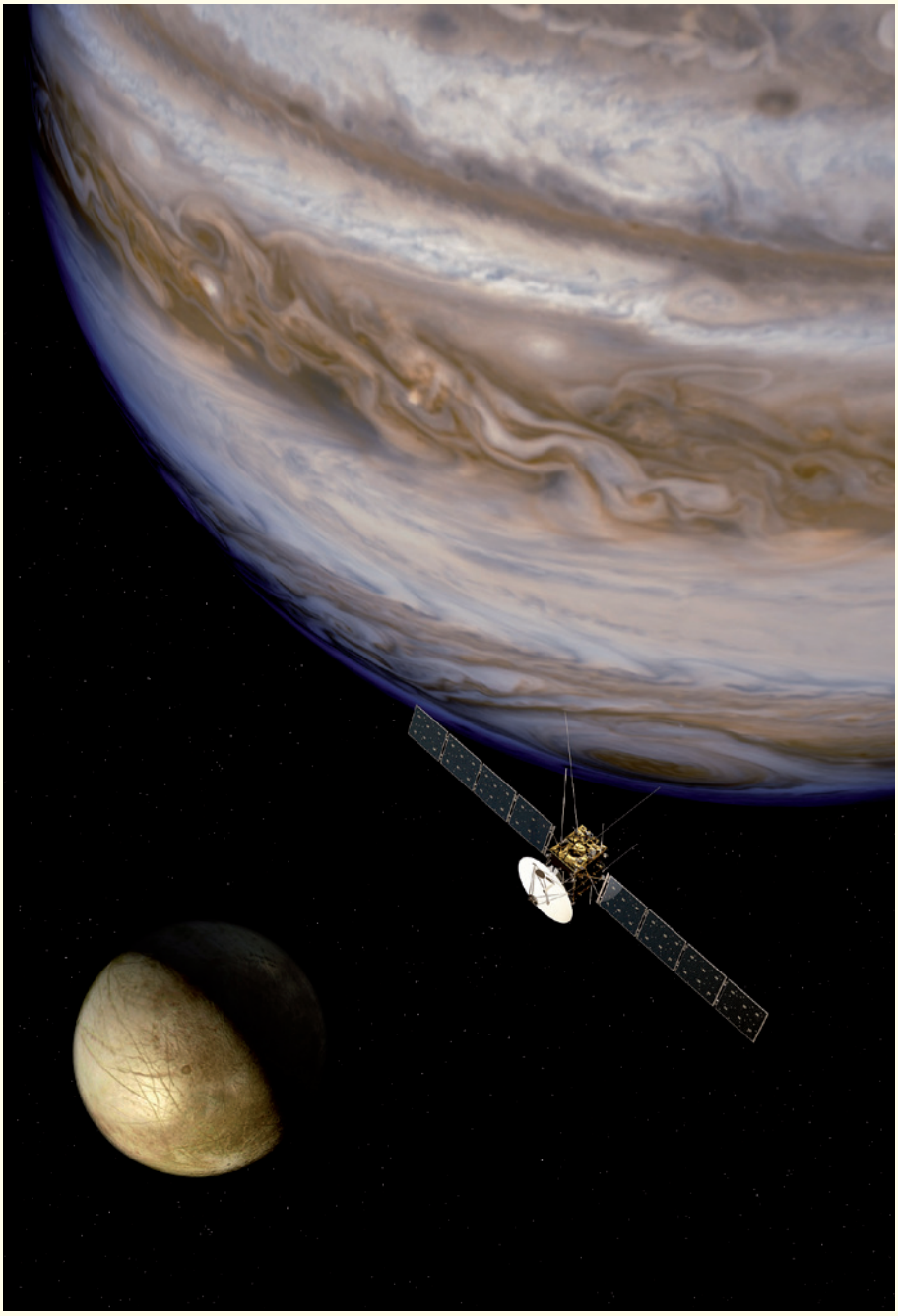

Figure 2. Artist impression of ESA's Jupiter Icy Moons Explorer. Credit: ESA

Additional Issues:

- *Advanced propulsion:* An enabler for science and industry and a cornerstone for space science and exploration
- *Small satellites and Cubesat development:* Small satellites, Cubesats and other similar initiatives were identified as a popular topic amongst the European space sciences community
- *Technology Development:* Low Technology Readiness Level (TRL) development funding is a worthy and important goal that the community strongly supports

Overarching Issues:

- *Data exploitation:* To improve framework conditions, manpower and infrastructure for space data preservation and exploitation
- *Sustaining (ESA) missions related large communities:* upstream and downstream support to mission teams and/or networks

1.
Background

The mission of the European Space Sciences Committee (ESSC) of the European Science Foundation (ESF) is to provide an independent voice on European space research and policy. It is the ESF's expert body on space research and provides advice to ESA, the European Commission (EC) and the national space agencies. The ESSC, established in 1975, grew out of the need for a collaborative effort that would ensure that European space scientists made their voices heard on the other side of the Atlantic, in an era when successive Apollo and space science missions had, for the first time, propelled the idea of space exploration into the collective consciousness. Today the ESSC is represented *ex officio* in ESA's science advisory bodies and at ESA's Ministerial Councils with observer status and has been providing expert advice to the EC and European space stakeholders since 1992. The ESSC has a permanent relationship with the Space Studies Board (SSB) of the US National Academies – National Research Council. The Chair of the SSB is an *ex officio* member of the ESSC.

As far as the EC is concerned, specific recommendations have been provided concerning the space sciences content of the Framework Programmes 5, 6 and 7. The ESSC has also provided input regarding the content of the 8th Framework Programme, outlined in its report to the EC in March 2011.[1] The present document offers further input to the discussion for the definition of the new instruments within the Horizon 2020 Space Programme, and in particular for its Strategic Research Clusters (SRCs) concept.

As currently envisaged, SRCs have long-term objectives that fall within the time frame of H2020 and are to be realised by the end of the Framework Programme. An SRC will require coordinated action amongst smaller projects in order to achieve the envisioned outcome. The topic of an SRC should contribute to the competitiveness and the non-dependence of the European space sector, both in industry and research, and should thus link to broader EU policies and legislation. It is envisaged that the subject of an SRC is a field where Europe has heritage in, where Europe can achieve a leading position or when the topic can be a European strong-hold in international partnerships. This 'top-down' approach is definitely needed in addition to the traditional annual calls. Similar instruments were advocated by several actors, in particular the ESSC,[2] in order to deal with the lack of long-term coordination as well as the often fragmented results and research coming from the bottom-up calls.

The present document details the outcome of the deliberations that took place at the ESSC 44th and 45th plenary meetings in 2012 and 2013. The broader European space sciences community was consulted during the process and significant input was provided to the ESSC through two online surveys that took place during the first half of 2013. The following sections outline i) a description of the surveys; ii) the ESSC recommendations for the space SRCs of H2020 and iii) certain critical overarching elements to be considered.

1. *ESSC Contribution to the EU FP8/Common Strategic Framework*, European Space Sciences Committee, European Science Foundation, Strasbourg, March 2011, ISBN 978-2-918428-40-4.

2. *Ibid.*

2. Description of the Surveys

The first ESSC survey was available online from 15 January to 8 February 2013. The ESSC network was mobilised in order to sample the opinion of scientists in the broader European space sciences community and provide ideas for SRC topics. Inputs from the first survey were presented to the ESSC and combined with the discussions that took place in the second EC workshop on H2020 Space in Madrid (18-19 February 2013) which was devoted to space sciences. The ESSC office combined the community proposals into seven SRC topics that were sufficiently generic and inclusive to provide for the needs of the space sciences community at large.

2.1 The first survey results

The first survey gathered a total number of 185 participants, who suggested 177 potential SRC topics. The proposals were grouped in four main domains, corresponding to the four ESSC panels (as depicted in the table below), with the addition of one cross-disciplinary category. Table 1 presents some of the most popular topics that were submitted from the community, grouped by panels operating within the ESSC. The second column of this table gives the number of individual scientists who expressed their opinion on what the SRC topics should be. As expected, a large number of these proposals had too narrow a focus. The main themes that stood out after compilation and analysis of the proposals served as the basis for the identification of the SRC candidates by the ESSC.

2.2 The second SRC survey

The second survey was available during April 2013 and allowed the European space sciences community to provide feedback on the SRC candidates that resulted from the first survey. A total number of 190 participants reviewed and profiled the topics.

Table 1. Highlights from the first ESSC survey. The number of proposals refers to individual proposals, often with overlapping topics

Domain	Number of proposals	Main themes of proposals
Astronomy and Astrophysics	38 topics	Solar physics and space weather, NEOs (Near Earth Objects), data exploitation, instrument development
Solar System Exploration	41 topics	Technology development, planetary protection, exploration, SSA (space situational awareness)
Space Life Sciences	40 topics	Human physiology, coordinated /integrated life sciences enabling human exploration
Earth Observation and Earth Sciences	39 topics	Atmospheric models, UAVs (unmanned aerial vehicles), data handling
Cross-thematic	19 topics	Technology development, commercial space flight, space data handling, multidisciplinary research, components for space vehicles

With guidance from the Committee, the ESSC office in ESF regrouped the proposals into seven topics that optimally combined the interest of the community with the SRC structure, in particular their profiling criteria (cf. Table 2). The following SRC topics were formulated:

- *Data and Knowledge-based Management and Exploitation*, dealing with data collection, archiving and exploitation in European space sciences.
- *Space Situational Awareness – Near Earth Objects*, dealing with the detection, characterisation, mitigation and exploitation of NEOs.
- *Space Situational Awareness – Space Weather.* The focus of this activity would be an integrated approach to space weather data and systems.
- *Scientific Research Enabling Space Exploration.* The primary thrust of this topic will be to further study the effects of long duration space flight and simulations on crew health and performance.
- *Life and Planetary Protection.* The theme of this SRC would be an integrated approach to space analogue sites encompassing life in extreme environments, planetary protection aspects and search for life related research.
- *Radiation-hard Components.* The topic of this SRC would be the development of off-the-shelf rad-hard components for the European space industry.
- *Space Data for Climate Models.* The long-term objective would be to develop well-calibrated space data to initialise, constrain and validate climate models and suitable tools.

As with the first survey, these topics were described in detail and were distributed to the community, who was asked to profile and comment on these topics. The criteria that were proposed to the community for characterisation of the SRC topics are presented in Table 2.

Apart from the profiling criteria, the participants were asked to provide answers to the following questions:

- Which should be the short-term, mid-term and long-term goals of this SRC?
- How would addressing this SRC contribute to 'non-space' societal issues?
- What are Europe's main strengths in the issues proposed by the SRC?
- Do you have any general comments on the proposed topic?

The inputs to the second survey were gathered and presented to the ESSC for deliberation at the 45th ESSC plenary meeting in Brussels in May 2013. From these discussions and deliberation, the ESSC proposed four SRC themes, which are described in the next section, and produced a set of recommendations on overarching issues pertaining to H2020 (see section 5).

Table 2. Profiling criteria used in the second ESSC survey

Criterion	Description
Need for a long-term programme	How strong is the need for long-term coordination in the topic?
European competitiveness and non-dependence	To what extent can the proposed topic help the European space sector to build or maintain a strong position in the field?
European scientific and technical leadership	How strong is European S&T in the proposed field?
Innovative nature	How is the proposed topic likely to offer the possibility for novel approaches or concepts?
Complementarity and compatibility within the existing European programmatic landscape	To what extent would potential activities within this particular SRC extend, enhance or help on-going or planned European research activities?
Interdisciplinarity	To what extent does the proposed topic require the involvement of many scientific and technological disciplines?
Size of involved/interested community	How big is the community potentially involved in the proposed topic? How likely is it that the community will be large enough to justify the setting up of an SRC?
Relevance for non-space societal issues	To what extent would the proposed topic offer the possibility of advancement in non-space fields or can it be of potential use to broader societal challenges?

3. Recommended Strategic Research Clusters Topics

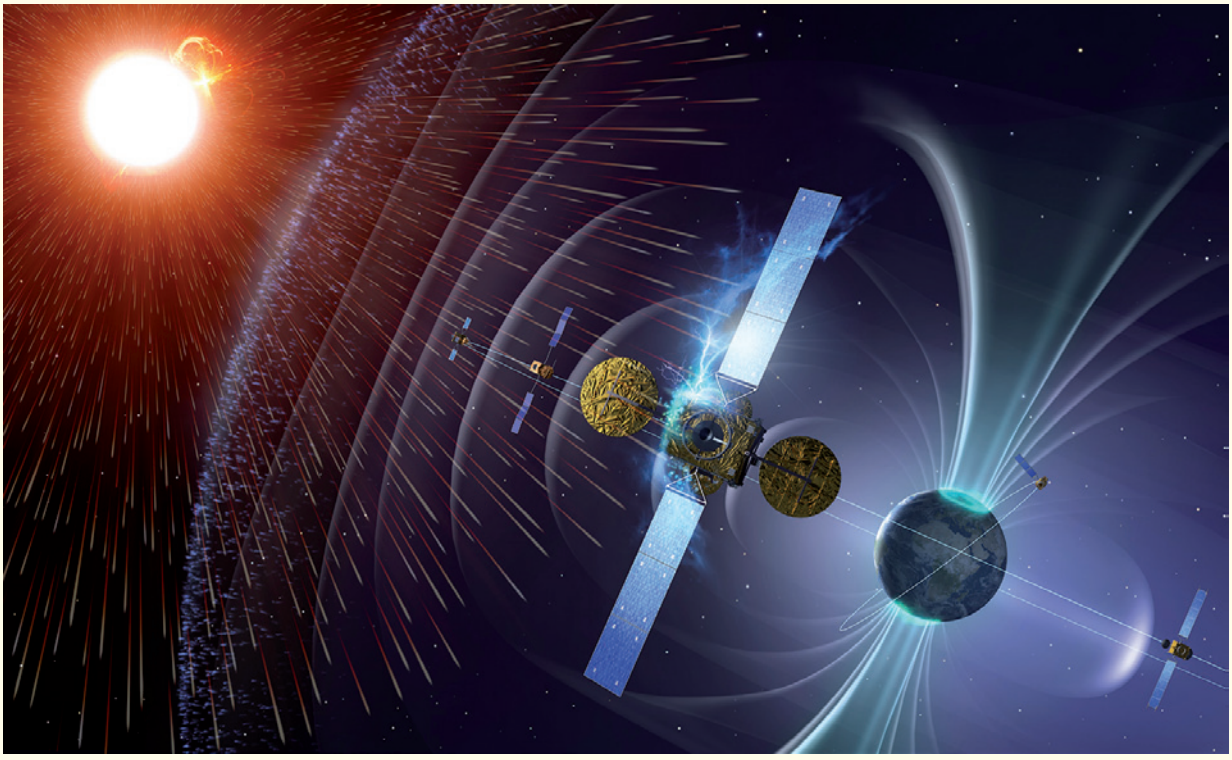

Figure 3. Space Situational Awareness aims to monitor (and eventually predict) Space Weather phenomena, in order to protect space assets from harmful effects. Credit: ESA

The ESSC proposes four areas that would serve well as Space Strategic Research Clusters in the domains of **Space Weather**, **Human Space Exploration**, **Climate Science**, and **Astrobiology and Planetary Protection**. Europe has world-class scientists in those areas and those SRCs will contribute to maintaining a European leadership and enhance European autonomy and competitiveness in those fields. The four SRC proposals are described below.

3.1 SRC proposal for Space Situational Awareness – Space Weather

The focus of this activity would be an integrated approach to space weather data and systems. Our fundamental understanding of space weather phenomena is still insufficient to provide very efficient forecasts or even warnings. Solar weather activity has an impact on all aspects of European society, in particular on aspects such as satellite communications (Galileo), energy pipelines, airline safety,

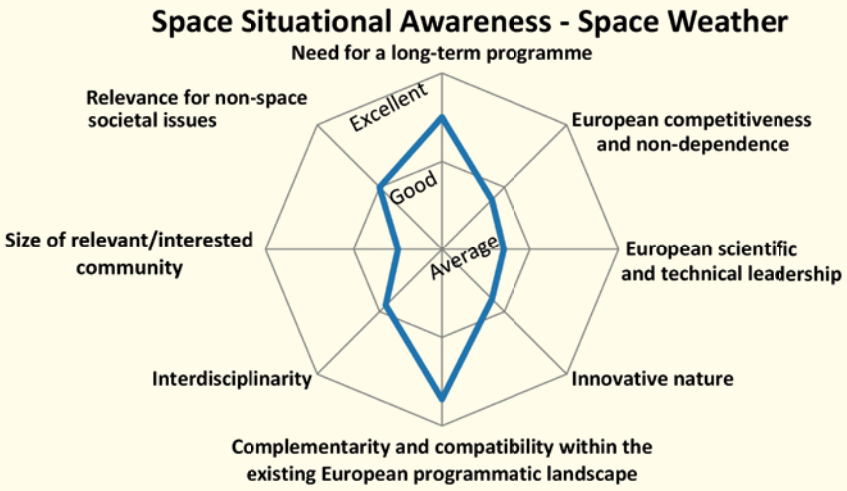

Figure 4. Community profiling from the ESSC second survey regarding the proposed SRC on Space Weather. The blue line traces the average for the indicated criteria of the community profiling exercise. Details of the survey methodology and questions can be found in section 2.

etc. In many of these areas Europe already has an impressive track record in terms of research and development, contributions to space missions and scientific publications.

The final goal would be to understand solar activity impact on the Earth and its environment to a level allowing prediction.

Areas of coordination within this SRC can be:

- To develop a coupled system of models that can forecast space weather from the Sun to the Earth's surface to help protect satellites, power grids, aviation, navigation and other forms of modern technology. The coordination action will ensure support for the science underpinning space weather.
- Support for observatories (digisondes, magnetometers, neutron monitors, radio burst monitors and coronagraphs and others) to guarantee continuous high quality near real time data delivery, as well as European autonomy in space weather monitoring. This is an area where the EC can really complement ESA efforts in the domain.
- From a space mission definition point of view, the current level of knowledge of space environment often leads to excessive design margins ('overdesign') and higher mission costs than necessary. The coordination action will lead to the development of engineering standards to deal with 'normal' space weather as well as low frequency, high impact events. This is the area that will benefit most the European space industry, as it will provide the necessary standards for design optimisation.
- To develop models, based on space data, of the spatial and energy distribution of Solar Energetic Particles (SEPs) and of the extreme gamma radiation during the dynamics of intense events, with the aim of assessing their role in determining the absorbed dose in space. The coordination action will help to quantify and forecast the risk for human flights and space systems during the most energetic phenomena, and to optimise the protection for astronauts.

3.2 SRC proposal for Scientific Research Enabling Human Space Exploration

The primary thrust of this research domain will be to further study the effects of long duration space flight and simulations on crew health and performance, to further develop efficient countermeasures and to facilitate post-flight re-adaptation to the terrestrial environment. Such basic and upstream research is a clear pre-requisite activity aimed at improving long-term capability for interplanetary travel and life on planetary surfaces. The priorities in this research field were defined in a roadmap issued from the

Figure 5. Robonaut 2, July 2009. Credit: NASA

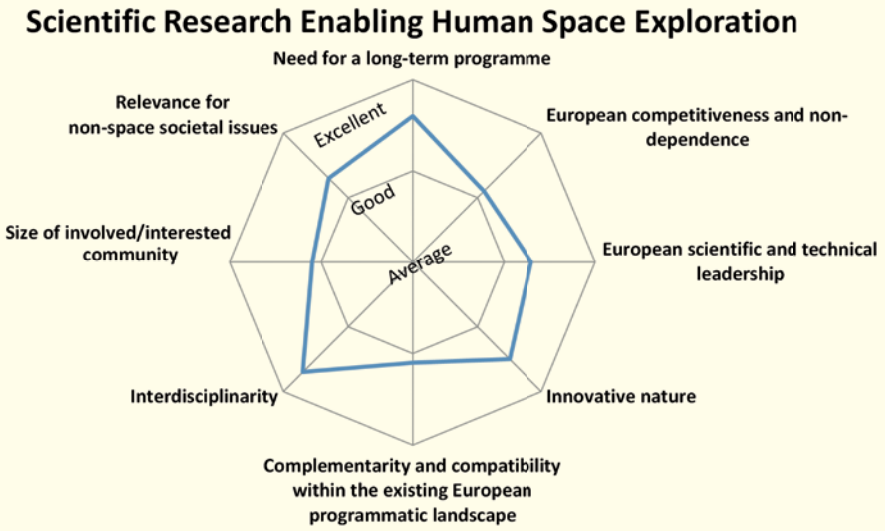

Figure 6. Community profiling from the ESSC second survey regarding the proposed SRC on Scientific Research Enabling Human Space Exploration. The blue line traces the average for the indicated criteria of the community profiling exercise. Details of the survey methodology and questions can be found in section 2.

EU-funded THESEUS coordination project that included more than 123 scientists worldwide.[3] The present suggestion is to study the priorities highlighted in this roadmap to enable space exploration. The main areas of this cluster can be:

- Optimisation of habitat design for space exploration, including precise characterisation of long-term health effects of living in these habitats (e.g., effects of low oxygen, low ambient air pressure, zero/microgravity, radiation, stress and confinement).
- Demonstration of closed loop life support technologies focusing on multiple aspects such as water, air, food, waste, etc. in combination with human crew in an isolated environment.
- The artificial gravity platform can be considered as part of this SRC. Such a platform should be considered a long-term perspective for Europe related to human physiology, psychology and well-being during long duration missions.
- Integrated view of adaptation to the space environment (medicine, multiple stressors, interpersonal variability, accepted risk, autonomy, etc.).
- Integrated view of countermeasures to multiple stressors (interaction between different countermeasures, interpersonal variability, accepted risk, autonomy, etc.).
- Evaluation of the risks after exposure to radiation and understanding of DNA repair mechanism damaged by radiation.

It is recommended that this SRC topic is initiated as soon as possible due to the uncertainty of the status of the ISS after 2020.

3. *Towards Human Exploration of Space: a European Strategy – Roadmap*, Strasbourg, March 2012, ISBN 979-10-91477-00-0

3.3 SRC proposal for Astrobiology and Planetary Protection

The theme of the SRC would be an integrated approach to space analogue sites that encompasses life in extreme environments, planetary protection aspects and 'search for life' research. The origin and distribution of life is one of the most fundamental questions. Research on the origins of life and possibility of 'second life' contributes to our basic knowledge of life including the fundamentals of human biology. European researchers in astrobiology have an excellent reputation in the international scientific community. Technological advances put the goal of this topic within reach for the first time in human history and Europe should not miss the chance of taking the lead.

The main areas of this cluster can be:

- Defining the limits of life, using Earth analogue sites.
- Understanding the prerequisites for the origin and evolution of life, studying terrestrial life under

Figure 7. Acidophilic micro-organisms thrive in the acidic waters of Rio Tinto, Spain. Credit: F. Perez, CAB

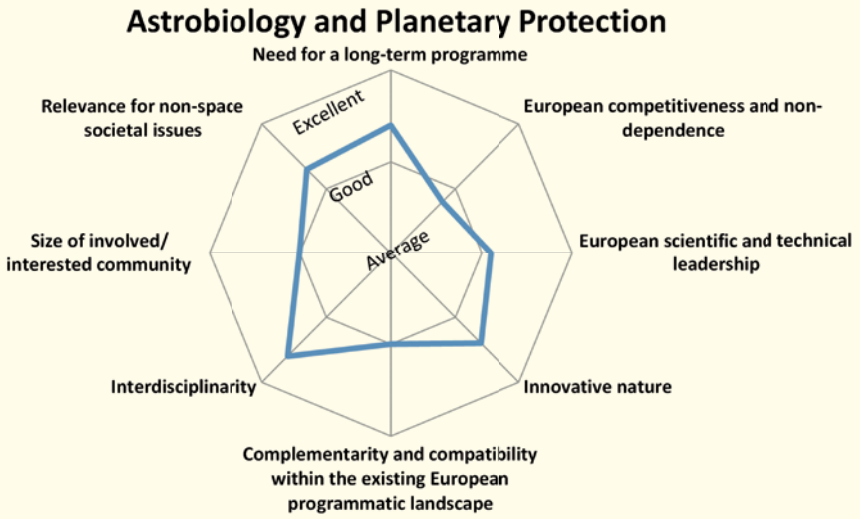

Figure 8. Community profiling from the ESSC second survey regarding the proposed SRC on Astrobiology and Planetary Protection. The blue line traces the average for the indicated criteria of the community profiling exercise. Details of the survey methodology and questions can be found in section 2.

simulated space and planetary conditions, e.g. Mars, Europa, Titan and Enceladus.
- Development of life detection procedures in preparation of planetary missions.
- Using the ISS environment as a large facility to study responses of organic molecules and micro-organisms to outer space and simulated planetary conditions.
- Development of a Decontamination Centre for Planetary Protection, dealing both with spacecraft decontamination as well as assuring safe sample return to Earth.

3.4 SRC proposal for Space Data for Climate Models

The long-term objective of this SRC would be to develop well-calibrated space data with quantified uncertainties to be used to initialise, constrain and validate climate models and suitable tools. The aims of this SRC include the detection and attribution of climate impacts to forcing factors and the provision of information needed for climate adaptation strategies.

Europe hosts several major actors in the field of climate modelling (ECMWF, MPI, UKMO, Météo-France, CNRS/IPSL/LSCE, etc.) as well as in climate-relevant space observations from various agencies (ESA, EUMETSAT, CNES, DLR, etc.). The European scientific community has accumulated considerable experience and expertise in climate science and modelling, through GMES/Copernicus and the ESA Climate Change Initiative (CCI), among other initiatives.

Satellite data worldwide (not only European) should be used, as well as climate records across all fields, i.e., ocean, land, cryosphere and atmosphere. The programme will be closely coordinated with Copernicus, the ESA CCI and other relevant programmes and would have significant societal impact.

Work would include:
- Intercalibration of satellite instruments, validation of satellite data and cross calibration/validation with climate observations and essential climate variables (ECVs). Validation phase shall include: continuation of ground based networks, development of new validation instrumentation for new parameters, validation by aircraft measurements and UAV, combined validation campaigns using ground and airborne techniques.

Figure 9. Different spheres of the Earth system. Credit ESA

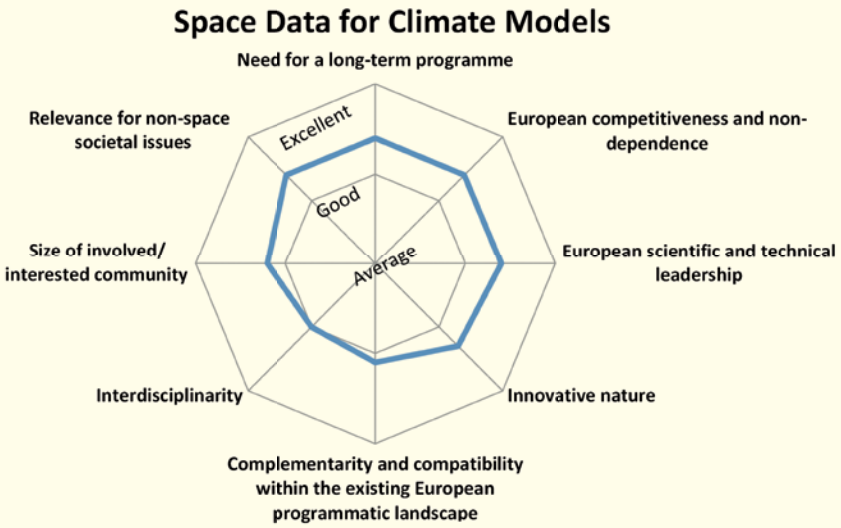

Figure 10. Community profiling from the ESSC second survey regarding the proposed SRC on Space Data for Climate Models. The blue line traces the average for the indicated criteria of the community profiling exercise. Details of the survey methodology and questions can be found in section 2.

- Consistent algorithm development across platforms and instruments.
- Development of generic tools to 'translate' climate observations to model parameters needed in climate models.

A comparison between the profiling for the four ESSC proposed SRCs can be seen in Figure 11, where the four topics have been plotted on to the same chart.

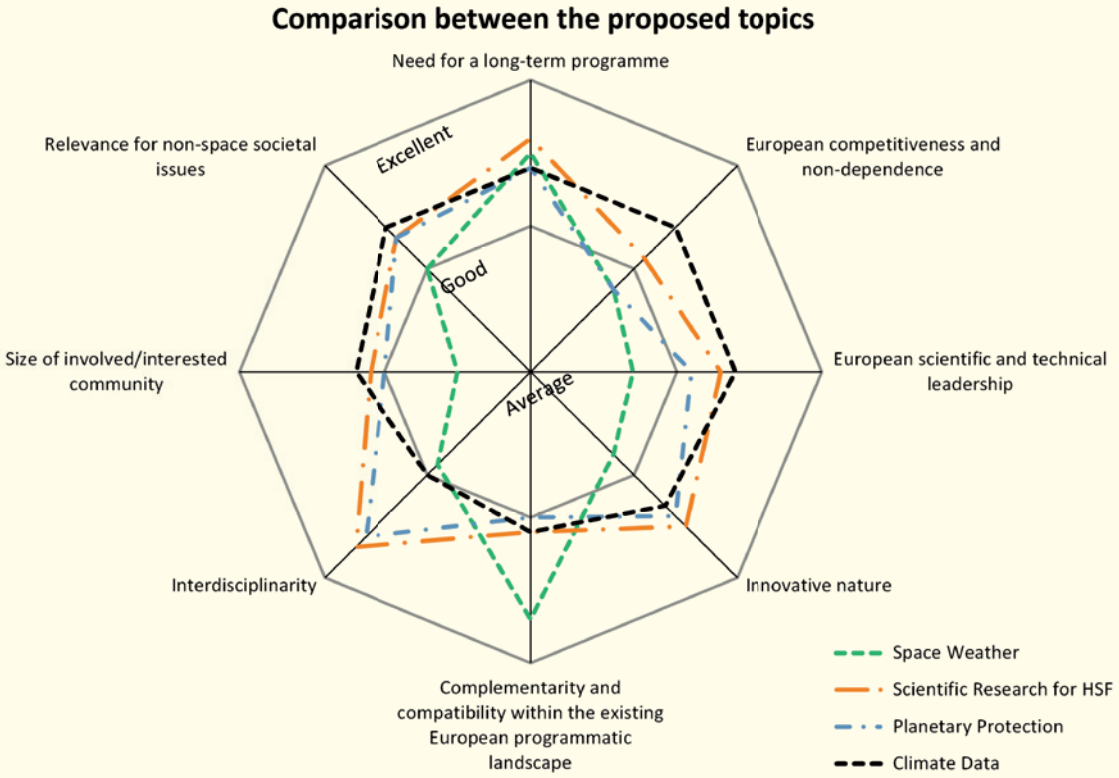

Figure 11. Community profiling from the ESSC second survey regarding all the proposed SRCs. The various traced lines correspond to the individual topics, as indicated in the figure legend. Details of the survey methodology and questions can be found in section 2.

4.
Additional Issues

During its deliberations on the SRC 'candidates', the ESSC came up with a list of three additional topics also to be considered by the EC. The Committee chose not to expand these topics as SRC proposals either due to their focus or their unsuitability for the SRC coordination framework. Nevertheless, they remain critical topics and the means through which these topics could be implemented will require further discussions and consideration. These topics are listed hereafter.

4.1 Advanced propulsion

Advanced (nuclear/electric) propulsion was recognised as an enabler for science and industry and a cornerstone for space science and exploration by the scientific community, both during the EC sponsored workshops as well as the community surveys. The ESSC recognises the importance of the topic to the European space sector but, due to the more industrial focus of the topic, refrained from elaborating on it.

Figure 12. CubeSats FITSAT-1, F-1 and TechEdSat after deployment from the ISS. Credit: NASA

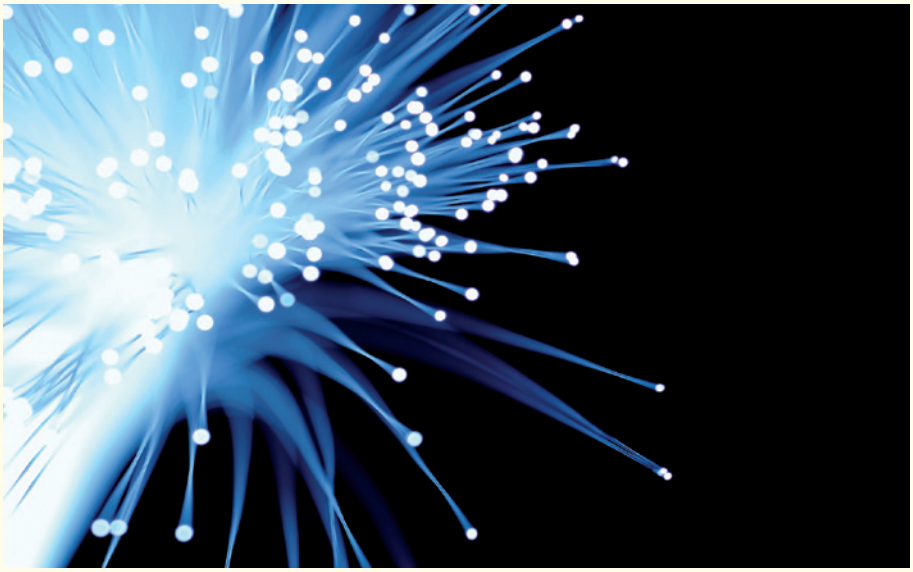

Figure 13. Optical fibres and photonics research paving the way to the all-optical computer. Credit: Photonics21

4.2 **Small satellites and Cubesat development**

Small satellites, Cubesats and other similar initiatives were identified as a popular topic amongst the European space sciences community. The specificity of funding for particular Cubesats is probably inappropriate for the encompassing nature of an SRC. In these instances, support through an annual call seems a more relevant approach and H2020 calls should reflect the importance of small satellites for education and SMEs.

4.3 **Technology development**

Low Technology Readiness Level (TRL) development funding is a worthy and important goal that the community strongly supports. H2020 could thus support 'upstream' Technology Development (TD), i.e., TD at TRL 0-4, through EC-funded activities, although innovative R&D funding could be more appropriate in this case. Indeed, an SRC is by definition a coordination instrument and the funded projects should help advance a final goal.

5.
Overarching Issues

During the ESSC deliberations, two issues were recognised as critical for better structuring the European scientific community and its competitiveness in the international arena. It was strongly emphasised that these elements should be considered beyond the SRC discussion and taken up as definite programmatic priorities in H2020 Space.

5.1 Data exploitation

One consistent request that came up in almost all SRC discussions was the request for the establishment of an infrastructure for data analysis and archiving. The main aim of such an endeavour would be to improve framework conditions, manpower and infrastructure for space data preservation and exploitation, including the development of archives and tools for accessing, processing (including regular re-processing) and disseminating space data, and integrating the use of space data in the context of the European e-infrastructures for e-science, including data modelling.

Ideally, European space research would benefit from the development of robust cloud services that go beyond simply making data available, with the aim of providing tools for analysis and visualisation. Space data e-infrastructure should support R&D actions either focused in specific scientific domains, merging space data with knowledge and data developed on the ground, or aimed at linking data in different domains to pursue cross-disciplinary scientific goals.

During the deliberations in the ESSC plenary meeting, the subject was found to be too overarching for an SRC. Nevertheless, this was considered to be a vital issue and it was suggested that adequate mechanisms and funding should be identified within H2020 for supporting the scientific exploitation of European space data.

5.2 Sustaining (ESA) missions related large communities

The recommendation that the EC should contribute to upstream and downstream support to mission teams and/or networks had already been made by

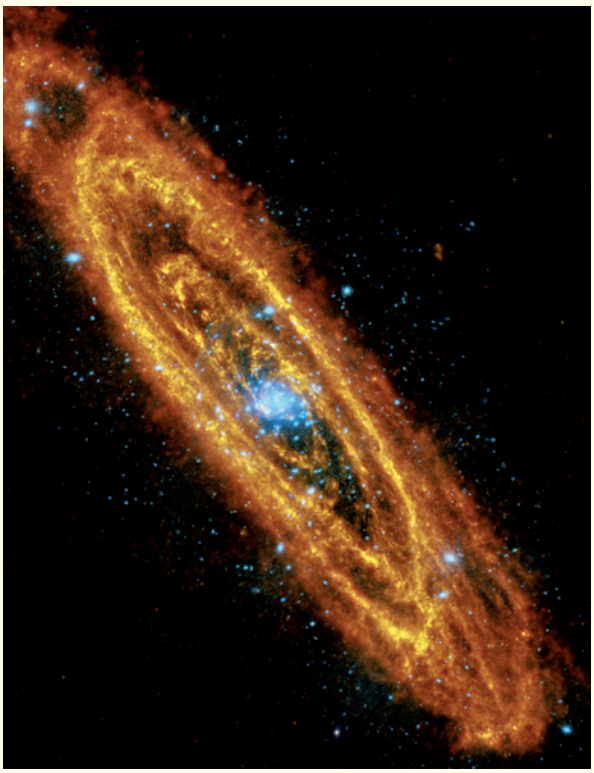

Figure 14. Andromeda Galaxy in infrared and X-rays, as a combination of images from the HERSCHEL and XMMS-Newton spacecrafts. Credit ESA

ESSC to the EC and was already recognised as a critical aspect to be captured within the H2020 programme.[4] As mentioned in the ESSC contribution to the H2020 framework, the EC could provide adequate support for pan-European consortia in all domains of space science, and not only to provide the additional funds that are also needed, for instance to support post-doctoral students.

Sustained support through the Framework Programme would alleviate the uncertainty that is present in the current funding model of ESA missions for the pre-development and exploitation phases, further enhancing the European role in the international level. This could also provide a good link between ESA missions and the EU space policy. If the SRC instrument is not appropriate for such an action, other ways to support extended communities should be identified.

4. *Ibid.*

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