



# Horizon 2020 2018-2020 SPACE Work Programme Consultation



## European Space Sciences Committee contribution

### **1. The European Space Sciences Committee**

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The European Space Sciences Committee (ESSC - [www.esf.org/space](http://www.esf.org/space)) of the European Science Foundation is an independent committee that regularly provides expert advice to European and National research funding and research performing organisations that support space sciences in Europe. ESSC members are drawn from experts active in all fields of space research on the basis of scientific expertise and recognition within the community, they are nominated *ad-personam* and therefore do not represent any organisation or country.

The ESSC covers the whole spectrum of space sciences, it is structured around panels (Astronomy and Fundamental Physics, Earth Sciences, Life and Physical Sciences, Solar System and Exploration) that reflect the variety of space-related disciplines.

The mission of the ESSC is to facilitate and foster space sciences at the European level by providing unbiased, expert advice on European space research and policy via recommendations or reports. Furthermore, ESSC provides a unique focal point to assist European national councils and agencies to achieve optimal science return and harmonise strategic priorities in space activities.

The following sections highlight the recommendations and input of the ESSC to the EC consultation for the 2018-2020 work programme of Horizon 2020 (H2020) SPACE. There are three main areas for which ESSC provides inputs: transversal issues that touch all aspects of the H2020 SPACE calls, Space Science and Technology related issues and Earth Observation (Copernicus) related issues.

### **2. Transversal issues on the future H2020 Space call**

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The ESSC wishes to highlight six issues of transversal relevance to the programme:

#### **2.1. Continuity, coherence and efficiency**

Over the past years, the ESSC advocated for continuity of topics supported within the EU science and technology development programme<sup>1</sup>. Such stabilised support on key topics, using a mix of funding schemes (Coordination and Support Actions, research projects), allows researchers to build on progress made through supported investigations and activities, creates a programmatic critical mass, allows for the relevant communities to gain in structure and coherence, and finally, increases the programme's efficiency.

In this context, the ESSC welcomed the introduction of the Strategic Research Clusters (SRCs) mechanisms in the first call of H2020, and the integration of supported projects (operational grants) following subsequent calls.

The two SRCs implemented so far are focussed on technology development (Space Robotics Technologies and In-Space electrical propulsion and station keeping). Although these topics can be considered as enabling for space science, they are not scientific topics as such. In November 2013, the ESSC produced a set of recommendations (based on a wide community consultation) for topics to be

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<sup>1</sup> 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.

addressed through SRCs<sup>2</sup>, and advocated four potential topics that would specifically benefit from stabilised support:

- *Space Situational Awareness - Space Weather*  
An integrated approach to space weather data and systems. Goal: understanding the solar activity impact on the Earth and its environment at a level allowing prediction
- *Scientific Research Enabling Human Space Exploration*<sup>3</sup>
  - 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.
- *Astrobiology and Planetary Protection*<sup>4</sup>  
An integrated approach to space analogue sites that encompasses life in extreme environments, habitability conditions in the Solar System and beyond, planetary protection aspects and 'Search for Life' research
- *Space Data for Climate Models*  
To develop and provide well-calibrated space data with quantified uncertainties to be used to initialise, constrain and validate climate models

**Recommendation:** The Work Programme 2018-2020 should include support for at least two new SRCs. These new SRCs should be focussed on scientific topics (see above) to complement the technology aspects covered through the first two SRCs.

## 2.2. Increased feedback from the H2020 process

The ESSC welcomes the opportunity to provide direct input on the elaboration of the biannual work programmes and stresses that this consultation step is necessary to allow implementing a programme that fits with community expectations and latest science and technology developments. The Committee considers that this approach should also be adopted when writing the annual calls text and attributing budgets to the different call lines.

**Recommendation:** The ESSC recommends that community consultation on H2020 (or forthcoming programme) work programmes are complemented by an additional feedback mechanism on draft call texts, before their release. This would allow collecting inputs at a finer level of detail on coherence, inclusion and budgetary balance between the topics addressed by annual calls.

As to the evaluation and selection process, the ESSC considers that it could involve more interactions and feedback mechanisms between the applicants and the evaluators. This could be ensured by the introduction of a rebuttal step. Such a step would allow applicants to provide a 1-page comment on the individual evaluators' assessment before the review panel meet and finalise marks and ranking lists. This would allow alleviating and/or clarifying any factual mistake or misunderstanding that reviewers may make and eventually make the assessment process more robust. It is perceived as well that the level of feedback for non-selected applications should be increased in order to allow applicants to strengthen their concepts.

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<sup>2</sup> Space Strategic Research Clusters in Horizon 2020 – ESSC-ESF Recommendations

<sup>3</sup> See also THESEUS page 6

<sup>4</sup> See also AstRoMap page 8

**Recommendation:** Introduce a higher level of feedback in the assessment and selection process by introducing a rebuttal step before the review panel meets, and by providing more information in the evaluation summary reports.

### **2.3. Space Data Exploitation**

The request for the establishment of infrastructure for data analysis and archiving, is a consistent appeal from the scientific community. There is a large amount of space mission and ground-based observations acquired by European scientists and agencies that would gain in productivity if it were organised in a coherent way, shared via public databases, and properly archived. Also, facilities related to space exist in many European countries, which could be made available for other scientists and students. The full spectrum of space sciences communities in Europe would largely benefit from such coherent organisation, which would enable them to be competitive at an international level.

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 dissemination. It would also allow integration of the use of space data in the context of the European e-infrastructures for e-science, including big data and data modelling.

European space research would additionally 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 ('big data') should support R&D actions either focussed 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. GAIA can serve as an example of a large data set that is of interest for astrometry, galactic astrophysics but also for NEO detection and Exoplanet identification.

**Recommendation:** The H2020 programme should encourage and mobilise support to research infrastructures that would i) facilitate networking, pooling and sharing data and facilities and ii) let researchers revisit existing data with new paradigms and algorithms for data interpretation / presentation / combination. This would also permit the use of data to create knowledge on 'secondary' scientific questions for which sensors were not primarily designed.

### **2.4. Maintaining communities, securing knowledge and know-how**

There are several large European and international missions/initiatives (including microgravity experiments, planned or underway, that span a long period of time and/or have transformative impact on the scientific community involved. From genesis to operations and data exploitation, the full life cycle of missions requires expert and knowledgeable communities that are in a position to cope with the specific challenges, and exploit the opportunities, that are inherent to these endeavours.

During the lifetime of a given mission, some phases are characterised by a lower level of community support from programmatic agencies (e.g. pre-development phases, multi-year cruising phases, as for BepiColombo or JUICE or data exploitation phases). This may result in the loss of competencies and know-how in the teams involved, as well as a higher level of uncertainty on the optimised operational and data exploitation phases.

This is a context where the ESSC sees clear complementarity between programmatic agencies and the H2020 programme. By accompanying communities during periods of lower support, the H2020 programme can help maintain (and enhance) scientific excellence, securing Europe's position as a reliable international partner, and increasing the scientific return of missions. This support could also serve as a link between space agencies and EU space policy.

**Recommendation:** Provide support to ensure that mission communities are able to maintain excellence and leverage scientific networks over the entire life cycle of the mission.

## 2.5. CubeSats

CubeSats are small platforms composed of one or several elements (Cubes) of 10cmx10cmx10cm, they usually weigh less than 10 kg and are launched as piggyback payload. From less than 20 launched per year in the period 2005-2011, the number of CubeSat launched increased dramatically to reach more than 120 in 2014 and is continuously rising. CubeSats can be used in many different ways to address scientific issues in most parts of the space sciences spectrum (Earth observation, heliophysics, planetary sciences, astronomy and astrophysics; astrobiology); they can also be used for technology development and demonstration, as well as for educational purposes at a relatively low cost, and with relatively fast development time.

CubeSats provide a new set of mission opportunities sitting between the sub-orbital investigations and the bigger and more expensive orbital platform, but they are also more than 'fast and cheap' platforms. Although they have obvious limitations (e.g. size, power, control, data link), they can complement ongoing investigations by filling coverage gaps (geographic and time), for example, or by allowing for new measurements such as those made possible by constellations.

The specific character of CubeSats missions seems to be particularly suited to the magnitude and objectives of the H2020 SPACE programme. This programme has the capacity to create a critical mass within the community, and build momentum towards the development of a European CubeSat programme to be developed and implemented in the frame of the H2020 successor.

**Recommendation:** The ESSC recommends that the H2020 2018-2020 work programme address the identification of scientific opportunities made possible with CubeSats, and provide support in order to strengthen and expand the European CubeSat community and to develop CubeSat missions.

## 2.6. International Cooperation

The international space sciences landscape is evolving at a rapid pace, new capacities are appearing and scientific and technological milestones are being completed in non-European countries. Besides the USA and Russia, this is particularly the case in Japan, China and India. Although at the scientists' level, cooperation is a success and progresses internationally, several collaborative projects are hindered by lack of willingness or of capacity to achieve an agreement at high space agency levels for political and/or export regulation reasons.

As to the actual implementation of international cooperation within the framework of the H2020 programme, engaging with non-European countries (that are not eligible for H2020 funding) on H2020-funded activities is a real challenge in terms of administration and alignment of funding mechanisms. Upstream effort to secure national funding and ease access to this funding for non-eligible international partners would certainly be a way to facilitate and stimulate international cooperation in H2020 (the EU-China Co-Funding Mechanisms – CFM can be considered as an example of such a mechanism). Here ESSC can certainly play a role as an empowered intermediary that would help pave the way for, and facilitate, discussions among decision-makers.

Beyond the obvious interest in science return optimisation, in times of stringent economic conditions international collaborations could help avoid duplicating efforts and save money.

**Recommendation:** In this context, the H2020 programme could support forums, workshops, and consultation meetings inviting the science community, space agencies' representatives and other stakeholders to discuss how to move forward with potential promising international collaborations, that are bottom-up initiatives, demonstrating clear complementarities and resulting in a win-win situation for the scientific communities involved).

### 3. Recommendations on the H2020 Thematic areas

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#### 3.1. Theme 1 – Space Science and Exploration

Regarding the Space Sciences part of the H2020 SPACE framework programme, the ESSC would like to bring to attention the following points:

##### *3.1.1. Integration of ground and space research*

As science progresses and tackles more difficult problems, it is becoming increasingly necessary to follow a 'System Approach' in order to answer scientific questions. This is particularly true in areas where there are multiple, complimentary assets available to the communities, both in space and on ground (free flying and Earth based observatories). An integrated approach between ground and space research on selected topics across the full space sciences arena has high potential for progress.

Another aspect of this issue of coordination between ground and space concerns tackling the same problem from different sides (conventional and microgravity/space environments). For example, serious interaction between life scientists and physicists is advisable, since in several cases claims about microgravity effects on biological systems were not supported by a sound physical background (for example: cell mobility studies).

**Recommendation:** The H2020 programme should include a topic for research activity integration between ground research centres and space-based investigations.

##### *3.1.2. Health research in Space*

A lot of data are available, and will become available soon, about situations showing analogies between spaceflight and clinical conditions, for example in immobilised patients, patients with osteoporosis, autoimmune problems, nutritional effects, and otherwise deconditioned subjects. Identification, inclusion and interlinkage of such data could lead to benefit for the patients from a "product-perspective." Bedrest is a good example, as it has provided interesting data with vibration, exercise, etc. There other areas of space research that this can be applied to as well, from radiation research to immunology. This would have a direct impact on both space and medical research, taking advantage of and amplifying the work done in space, linking it to commerce and applications for the benefit of Europeans.

Additionally, there is opportunity for knowledge from 'spin-in' effects from current medical research undertaken. Advances in telemedicine and individualisation of patient care based on many parameters has strong implications on patient treatments. It is also interesting when thinking further about "healthy patients," self-diagnostics and self-optimisation nowadays (see Google's research and patent for glucose sensing contact lenses to place on the cornea to measure glucose). This could be as valuable for space exploration as it is for patients on Earth. Understanding why some of the crew are affected by space flight more severely than the rest is one such example. (Several papers guide in this direction and are reflection likely of the genetic and epigenetic effects.)

A more systematic approach including available data on genetic susceptibility to certain physiological changes could also be considered in the programme with translational approaches as it could be equally important to patients on Earth. The expected impact is a better understanding of such inter-individual effects which are disease-relevant for Earth patients. In addition, this can pave a way for more appropriate and individualised prevention programmes and therapies, respectively, for space crew.

**Recommendation:** development and application of new, non-invasive health monitoring tools by taking advantage of co-fertilisation effects based on space and Earth needs, hereby taking full advantage of the unique and highly visible "test bed" of space.

**Recommendation:** The immune system changes radically in new environments on short and longer scales. The H2020 programme should facilitate the identification of autoimmune response related patterns in space and on Earth and the development of appropriate countermeasures to negative effect. The expected impact is the prevention of disease patterns when a person moves from one environment to another

**Recommendation:** support should be given to controlling metabolism as a scope to modulate energy consumption and to hereby affect ageing, inflammation and disease progress/processes. Here the expected impact is reducing risks and improving perspectives for space flight, given the implications for reducing payload/resources for missions to outer space. Further understanding of these mechanisms also has the potential to be very beneficial for patients on Earth.

Also related to space research relevant to health, the ESSC wishes to draw the attention of the European Commission to the findings and recommendations expressed in the framework of the FP7 THESEUS Coordination Action (Towards Human Exploration of Space: a European Strategy – 2010-2013 - FP7 Grant Agreement n°242482). Overall, the THESEUS project involved 123 experts from 23 different countries. The project addressed knowledge gaps and put forward a suite of research recommendations to enable human exploration of space beyond Earth orbit; these were structured around five topical areas:

- Integrated Systems Physiology  
Report: [http://www.esf.org/fileadmin/Public\\_documents/Publications/Cluster1\\_web.pdf](http://www.esf.org/fileadmin/Public_documents/Publications/Cluster1_web.pdf)
- Psychology and Human-machine Systems  
Report: [http://www.esf.org/fileadmin/Public\\_documents/Publications/Cluster2\\_web.pdf](http://www.esf.org/fileadmin/Public_documents/Publications/Cluster2_web.pdf)
- Space Radiation  
Report: [http://www.esf.org/fileadmin/Public\\_documents/Publications/Cluster3\\_web.pdf](http://www.esf.org/fileadmin/Public_documents/Publications/Cluster3_web.pdf)
- Habitat Management  
Report: [http://www.esf.org/fileadmin/Public\\_documents/Publications/Cluster4\\_web.pdf](http://www.esf.org/fileadmin/Public_documents/Publications/Cluster4_web.pdf)
- Health Care  
report: [http://www.esf.org/fileadmin/Public\\_documents/Publications/Cluster5\\_web.pdf](http://www.esf.org/fileadmin/Public_documents/Publications/Cluster5_web.pdf)

An integrated approach was also elaborated and formulated in the form of a roadmap [http://www.esf.org/fileadmin/Public\\_documents/Publications/RoadMap\\_web\\_01.pdf](http://www.esf.org/fileadmin/Public_documents/Publications/RoadMap_web_01.pdf)

### 3.1.3. Gravitational Waves Research

The discovery of gravitational waves may well be transformational for part of astrophysics, in the sense that, as gravitational waves sources are discovered, more and more astrophysicists, will be looking for electromagnetic counterparts. At this point, the leadership with ground detectors is in the US (even though Virgo is in Europe and GEO 600 physicists are member of LIGO). The leadership in space is in Europe, with the LISA Pathfinder, which appears to be very successful. But the lesson to be taken from LIGO is that leadership means not only a good detector but also a large scientific community (the LSC, LIGO Scientific Collaboration). This is probably where European Union investment could make a difference.

**Recommendation:** Provide the framework for the setting up of a wide network of physicists/astrophysicists whose work would be important in conjunction with the future gravitational wave observatory, this network would involve gravitational waves physicists or astrophysicists working on electromagnetic signals relevant to the same sources.

### 3.1.4. Heliophysics and Space Weather

The development of new modelling tools to predict the evolution of the magnetic configuration and activity of the Sun will be essential for the optimised design and operation of future space missions devoted to the exploration of the Sun and the circumsolar region, which require detailed advance

planning. Future European space missions will be characterised by complex mission profiles – close to the Sun, out of the ecliptic – with consequent maximum science return. Spin-off of such efforts can be envisaged on space weather and space climate prediction capability. The Solar Orbiter ESA/NASA mission to the circumsolar region will be launched in 2018. For the first time, the exploration of the heliospheric region close to the Sun and the observation of the solar polar regions will become possible.

Most present day space weather tools are based on data providing either now-cast or short-term forecast, and cannot fully include coronal expansion and eruption effects. In recent decades, the development of UV spectroscopy, and imaging of the solar corona, has shown the potential of diagnostic techniques for investigating the dynamics and activity of the solar corona and for detecting coronal magnetic fields, possibly in the near future. Enhanced capabilities to detect solar corona magnetic conditions, dynamics and activity will be a determining factor in our future ability to achieve effective space weather forecasts. These forecasts will take into account all solar phenomena affecting the Earth magnetosphere, starting at the time of emergence from the sun, and model their further development in the Heliosphere days before they reach L1, which is where today's short term prediction starts, at best.

**Recommendation:** Support science efforts to achieve the capability to predict the solar cycle with high accuracy, and to model the evolution of the dynamics and activity of the Sun, in order to guide optimisation and scientific operation of future space instrumentation for solar and coronal research. This will also facilitate the planning months/days ahead of the coordinated observations of six remote-sensing and 4 in-situ instruments on the Solar Orbiter, optimising the scientific return of this future key solar mission.

**Recommendation:** Support science efforts to achieve the capability to predict essential CME characteristics via solar spectrometric and coronal observations (in particular magnetic fields, velocity and density) a few days prior to their arrival at Earth, so as to improve forecast possibilities for magnetic storms beyond today's forecast capabilities (tens of minutes to a few hours).

**Recommendation:** Support efforts of the geo-space science community to implement a system-science approach in order to improve our understanding of the magnetosphere. In particular, the EC should support efforts to understand energy coupling, storage and release in the magnetosphere, which are mechanisms that have the potential to create devastating disturbances of manmade infrastructure. Such a system-science approach implies a global coordination of observations, utilising the unique fleet of spacecraft in geo-space, which is presently still operative, and extended complementary ground-based supporting facilities, such as magnetometers, radars and optical instruments.

In relation to these recommendations the ESSC wishes to draw the attention of the European Commission services to the findings and recommendations expressed in the recent COSPAR / *International Living with a Star* Roadmap document, which addresses similar issues from the vantage point of 28 international experts.

(<http://www.sciencedirect.com/science/article/pii/S0273117715002252>)

### 3.1.5. *Space Surveillance and Tracking (SST)*

Within the framework of SST, European near-Earth-object research is in need of continued support. A new opening in the field would be the extension of present funding towards including all European countries with significant responsibilities. For example, organisation of the North-European dimension in these NEO studies is under way, with the intention to utilise existing assets for NEO research (for example, the Nordic Optical Telescope, NOT). In this context the extensive datasets from the GAIA

and BepiColombo mission will constitute a valuable resource for further investigation of NEO threats to Earth.

**Recommendation:** Introduce a funding instrument to complete the European participation in Space Surveillance and Tracking, this instrument should allow for an innovative approach in NEO detection methods.

### 3.1.6. Astrobiology

The ESSC wishes to draw the attention of the European Commission services to the findings and recommendations expressed in the first European roadmap for astrobiology. This roadmap, produced in 2015 and published open access in *Astrobiology* in March 2106 (Horneck et al. 2016 - <http://online.liebertpub.com/doi/10.1089/ast.2015.1441>), was developed through the FP7 AstrRoMap project (20013-12015 – Grant Agreement 313102). More than 45 European experts were involved in the formulation of this roadmap. The AstRoMap Roadmap identifies five strategic research topics, specifies key scientific objectives for each topic, and suggests ways to achieve these objectives using a stepwise approach. The five AstRoMap Research Topics are i) Origin and Evolution of Planetary Systems, ii) Origins of Organic Compounds in Space, iii) Rock-Water-Carbon Interactions, Organic Synthesis on Earth, and Steps to Life, iv) Life and Habitability and v) Biosignatures as Facilitating Life Detection

### 3.1.7. Planetary Protection

Exploratory space missions with planetary protection requirements are becoming more and more important in the next decade. Highly sterile spacecraft/landing craft are essential in order to allow for investigations on areas that might be able to harbour life. New, effective methods, useable on the sensitive surfaces and equipment of today's missions, are needed to provide an alternative to the standard dry heat (used since the Viking missions) or H<sub>2</sub>O<sub>2</sub> gas treatment. These methods (e.g. Cold Atmospheric Plasmas) may also find applications in space habitat management or on Earth (clean rooms, hospitals, injuries disinfection).

**Recommendation:** The H2020 programme should facilitate i) the development, evaluation and standardisation of alternative sterilisation methods for spacecraft and instruments for exploratory space missions with planetary protection requirements and ii) the investigation of the relevance of these methods to Earth applications.

### 3.1.8. Exploration Enabling Technologies

The scientific and technical challenges posed by the exploitation and exploration of space can contribute to the development of new, innovative products relevant to Earth. In addition, existing technologies are optimised for Earth conditions and research studies for their optimisation in space are needed. This includes handling of fluids, two-phase heat transfer and combustion. Progress in such areas (space validation) can help making space activities safer and cheaper. The H2020 programme should support the development of enabling or disruptive technologies, which promise to significantly augment space exploration capabilities and which can be adapted for Earth applications.

**Recommendation:** Specific activities for 'space validation' of technologies should be included in the H2020 programme and supported.

**Recommendation:** Provide support to projects for robot-human interaction for space exploration (including communication), and its proof / validation, to enhance future human spaceflight. New paradigms for planetary exploration can be explored in Augmented Reality environments.



**Recommendation:** Development of high-power, on-board energy production capabilities (i.e. nuclear power) was recognised as an enabler for science and industry, and a cornerstone for space science and exploration by the scientific community. Support on this topic should be provided.

### **3.2. Theme 3 – Earth Observations (Copernicus)**

The success of the Copernicus Sentinel programme relies heavily on access to the data. The current data dissemination systems are not optimal for the application and user uptake of the data, and create a bottleneck. Given the large data streams, new methods of data access and data processing, based on grid and cloud computing could be implemented, in order to allow full exploitation of the Sentinel data.

Whilst the focus on Copernicus exploitation is understandable and even laudable, H2020 Space must not evolve into support for monopolistic, established Copernicus services. Continued investment in future EO systems and applications is needed to develop European EO and to showcase European EO engineering and innovation.

#### *3.2.1. Copernicus – Big Data*

The Copernicus program offers unique datasets with high temporal resolution, which require a new paradigm in data processing. An important aim would be to develop processing systems based, for example, on cloud computing, that enable data processing, and which do not require user facilities to download and store the input data. Instead of bringing the data to the processors, the processors should be brought to the data. This would allow for improved efficiency in data processing and distribution, greater uptake of Copernicus data, and standardisation in products, algorithms, validation and reliability. The ESA TEP is an example of an external initiative that has proved to be successful.

**Recommendation:** the H2020 Space Big Data call should facilitate the development of systems that promote scalable, adaptive data processes, integrated with/at the ground segment. The call should include specific challenges for systems that can be implemented across the CCGS system-of-systems.

#### *3.2.2. Copernicus - future Copernicus Services and new Missions*

Future EO services, including those based on Copernicus datasets, will benefit from the continued development of new applications of EO data and the development of new missions and algorithms. H2020 Space should ensure that fundamental Earth Observation research is promoted within the EU. Such a call would secure the progress made in European EO, following the launch of the first Sentinel platforms. It would promote innovative uses of EO data, especially Copernicus data, for the next generation of services and applications.

**Recommendation:** the H2020 programme should include a call for next generation Earth Observation missions and applications towards future EO services. The call may also specify the integration of Copernicus and third party data.

#### *3.2.3. Copernicus - EO techniques*

The Copernicus missions provide unprecedented access to high quality operational EO datasets. The Copernicus system could be further leveraged by low cost platforms in complementary orbits. Constellations of small satellites (micro- and CubeSat) have the potential to be used as the follow-up to the current Sentinel series. Such small satellites need a change of the way of designing and building, from the current risk-avoiding approach, towards building in a higher -but acceptable- risk level. This would result in increased EO capabilities at relatively low cost, together with greater uptake of Copernicus data and new EO services.

**Recommendation:** the H2020 programme should allow for exploring options for low cost, innovative technologies and platforms that can provide added value to the Copernicus missions (such as passive tandem SARs, high-resolution fluorescence and trace gas imagers). This should not be focused solely on the platform itself, but include all aspects, from the hardware to the final data product.

#### *3.2.4. Copernicus - Applications and user uptake*

The Copernicus Sentinel observations have to be validated using airborne and ground-based data. This is needed in order to achieve improved, continuous quality assessment of the Sentinel data set, and will foster stronger interactions between the ground-based and satellite user communities. Currently, the resources for validation activities are far from sufficient.

Specifically this is of great importance for the implementation of the COP 21 agreement. This agreement calls to strongly reduce greenhouse gas emissions, which has to be verified by Earth observation data. Although there is not yet a European CO<sub>2</sub> satellite mission in-orbit, Sentinel observations of co-emitters, such as NO<sub>2</sub>, CO and methane, can be used to verify reductions of the CO<sub>2</sub> emissions. This would result in global improvements of the emission inventories of greenhouse gases, and would allow verification of the reductions agreed at COP21. In addition, this would contribute to European leadership in CO<sub>2</sub> observations from space.

**Recommendation:** the H2020 programme should make dedicated resources available to support existing (research) networks that are essential for the validation of Sentinel data products. Activities that need to be performed include the timely processing of data.

**Recommendation:** the H2020 programme should facilitate the development of an inverse modelling system that derives CO<sub>2</sub> emissions from Sentinel observations of co-emitters, such as NO<sub>2</sub> and CO, as well as for methane, to support COP 21 and global climate treaties.

## **4. Conclusions**

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Overall the ESSC commends the increased, and increasingly balanced, support for space sciences in the H2020 programme (compared to FP7). The first two work programmes support priority topics and initiate new investigations and collaborations. The introduction of better visibility and continuity through the bi-annual work programmes and the SRC concept is certainly seen as strengthening the programme, its impact, and its efficiency. The H2020 SPACE calls are critical for allowing out-of-the-box thinking by scientists and companies, without them having to fit into top-down space programmes, and for allowing projects to bridge fields across all of space science.

Indeed, the programme approach and content can still be optimised and has to adapt to a fast-changing environment, the ESSC hopes that the elements presented above will improve the program and make it more relevant and coherent. In this context, continuing and increasing the level of interaction between the scientific community and the programme, advisory bodies, executive bodies and Committee is key so as to continuously monitor and optimise its efficiency. The ESSC is ready and willing to actively contribute to such an increased level of interaction.

In the long run there is a need for a unified strategy between all European space players to direct future calls and programmatic orientations. As 2018-2020 will be the last H2020 SPACE work programme, it is critical that the European Commission engage the scientific community with a view to defining the H2020 successor programme as soon as possible, and through a process that will be as transparent as possible. Here again, the ESSC is ready and willing to act as a key contributor and partner.