ESRE reflections on space-related R&TD and its governance in Horizon Europe

Provided by ESRE

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Content

ESRE

The Association of the European Space Research Establishments — ESRE — was formally established in March 2016 as an international non-profit organisation. Present member organisations of ESRE are the national space research centers CBK (Poland), CIRA (Italy), DLR (Germany), INCAS (Romania), INTA (Spain), NLR (Netherlands), ONERA (France) and VZLU (Czech Republic).

Through ESRE, these national research centers strengthen their cooperation and propose European Research and Development (R&D) actions to advance science and technology both to support the competitiveness of the European space sector and to address the grand societal challenges.

https://www.esre-space.org/

I. Executive Summary

The preparation for the implementation of Horizon Europe is now shifting into its critical final phase. Important decisions will have to be taken both with regard to the new instruments, e.g. the new partnerships, as well as areas of research to be funded in the context of Horizon Europe's first work programme.

The Association of European Space Research Establishments (ESRE) is convinced that the envisaged introduction of "road-mapped research", possibly under the umbrella of a Co-Programmed Partnership for "Global competitive space systems" (CPP Space), has the potential for becoming the key "delivery tool" for new space technologies in the context of Horizon Europe.

However, since the space market is increasingly ruled by the "speed is king"-principle, road-mapped research in Horizon Europe can only support the competitiveness of the European space sector, as long as it will be efficiently managed. Therefore, this document provides in particular structural and topical recommendations with regard to the on-going definition and future implementation of the CPP Space.

In January 2020, ESRE published its White Paper 2020 "Selected Trends and Space Technologies Expected to Shape the Next Decade"[1]. Building on this extensive technical work the present document also provides key R&TD recommendations regarding the first space work programme of Horizon Europe (2021-2022) in order to support Europe's competitiveness and strategic independence in the space domain.

We hope that the European Commission, our partners and the stakeholders of Horizon Europe "Space" at large will consider our contribution to the discussion as constructive and helpful.

II. Background

Over the last decade, the appearance of new public and private space actors worldwide as well as unprecedented entrepreneurial leadership and private investment led to **increased international competition** for the European space sector, including industry, research establishments and academia.

The most notable development in this context was the emergence of "**New Space**", a new approach towards "doing space", led by companies like SpaceX, Blue Origin, Planet etc. which succeeded in integrating and advancing innovation in extraordinarily short cycles.

This development was in particular made possible by massively exploiting and spinning-in state-of-the-art technologies, manufacturing processes and management techniques from other terrestrial commercial sectors.

"New Space" also supports the emergence of a wide ecosystem of agile SMEs and start-ups extending the portfolio of future space-based services with a commercial, societal environmental dimension.

US institutions (NASA, DoD et al.) have also for a long time supported and are continuously supporting "New Space" by adapting their procurement and grant schemes for selected areas, no longer insisting on traditional public design authority, public standards and management schemes.

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[1] https://www.esre-space.org/publications/

So far, **Europe at EU and ESA level has not yet acted to a comparable degree** to adapt procurement rules in its space programmes, **leaving Horizon Europe as the only immediate public instrument** to transfer more influence and responsibility to industry, research and academia **in order to explore new ways of innovating space-related RTD**.

In this regard, Horizon Europe becomes also of augmented importance for space in the **aftermath of COVID-19 in which tendencies of stronger geopolitical superpower rivalries, de-globalization and further digitalization** are to be expected.

All of these developments underscore the necessity for Europe to maintain independent, affordable and state-of-the-art satellite constellations operating at European and global scale, also with a view to the European Green Deal.

It is therefore of utmost importance that **Europe takes all necessary measures to retain its competitiveness and its strategic independence** in the critical technology area of space.

III. Objectives/Structure of Horizon Europe

In view of the above and as the priority goal of Horizon Europe is to strengthen European competitiveness, **Horizon Europe should provide a higher influence to Industry, Research Establishments and Academia** (⇔ potential beneficiaries) with regard to the design and implementation of the research programme on space.

Such an approach would also be supported by the spirit of Horizon Europe's main funding instrument (the grant), which conceptually shall provide support to the beneficiaries and shall not be used to cover public R&D demand identified by public institutions (for this a procurement contract should be used).

Furthermore, **the administrative structures/bureaucracy needed for running the programme should be kept as lean as possible** in order to allow for speedy R&D results, in compliance with the fast-moving market.

In order to support not only the short-/medium-term competitiveness of the European space sector, but also its long-term competitiveness, and also in order to foster the new European actors using space - **Horizon Europe should cover both bottom-up and top-down research, at all necessary TRL levels** in a balanced manner and in all space segments.

Based on the experience from previous framework programmes and with a view to short-/medium-term competitiveness it appears necessary to introduce to a higher extent **road-mapped research and corresponding large-scale projects into Horizon Europe,** as such an approach facilitates better the timely delivery of the most urgently needed R&TD items.

Clearly, **road-mapped research** should only be undertaken in areas where there is **consensus among key stakeholder interest groups** about the strategic impact of the R&TD and where the complexity of the task requires a joint effort by many players.

A proper balance between measures fostering short-term/medium-term competitiveness (road-mapped research, **higher TRLs**, up to demonstrator level) and measures fostering long-term competitiveness (**lower TRLs**, collaborative research) would in our view be provided **by a ratio of about 60% to 40%**.

Large-scale-road-mapped research which would involve funding per roadmap **of the order of 50 m€ and more**, could be performed on a case by case basis making use of the instrument of a so-called **Programme Support Activity (PSA)** introduced in Horizon 2020 and modified according to lessons learnt (s.a. below).

In order to be better able **to coherently select and balance the weights between these roadmaps**, large-scale road-mapped research could also be pursued collectively under the umbrella of a **Co-Programmed Partnership, which typically involves an agreement/cooperation between the European Commission and the key stakeholders of the R&TD community.**

However, as **large-scale road-mapped research** in particular and as Horizon Europe specific work programmes items in general are by construction very much based on consensus, they are not suited for the identification of new, unknown and potentially disruptive ideas.

It is therefore suggested to set up also a continuously **open call for disruptive bottom-up ideas** (low TRLs) in the Horizon Europe "space research" programme.

Horizon Europe will not only address the area of "Generic Space Technologies", for which most of the comments/recommendations in this paper have been elaborated, but also the area of "space-related R&TD" in support of the EU's space programme.

Though this Horizon Europe programme element will be more driven by institutional aspects, many of our principal comments/recommendations should be also considered in this area.

IV. Road-mapped Research and its Governance/Implementation

In order to back strategic objectives like for example "Reusability in European Access to Space", Horizon Europe needs to develop and support ***strategic technology roadmaps*** identifying key sub-capabilities/sub-technologies (wrt. "reusability": e.g.: reusable engines, avionics, re-entry-capable structures, etc.) and related development times.

Such strategic technology roadmaps should be short, without providing too many technological details (⇔ be basically technology-neutral) and should be compiled by the potential programme participants, in general represented by their associations, in cooperation with space agencies, if Member States see a related need.

The designing, monitoring and assessing of a strategic technology roadmap by such a coalition of space agencies and sometimes associations has been named in Horizon 2020 a **Programme Support Activity**.

Ideas for the development of the **relevant sub-capabilities/sub-technologies should then be awarded via competitive calls** of the work programme. In case of large-scale projects providing critical elements of such a strategic roadmap, consortia would also have to provide a ***detailed technological roadmap,*** including milestones, for achieving the required sub-capability/sub-technology.

Furthermore, R&TD on sub-capabilities/sub-technologies should, where possible, be broken down to a level where it can be achieved by one collaborative project, even if it is a large-scale one, in order to make the strategic roadmap more manageable with regard to the number of R&TD deliverables.

In cases where one follows such an approach, also the awarding of R&TD proposals related to important sub-capabilities/sub-technologies to more than one consortium could be envisaged, in order to test different approaches in a competitive way, with the less efficient/productive consortia being phased out after the first *detailed technological roadmap/milestone review*.

Such reviews should be performed by the responsible Horizon Europe contract authority (⇔ **Research Executive Agency**, **REA**), supported by established experts only, with the termination decision taken solely by REA.

The above recommendations have also been derived after analyzing and looking for ways to improve the management of the currently running **Strategic Research Clusters (SRC)**, namely EPIC and PERASPERA.

The SRCs have tackled road-mapped research for the first time in Horizon 2020 and are based on the following construction:

- **A Programme Support Activity**, which is funded via Horizon 2020 through a Coordination and Support Action (responsible for the roadmap and the monitoring of its implementation), acting also as a co-manager of the operational grants (manager: REA), and
- **Operational (research) grants** (RIAs, RAs, awarded via the work programmes), practically implementing the road-mapped research

Translated into the language of the present SRCs, **our recommendations related to the governance of road-mapped research** can be stated more precisely by the following principles: First of all, Programme Support Activities should help the Commission to define the main contents of the roadmap and the main rules for its operations, whereas the REA should run the roadmaps via the work programme calls and the operational grants.

- **Large-scale PSAs** should feature **an inclusive membership including of research organisations** (and avoid dominant influence of space agencies, as they are not potential programme participants, and as such a scheme is only useful to identify public demand and not market/research needs)
- **Horizon Europe funds should finance first of all research activities. PSAs should therefore not be funded via Horizon Europe** as they should be in the very interest of the community and therefore carried out on a voluntary basis (see e.g. ACARE in aeronautics, this of course only works in the case of an inclusive membership), and such PSA funding should also be avoided because of the danger of incentivizing the build-up of additional bureaucracy
- **PSAs should not be involved in any form in the direct management of the operational grants,** in order to avoid conflicts-of-interest and too complex and slow decision-making processes, REA should “run” the roadmap
- Larger operational **grants should have a duration of 3-5-7 years** in the context of roadmaps, **with review and termination points** after three and five years, in order to support speed and continuity in the context of roadmap research, in order to avoid frequent changes in the research teams which are counter-productive with regard to a timely fulfilment of the roadmaps milestones
- **Roadmaps should in general not be changed substantially within a timeframe of 3 years**, which represents an acceptable time to achieve major results in international projects (⇔ operational grants), key milestones should be achievable after 3 and 3+2 and 3+2+2 years
- **PSAs and their roadmaps should not insist that operational grants should be managed according to the traditional management schemes** of space agencies, but also allow for the use of agile management methods

The PSAs may also assist the Commission in monitoring the progress achieved in the context of roadmap, mainly based on progress reports provided by REA.

Smaller-scale PSAs/roadmaps could also be used in the context of collaborative research, identifying some promising low TRL areas to be covered by a set of **some uncorrelated smaller-scale research actions**.

V. Co-Programmed Partnership

As stated earlier, in order to be better able to select and balance between the prioritised roadmaps, such roadmaps could also be pursued collectively under the umbrella of a **Co-Programmed Partnership on "Global competitive space systems" (CPP Space)**.

A Partnership Board could help the Commission with regard to identifying, prioritizing, balancing and monitoring the roadmaps and their corresponding research.

The working groups to support a Partnership Board would perform the dedicated work related to the individual roadmaps in exactly the same way as the above mentioned **Programme Support Activities** do in the absence of a Partnership.

Our principal recommendations related to PSAs given above therefore also apply for the Partnership, implying also that a Partnership should not be a goal in itself, but only be implemented if its structure allows for increasing the impact and speed of implementation of Horizon Europe.

The potential partners of this partnership, namely **ESRE**[2], **Eurospace**, **SME4Space**, **EARTO**, and **EASN**, together provide the feature of "inclusiveness", meaning that any interested European company or research organisation could at least join one of those associations.

Since for a Co-Programmed Partnership standard comitology remains in place and **since the Partnership and its Partnership Board would by construction only assume a purely advisory function** and take no formal decisions, there is in our view **no necessity to found a completely new formal "Stakeholder Association"**.

Hence, a simple "governance" agreement between the five partner associations should be envisaged, instead of following the more formal approach of agreeing on the statutes and the establishment of a new association, which ultimately would lead to the necessity of hiring staff for the new organization and to holding additional meetings such as a General Assembly in order to comply with the legal boundary conditions for associations. This would keep bureaucracy minimal.

A leverage factor of 1,2 envisaged for the "Space"-Partnership lies within the range of factors (1 - 1,5) presently being discussed in the context of other future institutional partnerships, like Clean Sky III and FCH Europe (Fluid Cells and Hydrogen).

Also for ESRE, a leverage factor of around 1 - 1,2 on average appears achievable for research partners, depending on the final definitions and rules as well as the topical contents of the Partnership.

[2] https://www.esre-space.org/

With regard to the high-level political and strategic goals of such a partnership, ESRE recognises that those could be more oriented towards the short-/medium-term aspects of competitiveness as encapsulated in the SRIA, that are mainly in the interest of industry, and only to a lesser extent in the interest of the public research sector.

At the same time **ESRE's expectation is that in the area of traditional collaborative research** and lower TRL road-mapped research, **the long-term competitiveness and the interests of the public research would stand more in the foreground**.

In view of the above, ESRE could support high-level objectives for the Partnership such as:

- Contribute to "Capturing/re-Capturing X%, Y%, etc. of global commercial and accessible telecom, Earth observation and launch services markets by 2028"
- Contribute to Capturing/Re-Capturing of these markets not exclusively but mainly via new cost-cutting technologies and services following "New Space"–type approaches
- Contribute to X% Increase of the number of experimental/technology missions performed by public research establishments

Clearly, while such high-level objectives are important in order to provide strategic orientation, the contribution of Horizon Europe/Partnership to the achievement of such objectives will not be readily quantifiable. On the other hand, the introduction of SMART Key Performance Indicators (KPIs) requires that the indicators relate to goals/milestones which lie within the realm of Horizon Europe. Before such KPIs can be defined, one would therefore first of all need more clarity with regard to the contents of the finally to be agreed upon *new* large-scale roadmaps (beyond on-going SRCs).

With a view to the approved SRIA and current inputs, **ESRE could envisage in particular large-scale road-mapped research in the following thematic areas:**

- Small satellite constellations, system concepts and bus and payload technologies/ architectures
- Commercial Telecommunication (possibly including optical and quantum-safe technologies, of which research might also partially funded via GovSatCom R&TD support); interoperability and integration with terrestrial systems
- Multi sensor systems solutions (such as new advanced optical and radar sensors), and/or multi-layers capacity with various orbits and platforms (e.g. High-Altitude Platforms) carrying multiple payloads for EO
- Technologies and systems for high-speed data handling, processing, storage and transfer
- On orbit servicing, assembly, manufacturing, new services including de-orbiting and active debris removal
- Disruptive and smart satellite technologies and concepts
- In-Orbit Demonstration and Validation programmes, technology maturation in the view of qualification
- Cutting-edge scientific instrumentation in support of space missions, development of advanced planetary robotic exploration techniques, early development work for potential future science and human and robotic exploration missions
- Reusability and micro-launcher, disruptive concepts and technologies for access to space, new space transportation services and concepts
- Next generation structural concepts
- Standardisation of services and actions promoting the use of Commercial Off-The-Shelf (COTS) components, mechanisms of qualification and certification
- Ground segment infrastructure protection and (cyber)security

For concrete examples supporting the above schemes please consult **ESRE's White Paper 2020** and in particular the proposed large-scale projects addressing innovative technologies therein. A list of the large-scale projects has also been attached for convenience in the Annex of this document.

Finally, ESRE would like to express its support for the idea to explore the possibilities for cooperation between the "Space"-Partnership and other Horizon Europe Partnerships, in particular with a view to promoting the emergence of new applications and services.

In this context, cooperation with Partnerships from the areas of "Information and Communication Technologies" and "Artificial Intelligence" might prove especially rewarding.

VI. Science in Horizon Europe

Before providing more ideas for research to be funded in the context of Horizon Europe in the Annex below, we would like to reiterate that it **remains of utmost importance that Horizon Europe continues the funding of "space science"-related activities** concerning data utilization or the development of new instrumentation for European space missions, as space science missions are not only highly relevant due to the underlying science but also as an important source of technological innovation with spin-off effects supporting Europe's competitiveness in the commercial market.

Against this background, this domain was also included in the SRIA endorsed in late 2019.

VII. Annex

1. Thematic Priorities for Partnership/Road-mapped Research/Collaborative Research

Proposals for Work Programme 2021-2022

In the following, ESRE proposes concrete R&TD elements for the envisaged Horizon Europe Partnership, road-mapped research and traditional collaborative research, not only related to "Space Technologies", but also with regard to R&TD in support of the "EU's space programme".

Proposed R&TD elements for large-scaled road-mapped-research/small scale road-mapped research/Co-programmed Partnership (Space Technologies) *(s. also ESRE White Paper 2020)*

- Distributed payloads on-board clusters of small satellites
- Elaboration of new concepts with regard to collaborative small satellite constellations
- Pre-development of a lidar instrument for an active CO_2/GHG Copernicus precursor mission
- Synergies among remote sensing platforms for improved spatial/temporal/spectral resolution
- Design, test and development of a prototype Galileo System Time based on a Composite Clock algorithm
- Design, test and development of a GNSS-based Emergency Warning System for dissemination of alert messages over diverse communication means
- Demonstration of feasibility and technological maturity of optical feeder links for very high throughput satellites in geostationary orbit
- Satellite supported quantum communications and networks

- Design and demonstration of technological maturity of a CubeSat constellation optimised for IoT applications
- R&TD on subcomponents for very high resolution optical and radar surveillance/observation sensors
- Miniaturisation of all kinds of sensors for small satellite constellations, HAPS and RPAS
- Technologies for autonomous and cooperative swarm exploration
- R&TD on new perception, reasoning and planning methods, based on Machine Learning and AI
- Partial demonstration of promising reusable launcher concepts
- Pre-identified structural optimised parts designed for Additive Layer Manufacturing (ALM) to improve ongoing or new missions

Proposed R&TD elements for traditional collaborative research/small-scale low TRL road-mapped research (Space Technologies) *(s. also ESRE White Paper 2020)*

- R&TD on compact and smart sensors for planetary exploration
- Technological maturity and demonstration of very low temperature electronics for scientific exploration missions
- Technological maturity and demonstration of freeform optics
- Technological maturity and demonstration of efficient and compact spectrometric technologies
- Autonomous robots with different mobility capabilities
- Robust rover technology for long-range exploration, including on-board autonomy as well as manipulation and sample handling capabilities
- Autonomous systems with high reliability, and able to work in all lighting conditions (Automated Rendezvous and Docking – AR&D –, proximity operations, target-relative navigation)
- Mechatronic devices for subsurface sampling, drilling and excavation of planetary regolith in reduced gravity field
- Utilisation of data science technologies for analysis of planetary exploration datasets
- Conceptual and subsystem R&TD related to space debris mitigation, avoidance and removal
- R&TD on subsystems and standards for larger CubeSats
- R&TD on optical beamforming technologies
- Increased H/W and S/W modelling functionalities and simulation capacities (also in real-time)
- Next generation light-weight robotic arms and hands for various use cases
- Compact, space qualified, high performance sensors for robotic sensing and operation
- Robotic CubeSat missions for testing cooperative tasks, e.g. formation flying, infrastructure assembly in on-orbit conditions
- Low cost, high performance digital processing systems, including AI solutions, for space applications
- Execution of small-scale ground and flight experiments (including COTS components and high speed flights) to determine optimal system configuration for (partly) reusable launcher
- Guidance Navigation and Control Systems for reusable launch vehicle
- Investigations on innovative lightweight structures and tanks production technology
- Advanced low-cost reusable propulsion system
- R&TD in LOx/CH_4 systems development
- Development of technologies strictly related to entry, descent, and landing
- Future inter-planetary travel ascent and landing technologies demonstrators

Proposed R&TD elements for traditional collaborative research/small-scale low TRL road-mapped research (R&TD in support of the EU's space programme) *(see also ESRE White Paper 2020)*

Copernicus

- Distributed payloads on-board clusters of small satellites
- Elaboration of new concepts with regard to collaborative small satellite constellations
- R&TD on radar sensors (including P-Band and L-Band SAR) and next generation of passive optical sensors (e.g. hyperspectral, fluorescence) and related image processing (for satellites, HAPS and RPAS)
- R&TD on subcomponents for very high-resolution optical and radar surveillance/observation sensors
- Real-time data processing of multi-source data from space, aerial (including stratosphere) and terrestrial sensors, developing both novel coordinated tasking approaches and data fusion technologies, e.g. in the areas crisis management and multi-mission planning
- Development and validation of concepts and models for environmental bioindicators that can be monitored from space
- Continuous data calibration between satellite-received data and simultaneous flight formation laboratories

Galileo

- Coverage improvement, resistance to interference and spoofing

2. ESRE's White Paper 2020 large-scale projects

Transversal

- Distributed payloads on-board clusters of small satellites.
- Elaboration of new concepts with regard to collaborative small satellite constellations.

Earth Observation

- Pre-development of a lidar instrument for an active CO2/GHG Copernicus precursor mission.
- Synergies among remote sensing platforms for improved spatial/temporal/spectral resolution.
- Calibration of satellite data with on-site gathered data.

Navigation

- Design, test and development of a prototype Galileo System Time based on a Composite Clock algorithm.
- Design, test and development of a GNSS-based Emergency Warning System for dissemination of alert messages over diverse communication means.

Communication

- Demonstration of feasibility and technological maturity of optical feeder links for very high throughput satellites in geostationary orbit.
- R&TD on quantum-safe optical telecommunications.
- Design and demonstration of technological maturity of a CubeSat constellation optimised for IoT applications.

Space Science

- R&TD on compact and smart sensors for planetary exploration.

- Technological maturity and demonstration of very low temperature electronics for scientific exploration missions.

Robotics

- Technologies for autonomous and cooperative swarm exploration.
- R&TD on new perception, reasoning and planning methods, based on Machine Learning and AI.

Access to Space

- Identification and evaluation of micro launcher concepts, including subsystem prototype demonstration.
- Identification and evaluation of reusable launcher concepts; identification of the most promising concept(s). Partial demonstration of promising reusable launcher concepts compared to state-of-the-art expendable launchers.

Synergies with other sectors

- Autonomous (cyber) event detection, containment and recovery, e.g. through data mining, machine learning, artificial intelligence/neural networks, quantum measurements, etc.
- Concepts of Space Traffic Control (STC)/Space Traffic Management in terms of technologies and regulation aspects.
- Pre-identified structural optimised parts designed for Additive Layer Manufacturing (ALM) to improve ongoing or new missions.