Horizon 2020

Work Programme 2018 - 2020

1. General Introduction

DRAFT

DISCLAIMER

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1. Introduction

This document, the general introduction to the 2018-20 work programme for the EU's Horizon 2020 research and innovation (R&I) programme describes the context to this major investment, the political drivers behind the setting of priorities, and the new features of this work programme which are aimed at boosting its impact. These measures include highly integrated focus areas, market creating innovation measures, better dissemination of results and open access to data.

Horizon 2020 is a €75billion seven year programme of investment in research and innovation, which began in January 2014. As such the programme has reached its half-way point. And even though the vast majority of the research and innovation activities are still either underway or yet to be started, already there is good evidence to show that it is starting to deliver against its ambitious aims and towards the impacts which are expected.

The overall scale of what is taking place gives an idea of what is at stake. The first Horizon 2020 work programme (2014-15) provided an investment of around €13 billion and the second work programme around €16 billion. As of April 2017 more than 138,000 eligible proposals have been submitted, with more than 12,700 contracts signed.

This will be the last work programme for Horizon 2020, although further work will be needed at a later stage to fill out the details for some of the priorities, notably for 2020.

The mission for the final work programme has four strands:

- **to complete the job; to deliver against the impacts (economic, environmental, social and knowledge) that are expected for the Horizon 2020 programme, taking into account the Interim Evaluation and the first two work programmes;**
- **to accelerate the positive changes underway and now being seen notably in the EU's economy, to which Horizon 2020 has already contributed;**
- **to maximise performance through a series of novel measures, notably for: market creating innovation; better interaction between the physical and digital worlds; resilience to crises; continued focus on sustainable development; and open access to research results;**
- **the last year of the programme will put in place a bridge to enable a smooth transition to any successor to Horizon 2020.**

During its final three years Horizon 2020 will provide investments of around €30 billion. By any measure this is one of the largest integrated single R&I programmes of its types in the world. It is worth recalling therefore, how this is to be achieved and what is expected.

Put simply, Horizon 2020 is addressing common challenges, and for this it is bringing together the top talent and ideas from wherever. Not only is Horizon 2020 drawing on the world beating excellence of EU universities, research performing and innovative companies

including small and mid-sized firms, and the centres of expertise in national laboratories and research organisations, it also teaming up with the best worldwide.

With Horizon 2020 it is possible to solve problems which are greater than could be tackled by one entity or country acting alone, and in the process increases efficiency, reduce overlaps, accelerate progress and boost impact. Most importantly, Horizon 2020 increases the amount of research and innovation that is carried out by the EU, through complementing and leveraging. It also drives up quality, including the research-related and transversal skills of those involved, to give an increased bang for every Euro spent.

Horizon 2020 is at the intersection of many of the EU's ten policy priorities, and these are embedded in the priorities for this work programme. As a result it will support EU competitiveness through the delivery of ideas, development of technology and processes, and innovative solutions for society's challenges; creating businesses, building market share and generating employment.

Also keenly reflected in the way Horizon 2020 is set up and in this work programme is the commitment to promote the policy goals of open innovation, open science and open to the world (three O's).

The final Horizon 2020 work programme has the potential to make a real and sustainable difference to the quality of life in the EU, as well as the EU's position in the world, towards implementation of the Sustainable Development Goals (SDG).

Strategic programming as a tool to boost impacts

Given the huge opportunity and major expectations for Horizon 2020, the design and development of the Horizon 2020 work programmes has attempted to draw together the maximum of the available information and intelligence, through a process described as strategic programming. Boosting impacts including more effective dissemination and exploitation of programme results was the most important guiding thread throughout the planning and development of the work programme.

The strategic programming work began with taking stock on the progress made with Horizon 2020, using 'gap analysis' of what was left to do from the Horizon 2020 Specific Programme priorities. At the same time a foresight exercise provided the opportunity to stand back and examine scenarios on where the EU might want to be in the future, and what would be needed to get there.

Ensuring the programme has wide relevance has also been key and helping achieve this there was an extensive programme of consultation with citizens and experts from all areas of the EU's economy and across society (see Annex 2). This process of consultation has been crucial in getting the proper alignment between this work programme under Horizon 2020, and a broader set of Horizon 2020 actions which includes Joint Technology Initiatives, TFEU Article 185 initiatives, and the European Institute of Innovation and Technology.

Learning the lessons – setting missions – maintaining flexibility

We take forward many valuable lessons which are reflected in the way this work programme is set up and will be implemented, notably by incorporating the results of the Interim

Horizon 2020 Interim Evaluation – 2017

Main points:

(i) Added value, underfunding and oversubscription

Horizon 2020 shows clear EU added value in terms of scale, speed and scope, attracting large numbers of applicants, including many newcomers. But with finite budgets, this has meant average success rates around 13%. Some programme parts fund fewer than 25% above-threshold proposals. To fund all high quality proposals would have needed an additional €60 billion. Fierce competition drives up excellence, but top class researchers and innovators should not be deterred from applying.

(ii) Fundamental research versus close to market innovation

There are concerns over a perceived increase in funding close to market projects (demonstrators, etc.) and, it is argued, a funding gap for collaborative research further from market (e.g. experimental/laboratory stage). Nonetheless, there is evidence of R&I support across the entire TRL scale in accordance with the intervention logic of each programme part.

(iii) The need to enhance societal involvement and societal impact

There is widespread support for further involving citizens and civil society organisations in Horizon 2020 in defining and implementing work programmes and projects. Technological development should be accompanied by research in the social sciences, e.g. better understand citizens' expectations and behaviour.

(iv) Boosting market-creating innovation

Horizon 2020 innovation support is working well, but predominantly directed at 'incremental' innovations, while disruptive innovations that can create new markets receive less support. Improving growth and creating jobs will be helped by recalibrating SME innovation support towards breakthrough technologies and ideas that can scale up rapidly, and on a fully bottom-up basis thus helping ideas which cut across boundaries of sectors and disciplines.

(v) Further simplifying the funding landscape

Horizon 2020 has introduced simplifications of rules and procedures, which are welcomed by stakeholders. It aims for enhanced synergies with other EU funding programmes, compared to its predecessor programme. Some stakeholders call for further rationalisation of the EU funding landscape.

evaluation of Horizon 2020 (see text box on the Horizon 2020 Interim evaluation). The comprehensive assessment this has provided was supported by a public stakeholder consultation which generated close to 3500 replies, and more than 300 position papers.

Multiple sources of evidence were combined and triangulated to ensure their validity. The analysis and findings showed that Horizon 2020 is a successful, well-performing and attractive programme. The evaluation also identified several broad areas for further improvement to be addressed in the final Work Programme.

We need to build on these things that are already working well, but where there is potential to do even better. This fits with and supports the Commission's Budget for Results Initiative[1], aiming to maximise the results of EU spending and added value.

The main directions are clear. There are improvements to the open, challenge-led approach of Horizon 2020, which gives flexibility and space to proposers and helps to focus on solutions and impacts. Overwhelmingly, the evidence (including the consultation feedback and through channels such as National Contact Points and umbrella stakeholder organisations) shows that programme applicants and participants like the challenge-based approach. This next work programme therefore extends the approach further, with **big mission-oriented high impact calls and broader topics,** each supporting a portfolio of projects. At the same time the essentially bottom-up parts of the programme will also continue as before, offering the space and flexibility which researchers seek.

Helping to deliver these missions and enhancing impacts, attention has been directed at the means for more effective dissemination and exploitation of results, linked to specific expectations for stakeholders, including policy makers.

All of this will be implemented and closely monitored in an intelligent way, aiming to ensure there is no downward pull on success rates nor that there is any negative impact on the widening participation aims of the programme.

In parallel with the challenge-based approach, we need to keep sufficient flexibility so that we can respond to unforeseen and rapidly developing events, as already has been shown with the events like the Ebola and Zika virus crises.

Key challenges and important features

The interim evaluation has also provided clear evidence on the challenges which lie ahead.

The increased focus on innovation is one of the standout features so far of Horizon 2020, but again there is still more to do, including addressing regulatory barriers to innovation, and giving special attention to market-creating innovation. In this vein also is the approach to support SMEs which already shows substantial achievements and is improved further in the final work programme.

Setting an appropriate balance between striving for more innovation yet also recognising that this can also require both upstream and nearer market R&I activities has been important. For this reason attention has been paid to the way Technology Readiness Levels (TRL) have been expressed and in which work programme parts.

There has been attention to the way cross-cutting priorities like climate action and sustainable development, gender equality, and the social sciences and humanities (SSH) are embedded in calls and activities through cross-programme integration. A true interdisciplinary approach with the full integration of SSH is crucial to deliver on the

[11] http://ec.europa.eu/budget/budget4results/index_en.cfm

ambition to solve global challenges and create jobs and growth. In the last Work programme of Horizon 2020 accordingly there will be an increased emphasis on integrating SSH wherever relevant.

Other measures have been taken in all work programme parts to reverse the trend of falling international cooperation including flagship initiatives of large scale and scope on topics dedicated to international cooperation in areas of mutual benefit.

There remain, however some key challenges and one of the biggest being the need to improve success rates. It is important that while Horizon 2020 will continue to fund only excellent proposals, there should also be a reasonable chance of success and that researchers' time spent in preparing proposals is neither wasted effort, nor perceived as such. Measures being introduced to alleviate low success rates include amongst others, further targeted use of two-stage calls where appropriate as well as clearer and better structured expected impact statements in the work programme. This has in some places and where needed, required being specific on who or what is expected to be involved in the achieving of impacts, one example being imposing mandatory participation of security practitioners in security research.

Another major concern has been the need to address the persistent divide in research and innovation performance between Member States. This is being tackled through measures that reinforce and complement the actions in the Widening part of Horizon 2020, the need to do more to reinforce synergies with other financial instruments and the need to reflect the important role that research infrastructures can have on development of the European Research Area (ERA).

Ensuring further openness of the programme by attracting newcomers, especially SMEs, also remains high on the agenda.

The Open Science agenda is being supported, notably through dedicated data driven actions, the embedding of approaches and the mainstreaming/promotion of Open Science principles.

There has also been a sustained effort to reflect Responsible Research and Innovation (RRI) issues in all work programme parts.

Finally, it needs to be mentioned that this work programme (2018-20) of Horizon 2020, and especially the yet to be fully developed coverage for 2020, will provide a bridge to link Horizon 2020 with its the successor framework programme.

2. Political Context

Building on the achievements of the previous Horizon 2020 work programmes and the experience with implementation so far, as well as taking account the Union's policy priorities, the following strategic orientations have been integrated into the work programmes for 2018-20:

I. **Increased investment in sustainable development and climate related R&I**: In the light of the Paris Agreement, marking a new era in the fight against climate change, the Horizon 2020 ambition of investing at least 35% of its total budget for climate action becomes more important as does the 60% objective for contributing to Sustainable Development, including in areas like health, food, energy, transport and resource efficiency which call for integrated responses. The focus areas (section 3.3) proposed for this work programme and in particular the one addressing the 'Building a low Carbon, Climate-resilient Future' will provide a very effective means to align R&I investments towards the climate and sustainable development targets. R&I actions should support Europe's priorities to implement the Energy Union, be number one in renewables reduce energy use, and achieve the full decarbonisation of the energy system early in the second half of the century, as well as increasing resilience to the impacts of climate change. Work related to the circular economy and the proposed focus area on 'Connecting economic and environmental gains – the Circular Economy' will also align R&I towards these targets. Both these focus areas should be mutually reinforcing.

II. **Integrating digitisation in all industrial technologies and societal challenges:** As emphasised under the Digital Single Market strategy[2], the combination of digital technologies (big data, internet of things, 5G, high performance computing etc.) with other advanced technologies and service innovation offers huge opportunities for increasing industrial competitiveness, growth and jobs and addressing societal challenges. Digitisation also alters the conduct of research (open science, open data, skills needs, user involvement etc.). Consequently the integration of 'digital' in all its forms, notably digital technologies, the use and management of big data and digital-physical integration should be substantially increased across Horizon 2020, including in all societal challenges. A dedicated focus area on 'Digitising and transforming European industry and services' should foster a better integration and coordination of the efforts conducted across the various parts of the programme and maximise their impact stressing the 'physical meets digital' dimension and showcasing major initiatives. In addition a particular emphasis needs to be put on cybersecurity (see also point IV.) and on addressing the societal impact of the digital transformation. 'Open Science' will be promoted throughout the Work Programme, in particular the 'Open Research Data' approach, and the creation of a European Open Science Cloud fostering the stewardship and re-use of research data and tools across disciplinary and geographical borders. The Commission is already working both bilaterally (South Africa, Australia) and in multi-lateral settings (G7, OECD, G20) to ensure that the EOSC is aligned to similar initiatives on a global scale, on the grounds of common standards, openness and reciprocity. The Strategic Forum for International Science

[2] Notably the DEI (Digitising European Industry) strategy, COM(2016) 180 – 19 April 2016

and Technology Cooperation (SFIC) will be kept regularly informed on the progress of these discussions.

III. **Strengthening international R&I cooperation:** International cooperation is necessary to ensure the EU's scientific leadership, industrial competitiveness and global commitments. It is indispensable to access research excellence and all types of know-how wherever it is located, and to tap into global talent, innovation networks and value chains. However, the participation of 3rd countries in Horizon 2020 has dropped compared to the previous Framework Programme, and the opportunity to use Horizon 2020 to establish international leadership is underexploited. Measures will be taken in the next work programme across all areas to reverse this trend and to maximise international cooperation for mutual benefit. This should notably include reinforcing and setting up new international cooperation flagship initiatives in areas of mutual interest. SFIC will be kept regularly informed on the implementation of the flagship initiatives. It is also envisaged to increase efforts to attract and retain researchers in Europe as well as to open mobility paths for European researchers elsewhere in the world, including the Marie Skłodowska-Curie actions (MSCA) and the European Research Council;

IV. **Societal Resilience:** Europe is facing multiple and seemingly sudden changes on multiple fronts, such as large migration pressures, cyber-crime, security threats as well as hybrid threats. Such events require, more than ever, capacities for coordinated EU responses.

Research on **security** threats, notably from terrorism (e.g. on the links between terrorism and other forms of serious and organised crime and on the forces leading to radical alienation) can underpin an effective and coordinated EU response. Better tools, whether technical or organisational, for reacting to natural and man-made disasters can reduce loss of life and material damage. Ensuring cybersecurity requires looking at vulnerabilities of critical infrastructures and digital services and calls for new technological as well as non-technological solutions, e.g. to ensure data protection, so that the full economic and social potential of digital technologies can be safely exploited. A dedicated focus area, 'Boosting the effectiveness of the Security Union', will address these issues.

Migration and more broadly the mobility of highly qualified people (including researchers) offer great opportunities to meet challenges faced by the EU (skills shortage, demographic change, etc.). At the same time, migration flows need to be managed, as highlighted by the European Agenda on migration. Research should help improve our capacity to foresee and address the challenges of (legal and irregular) migration and to develop effective policies for integrating migrants in our society and economy. Synergies will be sought between activities related to the 'Sustainable Development Goals' and 'Migration' to address root causes of migration, including, for example, activities related to poverty alleviation, food safety and security, sustainable agriculture and improved nutrition

V. **Market creating innovation:** Europe could perform better in capturing innovative ideas with the potential to create new markets and strengthen Europe's industrial base. The increasing proliferation of digital technologies and the rise of new business models and innovations at the boundaries between different sectors offer new

opportunities to spur economic growth and job creation. Innovation-friendly framework conditions are a prerequisite for such new markets to develop in Europe. A major new component in Horizon 2020 will be first elements of a European Innovation Council (EIC) which will focus on support for radically innovative firms and entrepreneurs with the potential to scale up their businesses rapidly at the European and global levels. Moreover Horizon 2020 will make better use of prizes and support large-scale demonstrators that not only test technological and non-technological innovations, but also address legal and standardisation requirements as well as citizen/user/consumer involvement. Stronger links will be created between the industrial technologies parts and the societal challenges, in particular, through the focus areas and with view to supporting the modernisation of Europe's industrial and economic base. Coordination and synergies between the European Institute of Innovation and Technology (EIT), other relevant parts of Horizon 2020, and the EIC will be ensured as well as with other EU programmes notably ESIF.

3.0 Implementation of Horizon 2020 work programme

The strategic orientations and priorities for the final Horizon 2020 work programme have been translated into calls for proposals and topics. Each call has a clearly defined mission, within a broad challenge, linked to expected impacts at the level of the call. Impact statements are provided at the level of the topic. These include where appropriate, relevant indicators to support effective proposal evaluation and ex post evaluation of progress towards achieving the expected impacts, at project and programme levels.

Focus areas

A small number of missions which cut across the programme boundaries are implemented as focus areas. Each of these aligns with major political or policy drivers, and are endowed with a substantial budget to allow for work of sufficient scale, depth and breadth.

Focus areas are expected to create an exceptional impact, addressing ‘big ticket’ challenges.

Focus areas are in effect 'virtual calls', which constitute the linking of topics from respective parts of Horizon 2020 through a new rationale, and thereby unlocking new types of impact and added value. This is achieved through aligning aspects of the implementation such as proposal submission deadlines and evaluation procedures, and also putting in place measures to share information and create synergies between ongoing projects throughout the life-cycle (e.g. publicity, project monitoring). At the same time, the 'contributing' calls and topics remain within the structure and logic of their respective work programme parts in Horizon 2020. Overall the effect is to get more from the same investment and build critical mass where it is needed.

The choice of focus areas accommodates both top-down perspectives i.e. in line with the political drivers, and bottom-up i.e. drawing on ideas generated at the thematic level.

Accordingly, focus areas were selected using criteria including:

- degree of fit with politically derived drivers;
- European added value, with convincing description of expected impact;

- potential for engagement of the stakeholder community;
- integration across the work programme;
- achieving integration of cross-cutting objectives, including coverage of the innovation chain.

The intervention logic of the focus areas is addressed through a coherent set of topics, and calls which will be implemented in a coordinated way as described above.

Four focus areas are described in Annex 1.

Other cross-cutting priorities

Other important cross-cutting priorities are given visibility and managed in a coherent way across the programme, but without the characteristics of a focus area.

For example, migration remains a pressing challenge and while not implemented as a focus area, will be addressed in the work programme across several thematic areas through an integrated and interdisciplinary approach to issues such as root causes, the management of migration and the integration of migrants in host societies. The goal is to mobilise expertise across disciplines, sectors and stakeholders that can spur innovative solutions, practices and policies.

Innovative solutions for inclusive, safe, resilient and sustainable cities are also a cross-cutting concern. These are addressed under areas such as governance, planning, citizen engagement, boosting equal opportunities, promoting social integration and community building.

Marine and maritime research for Blue Growth will be implemented through a strategic and coordinated approach across all challenges and priorities of Horizon 2020.[3] It will aim at unlocking the potential of resources from seas, oceans and inland waters for different uses and across the range of marine and maritime industries, while protecting the environment and adapting to climate change. Blue Growth will support sustainable growth in the marine and maritime sectors, through sustainable exploitation of marine resources for healthy, productive, safe, secure and resilient seas and oceans. The coordinated approach will involve not only the Blue Growth Call of Societal Challenge 2, but also relevant topics from other parts of Horizon 2020, including Societal Challenges on Climate Action, Transport and Energy which will be interlinked through a flagging system.

Market creating innovation

A major new component to be piloted in Horizon 2020 will focus on support for innovative firms and entrepreneurs with the potential to scale up rapidly at the European and global levels.

This new approach brings together instruments - SME instrument, prizes, FET-Open, Fast track to innovation - which can deliver breakthrough innovations and close to market

[3] REGULATION (EU) No 1291/2013 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2013 establishing Horizon 2020 - the Framework Programme for Research and Innovation (2014-2020) and repealing Decision No 1982/2006/EC – Annex 1 Broad lines of the specific objectives and activities

solutions. Further changes include making the SME instrument fully 'bottom up' so that innovative projects that cut across sectors and technologies can be supported. Moreover Horizon 2020 will make better use of inducement prizes to deliver breakthrough technology solutions. The Commission will also seek to provide simpler access to EU innovation support and ensure that the evaluation process targets innovations with the potential to create and capture new markets. These actions build on ideas generated by the Call for Ideas conducted in spring 2016, and will provide the first elements towards a European Innovation Council.

4.0 Communication, open access to research results and a new emphasis on data management

This Work Programme continues the new approach under Horizon 2020 to access to research results, to data management, as well as to communication.

Open access to scientific peer reviewed publications

As in previous Work Programmes, and following the policy outlined in the Horizon 2020 Regulation and the provisions of the Model Grant Agreement (article 29.2.), each beneficiary must ensure open access (free of charge, online access for any user) to all peer-reviewed scientific publications relating to its results.

Further information on Open Access in Horizon 2020 is made available on the Participant Portal.

Open access to research data and research data management

The Open Research Data Pilot (ORD pilot) in Horizon 2020 aims to improve and maximise access to and re-use of research data generated by projects.

This ORD pilot covers all thematic areas of Horizon 2020 in order to "make open research data the default option", as announced in the Communication 'a European Cloud Initiative – Building a competitive data and knowledge economy in Europe'. This is indicated in the introduction of the thematic work programmes4 Otherwise the setup of the ORD pilot remains the same and is described in Article 29.3 of the Horizon 2020 Model Grant Agreement(s) or its equivalent.

Open access applies to those data needed to validate the results presented in scientific publications. Additionally, projects can chose to make other data available for open access and need to describe their approach in a Data Management Plan (DMP, see below). However, as stipulated in the Horizon 2020 Rules for Participation (Regulation No 1290/2013 of the European Parliament and of the Council of 11 December 2013) the Commission takes into consideration the legitimate interests of the participants and any constraints pertaining to data protection rules, security rules or intellectual property rights. It therefore provides

[4] Note that some *instruments* are excluded, namely those co-fund actions that do not produce data, prizes, ERC proof of concept instruments, and the SME instrument Phase I.

robust possibilities for projects to partially or entirely opt-out of open access to research data before or after5 the signature of the grant agreement (see general annex L).

It needs to be stressed that in the evaluation phase, proposals will not be evaluated more favourably because they engage in data sharing, and will not be penalised for opting out.

Participating projects will receive dedicated support. In particular, any costs related to open access to research data and related data management and data sharing costs (including the creation of a DMP) will be reimbursed if they are incurred during the duration of the project, and specific technical and professional support services will be provided.

Further information on research data sharing is made available on the Participant Portal.

Horizon 2020 provides for the use of Data Management Plans (DMPs) detailing what data the project will generate, whether and how it will be exploited or made accessible for verification and re-use, and how it will be curated and preserved. Ideally, the DMP should address the relevant aspects of making data FAIR – findable, accessible, interoperable and re-usable.

The use of a Data Management Plan is required for all Horizon 2020 projects, except if they opt-out of sharing their research data for one of the reasons indicated in general annex L. Note that a DMP is not required at submission stage. Rather, projects must provide a first version of the DMP within the first six months of the project (as a deliverable), to be updated as appropriate. Further information on Data Management Plans is made available on the Participant Portal.

Communication by H2020 projects

As in previous Work Programmes, and following the policy outlined in the Horizon 2020 Regulation and the provisions of the Model Grant Agreement (article 38.1.), beneficiaries must promote the action and its results, by providing targeted information to multiple audiences (including the media and the public) in a strategic and effective manner.

Contribution to the corporate communication of the Union's political priorities

Horizon 2020 may contribute financially to corporate communication in 2016 in accordance with article 28 of the Regulation establishing the Programme. This contribution would cover the corporate communication of the Union's political priorities to the extent that they are related to the general objective of the Programme

5.0 Complementarity with other Work Programmes

Complementing this Work Programme are the direct research activities carried out by the Joint Research Centre through its own Work Programme, the indirect actions of the Euratom Programme and of the ERC, the joint actions of the Public-Public Partnerships (P2Ps), and the

[5] Once the project has started, opt-outs are possible via an amendment (to remove article 29.3. of the grant agreement) or by explaining why datasets are kept closed in the Data Management Plan. The latter is preferable, since it is a more flexible approach.

work of the European Institute of Innovation and Technology (EIT) in its efforts to build Knowledge and Innovation Communities (KICs).

6.0 Key websites

The key websites to help those submitting proposals for Horizon 2020 funding and for information are:

- the Participant Portal (incorporates a powerful search facility for the Work Programme) at http://ec.europa.eu/research/participants/portal/desktop/en/home.html
- Participant Portal Glossary http://ec.europa.eu/research/participants/portal/desktop/en/support/reference_terms.html
- the Horizon 2020 site on Europa at http://ec.europa.eu/programmes/horizon2020/
- the Community Research and Development and Information Service (CORDIS) at http://cordis.europa.eu/

Annex 1

Focus Area

'Building a low-carbon, climate resilient future'

Introduction

The COP21 Paris Agreement[6] (PA) marked the beginning of a new era in the fight against climate change. R&I is essential to find the ground-breaking solutions needed, including in particular the energy system where there are great opportunities for innovation and for reinforcing competitiveness.

This Focus Area covers all actions in the Horizon Work Programme 2018-20 that can contribute to the goals of the Paris Agreement, offering very large solution-oriented funding opportunities, and promoting broad international cooperation activities. It aims to develop solutions capable of achieving the carbon neutrality and climate resilience of Europe by the second half of the century. This requires a highly integrated approach through the multiple angles of society, economy, technology, industrial value chains and environment, health, land use and governance. It also underpins the Communication 'Accelerating Clean Energy Innovation', adopted in November 2016. It will help to achieve the expenditure target of 35% for climate action in Horizon 2020.

Mission

This mission will achieve the following key elements.

- **operationalisation of the PA goals, on the basis of high quality policy-relevant evidence from the scientific community.** The ambitious goals of the PA need to be translated into pathways for action, demonstrating how the required economic and social transformations can occur. Over the next decade, science is needed to underpin the next cycle of IPCC reports (2018-2022) that will contribute to the UNFCCC Global Stocktake process. At the same time, the accuracy and reliability of current greenhouse gas (GHG) emission monitoring needs to be improved to enable the signatories of the PA to assess their man-made GHG emissions at country and regional scales, and hence the effectiveness of the implementation of their mitigation policies.
- **accelerated transformation towards carbon neutrality, through the co-design, co-development and co-deployment of technologies and services by researchers, entrepreneurs and citizens.** The pathway to climate neutrality requires decisive action in the energy system, but it is crucial that mitigation also takes place in sectors such as transport, industry (including through key enabling technologies and in energy-intensive industries and manufacturing), agriculture-forestry and land use, and in the built environment. This should go hand in hand with fostering resilience, through an integrated approach that considers the complex nexus of natural resources and human activities. Critical innovation in services, in business models and in integrating digital technologies is also needed to support the deep economic and societal transformation required. Better understanding, quantifying and valuing

[6] http://unfccc.int/paris_agreement/items/9485.php

of the co-benefits of mitigation action such as improved health and nutrition, efficiency of resource and infrastructure use, environmental protection, quality of life, will also be crucial.

- **enhanced climate resilience in Europe and beyond**. In sectors such as infrastructure, water, agriculture and forestry, as well as in cities, research is needed into multiple risks and impacts, together with development of innovative solutions to minimise the adverse consequences of climate change. The impacts of climate change on health have to be assessed in order to develop effective actions to reduce exposure. Tailored tools, such as climate services, and approaches for understanding and implementing adaptation action at all levels, including local, are needed.
- **long term mitigation and adaptation policy planning, deployment of technology to reduce emissions and enhanced climate change resilience in developing countries.** International cooperation will be vital to inform and support countries' mid-century low-emission development strategies and first updates of their (Intended) Nationally Determined Contributions by 2020, as well as to address those regions which are most vulnerable to climate change. Technological cooperation, such the one envisaged by Mission Innovation, is also essential. Science diplomacy in this field should be a component of climate diplomacy, and actions should ensure coherence with EU Climate Diplomacy goals.

Components of the focus area[7]

An integrated package of actions in this work programme will contribute to achieving the desired mission of this focus area.

Leadership in enabling and industrial technologies - Nanotechnologies, Advanced Materials, Advanced Manufacturing and Processing, and Biotechnology (LEIT-NMBP):

Key enabling technologies provide the basis for innovation in most of the key sectors for decarbonisation. Innovative advanced materials and nanotechnologies enable reliable, efficient and affordable energy production and storage solutions, which are indispensable for the electrification of road transport and the integration of sustainable energy production sources in the electricity grid. Actions address research and innovation on materials for stationary and mobile storage solutions and for advanced sustainable energy production.

Decarbonisation in the construction sector – one of the main contributors to greenhouse gas emissions in Europe – requires further development, demonstration and validation of key breakthrough technologies for buildings and districts. The Public-Private-Partnership on Energy-efficient Buildings addresses these needs. It will target plus energy houses, the integration of smart materials in buildings, integrated storage systems, and the industrialisation and digitalisation of construction processes.

][Budget (tbc)]

[7] Contributions not confirmed and subject to revision

Leadership in enabling and industrial technologies- Space:

R&I in this work programme part aims to ultimately help countries to support and evaluate the effectiveness of their CO_2 emission reduction strategies by investing in novel space missions for an end-to-end monitoring system to acquire homogeneous and reliable datasets and to integrate those in advanced modelling systems for monitoring man-made CO_2 emissions. If the research results demonstrate sufficient technological maturity, these will be considered for the evolution of Copernicus, the EU programme for Earth observation and monitoring, which can be harnessed for a wide range of climate services. The use of Earth observation data and information, delivered by Copernicus and GEOSS, is key to better understanding the phenomena related to climate change processes and to monitor the emission of greenhouse gases. Satellite navigation (GALILEO) enabled services can also support societal resilience and facilitate smart technologies and services for various applications that reduce emissions, including green, safe and smart mobility

Societal Challenge 2 'Food security, sustainable agriculture and forestry, marine, maritime and inland water research, and the bioeconomy' (SC2):

Agriculture, forestry and the underpinning natural resources are increasingly affected by threats and shocks attributed to climate change. In the **agri-food** sectors, R&I addresses the need to increase resilience to climate change by adapting farming and food systems, , strenghtening underpinning ecosystems, addressing emerging threats to food safety, while ensuring long-term food and nutrition security. It will also mobilise the various bio-based sectors tackled by SC2 to move towards carbon neutrality, including the contribuition of the forest-based sector. Furthermore, R&I activities will allow better understanding the synergies and trade-offs between adaptation and mitigation measures in primary production. In the **marine and aquatic sector,** R&I will assess the effects of climate change on marine ecosystems and biological resources in view of better managing their response capacities and resilience, as well as the impact of climate change on fisheries and aquaculture. In line with the Communiqué of the G7 S&T Ministers, actions also focus on further developing observations of physical, biogeochemical and biological variables.

[Budget (tbc)]

Societal Challenge 3 'Secure, clean and efficient energy' (SC3):

European carbon neutrality requires the decarbonisation of the **energy system,** while ensuring at the same time a more efficient energy use, a secure supply of energy, affordable prices and low environmental impact. Increased R&I support in this work programme part therefore targets reducing costs and improving the performance of renewable technologies together with their integration into the energy system. Developing cost effective and reliable storage solutions is a further priority, complemented by reducing the climate footprint of cities, increasing energy efficiency in buildings and industry as well as decarbonising the use of fossil fuels and developing breakthrough low-carbon solutions for energy-intensive industries. Technological advances will have to be complemented by activities facilitating the market uptake of energy technologies and services, fostering social innovation, removing non-technological barriers and promoting standards.

Societal Challenge 4 'Smart, green and integrated transport' (SC4):

R&I in this work programme part aims to accelerate the decarbonisation of the **transport system** as a whole, by advancing electromobility and battery technologies, supporting the shift towards environmentally friendly mobility solutions, driving digitisation for more efficient (and safer) transport and mobility, developing disruptive and game-changing low carbon solutions, and allowing the emergence of new business models and innovation-friendly standards and regulations, in particular in urban areas. Decarbonisation of transport also requires continuous advancements in energy efficiency of both vehicles and the way people and goods move, through innovative approaches for design and manufacturing, the use of alternative fuels, Intelligent Transport Systems and behavioural change.

[Budget (tbc)]

Societal Challenge 5 'Climate action, environment, resource efficiency and raw materials' (SC5):

Actions in this work programme part aim to contribute to the IPCC and the Global Stocktake processes by addressing areas of relevance for the 6th IPCC Assessment Report cycle, including key knowledge gaps in climate processes, tipping points and Earth observation needs for improving predictability. The deep societal and technological transformation involved in the accelerated mitigation pathways required to achieve the PA goals will also be studied. In-depth assessments of impacts, vulnerabilities and risks and solutions for disaster risk reduction and enhancing resilience of human systems and ecosystems and climate-proofing of assets, sectors and critical infrastructures in support of decision making will be carried out, also through the development of climate services and the deployment of nature-based solutions. Special consideration is given to cooperation with strategic partner countries/regions and in particular key emitters and vulnerable regions.

Climate action beyond this focus area:

It should be noted that many parts of the Work Programme beyond this Focus Area will also contribute towards climate action objectives. The integration of digital technologies will play a central role, since ICT-enabled solutions are projected to be able to reduce EU carbon emissions by over 1.5 Gt CO2e by 2030. Smart manufacturing, smart buildings and smart energy are potentially the most promising areas, accounting for almost 75% of ICT-enabled potential carbon savings, while smart and precision agriculture could lead to 30% more yield. Consequently activities supported under the Focus Area 'Digitisation' are also very relevant to achieve the COP21 goals.

Many synergies also exist with actions under the Focus Area 'Circular Economy', including the Sustainable Process Industries (SPIRE) initiative, since improving the efficiency and effectiveness of resource use (both primary and secondary) will help boost energy efficiency while also leading to a reduction in greenhouse gas emissions.

Focus Area

'Connecting economic and environmental gains – the Circular Economy'

Introduction

The circular economy makes both environmental and business sense; its benefits are: improved global competitiveness; growth that no longer requires increasing consumption and extraction of resources, energy, water and primary raw materials; less waste; and maintaining the value of products and resources in the economy for as long as possible. Given the increasing competition for resources, the circular economy will be indispensable in averting wars.

The European Commission has adopted an ambitious Circular Economy package[8], with actions to stimulate Europe's transition towards this new model. It covers the whole cycle: production, consumption, waste management and secondary raw materials. It recognises the key role of research and innovation.

Realising the circular economy needs more than traditional R&D or a piecemeal approach to technologies: it needs changes in entire systems, from the joint efforts of researchers, technology centres, industry, the primary sector, entrepreneurs, users, governments and civil society. It needs regulatory frameworks; and additional public and private investments.

This focus area will consolidate relevant R&I initiatives to make a strong contribution to sustainable development goals, to climate action and to industrial competitiveness. It will reflect the interface between products, services, waste and chemicals, linked to EU policy work on raw materials, a plastics strategy, the product policy framework and initiatives towards a non-toxic environment. It will also boost the contributions of Horizon 2020 to sustainable development and climate action.

Mission

The mission is for Europe to lead the way in developing an economy which minimises waste and pollution, and uses its resources efficiently.

The contribution of this focus area will be in renewing Europe's industrial capacities and boosting growth, in a world of finite resources. This will need new technologies, new business models, and their uptake by industry and SMEs; linking different sectors and public bodies; developing integrated value chains; and better communication to engage society and consumers. The impacts will be observed in:

- A measurable improvement in the efficiency and effectiveness of resource (primary and secondary use), including energy;
- Measureable reductions in waste, environmental pollution and greenhouse gas emissions; transforming recyclable waste into a flourishing market of secondary raw materials;
- Sustaining and making use of natural cycles;

[8] *Closing the loop - An EU action plan for the Circular Economy*, COM(2015)614 final

- Competitive advantages for existing businesses;
- New businesses opportunities, including disruptive innovation;
- Security of raw materials supply.

Components of the focus area[9]

This focus area will be achieved through extensive integration between the Industrial Leadership and Societal Challenges parts of Horizon 2020. The R&I side of the approach will focus on enabling technologies, including digitisation, combined with cross-sectorial efforts, systemic innovation and demonstrators targeting high technology readiness levels (up to TRL 7). This will deploy a large array of instruments including demonstrators, covering the research to innovation cycle, including end-users, and addressing the supply and demand-side to help create markets.

Leadership in enabling and industrial technologies - Nanotechnologies, Advanced Materials, Advanced Manufacturing and Processing, and Biotechnology (LEIT-NMBP): European high-tech building blocks serving circular economy approaches

The Sustainable Process Industries (SPIRE) initiative, addressing eight key European industrial sectors, will enable a more efficient use of resources (raw materials, water etc.) and energy (including renewables); high-tech and eco-efficient production facilities and materials; and minimising and re-using waste, including CO_2 (and other gaseous effluents). Through industrial symbiosis between the eight industrial sectors, SPIRE is looking at integrating, demonstrating and validating technologies and business models, and fostering their uptake; this will build up a true European industrial renaissance and will make an indispensable contribution to the circular economy. The same activities also contribute significantly to a low-carbon future and energy security. The priorities for the period 2018-2020 will be in adaptable processes able to use different feedstock and alternative energy sources; innovative processes leading to CO_2 reduction and valorisation as new feedstock; new methods including digitisation for process optimisation; and new approaches to water as feedstock and energy source.

The NMBP part will also supply activities in advanced materials to catalyse the circular economy; industrial biotechnology for e.g. biodegrading plastics; and new, sustainable business models based on emerging value chains and eco-design.

[Budget (tbc)]

Societal Challenge 2 'Food security, sustainable agriculture and forestry, marine, maritime and inland water research, and the bioeconomy' (SC2): the bio-economy aspects of the circular economy.

The activities will help increase efficiency and minimise losses and waste throughout primary production, the food chain and bio based industries. They will include social innovation as a

[9] Contributions not confirmed and subject to revision

powerful driver for solutions. Life-cycle assessment, de-toxification and measurement tools will boost the secondary raw materials market

These activities will help add value to terrestrial and aquatic biological resources and develop new avenues for putting in place the '3R principles' of Reducing, Reusing and Recycling. A circular economy will need new economic activities and technologies, which require proof-of-concept and integration in existing value chains, including in the rural sector. The funding will also serve to strengthen the links between rural, coastal and urban resource flows, and to foster more diverse farming models (e.g. mixed farming and agro-forestry) with optimised nutrient flows on and across farms. Food waste is a major issue for the circular economy, where social innovation is particularly important in providing solutions for valorisation of biowaste. Land and sea residues (agricultural, aquaculture and fisheries), and other organic waste streams, also have considerable potential. The more efficient use of fertilisers and the recycling of nutrients are critical circular economy issues for agriculture – and mitigate damage to seas through eutrophication and de-oxygenation.

Because it is based on renewable resources, the bio-economy is a key enabler of the circular economy and must be based on the sustainable and resource efficient production and use of the biological resources. Bio-based industries are leading innovators in industrial symbiosis and the more efficient use of waste and by-products, for example through innovations in bio-refineries aimed at the integrated production of food, bio-based products and energy.

[Budget (tbc)]

Societal Challenge 3 'Secure, clean and efficient energy' (SC3): reuse of carbon dioxide

Using captured CO2 and hydrogen made from renewable energy to produce fuels is not only a means to replace fossil fuels, but also a promising solution for seasonal energy storage. There are still relevant and significant scientific and technological challenges to be able to exploit the CO2 as a chemical and fuel feedstock in a systematic manner. There is therefore a need to develop highly energy-efficient CO2 utilisation technologies for chemical energy storage or displacement of fossil fuels that allow for upscaling in the short to medium term. New solutions for the conversion of captured CO2, either from power plants or from carbon-intensive industry to useful products such as fuels or chemicals will create new markets for innovative industrial sectors as well as contribute to achieving a Circular Economy.

[Budget (tbc)]

Societal Challenge 5 'Climate action, environment, resource efficiency and raw materials' (SC5): transition to circular economy business models and practices, and sustainable sourcing or raw materials, also from secondary sources

The R & I activities will investigate new products, processes and business models, to use raw materials and other resources more efficiently and effectively in production and consumption. Attention will be paid to product durability, for instance through methods to test for premature obsolescence. The activities will also aim to facilitate the use of secondary raw materials while at the same time reducing potential adverse health and environmental impacts. Research will also investigate the consequences of the transition to the circular

economy, in order to identify potential risks, side-effects and regulatory challenges, as well as policies that can effectively support the transition and mitigate potential adverse effects. Demonstration actions will focus on circular economy approaches in water management and in urban contexts. Digital solutions will play an important role as enablers of the circular economy.

There will also be support for greater resource efficiency in raw materials value chains. This will cover sustainable and responsible extraction and sourcing of raw materials, sustainable processing, including metallurgical processing and processing of wood waste, advanced and resource-efficient waste management systems and technologies and recycling of wood and of mineral and metallic raw materials from complex products complex products, including those containing significant amounts of critical raw materials.

[Budget (tbc)]

Digitisation is a potential game changer for the circular economy, to be pursued across the various contributions. In manufacturing and processing, the convergence of digital echnology with advanced process technologies, in the context of the 4th Industrial Revolution, can enable a paradigm shift from a linear economy (take-make-throw away) to a model of closed production and consumption loops, which include sharing, reuse, remanufacturing, harvesting of components and recycling of materials. Digital technologies such as IoT and big data are enablers for creating such loops, enabling new modes of production (e.g. on demand) and consumption (e.g. sharing), as well as new business models (e.g. product as a service).

Social sciences and humanities should complement the technological drivers, with approaches ensuring a good governance of the circular economy, the 4th Industrial Revolution and frugal innovation; with a fair distribution of the productivity gains.

In addition, related activities are financed by other parts of the Horizon 2020 Work Programme including bottom-up parts such as the European Research Council (ERC),

Circular economy beyond this focus area:

Other EU R&I policies also relevant to the circular economy are as follows listed below.

Innovation deals: The innovation deals[10] have been included as a pilot in WP 2016-2017 under the focus area "Industry 2020 in the Circular economy" and in the Circular Economy Communication. A review of this pilot is foreseen for mid-2018. The ways in which innovation deals can be implemented through actions in WP 2018-2020 could be considered, taking into account the outcome of the review.

[10] https://ec.europa.eu/research/innovation-deals/index.cfm

Focus Area

'Digitising and transforming European industry and services'

Introduction

There is huge potential still offered by further digitisation of products and services in terms of wellbeing, growth and creation of jobs. Advances related to digitisation, underpinned by key enabling technologies[11] (KETs), are also needed to provide solutions to several major societal challenges, such as improving the monitoring of health and the support to the elderly, tackling climate change through reducing energy consumption and improving the management of the energy system, increasing the safety and the efficiency of transport systems, closing the digital gap between rural and urban areas and improving the sustainability, productivity and transparency of agriculture and food systems.

In April 2016, the Commission issued a communication outlining its strategy for allowing the European Union to fully seize these digital opportunities. Beyond the support to key technological areas, an essential aspect is to foster the uptake of digital technologies and innovations, as well as synergies with other key enabling technologies. This will contribute to the Digital Single Market Strategy of the Commission.

The ongoing digitisation of industry and services has a profound effect across all sectors. On the manufacturing side, it leads to customised products, distributed and localised production and new innovation models that empower citizens and communities, as well as improved knowledge and facilities sharing. It is underpinned by research and innovation in relation to several technological trends. The Internet of Things, Big Data, Cloud, high-performance computing and artificial intelligence are the most prominent ones. In many application cases, disruptive innovation actually comes through the convergence of these trends. Moreover, the full transformative potential of digitisation can only be realised if it is demand-driven and if it responds to the needs of the 'physical' world, through a close involvement of users across all industrial sectors with a true multidisciplinary approach aimed at systemic rather than incremental improvement to the benefit of society.

Such transformation will substantially change the working environment and will strongly impact the workforce, people and the whole society.

Mission

The mission is to support digitisation as a driver of this major transformation in an integrated manner. Grouping digitisation and related transformation in a single focus area will reinforce coordination, allow to address uptake and investment barriers, and lead to synergies, knowledge transfer and common technological developments and standards that will support platforms and applications across sectors. This will in turn enable economies of scale and foster the emergence of user driven innovative solutions, products and services cutting across sectorial silos. By reaching out beyond EU Programmes towards MSs and Regions, it will increase political visibility and critical mass.

[11] KETs comprise micro and nanoelectronics, nanotechnology, industrial biotechnology, advanced materials, photonics, and advanced manufacturing technologies (see COM(2009) 512).

- **enabling all sectors and application areas to adapt, transform and benefit from digitisation,** notably by allowing also smaller and newer players to capture value;
- **developing industrial strategies, including new business models**, and leverage this major transformation to increase the competitiveness of EU industries and create new markets;
- **connecting to Member States and regions** in order to better align research and innovation agendas and develop synergies;
- **removing barriers for innovation enabled by digitisation,** by addressing issues such as up- and cross-skilling, harmonising regulatory frameworks and standardisation.

Components of the focus area[12]

A significant part of the focus area will be implemented with the two following types of activities:

Innovation hubs:

With the rapid pace of change in digital technologies, most industrial stakeholders, and especially SMEs, point out to the urgent need for facilities to experiment with and test digital innovations and other key enabling technologies before investing. For digital, innovation hubs solve this problem by providing easy access to the latest digital innovations and experimentation facilities and fostering synergies with other key enabling technologies. For materials, they bring together all the competencies and facilities required for up-scaling, fast adoption and wide spread technology transfer of, novel nano and material technologies in an open innovation environment.

cross-sectorial and integrated digital platforms and large-scale pilots for experimentation and co-creation with users:

Pilots and demonstrators could notably address the digital transformation of manufacturing, health and care, agriculture, nutrition, connected and automated driving, and include integration of space data and associated platforms.

LEIT-ICT will support a series of digital innovation hubs aimed at fostering:

- the take-up of digital game changers and digital manufacturing platforms by SMEs and mid-caps in the manufacturing sector,
- the acceleration of the design, development and uptake of advanced digital technologies by European industry in products that include innovative electronic components, software and systems, and especially in sectors where digital technologies are underexploited,
- an improved uptake of photonics and robotics technologies by end-user industry.

[12] Contributions not confirmed and subject to revision

Moreover, as part of the implementation of the Digitising European Industry initiative,

LEIT-ICT will contribute to the launch of a set of initiatives supporting the building of the digital platforms of the future in several application areas.

LEIT-NMBP, LEIT-Space, Societal Challenges 1, 2, 3, 4 and 6 will also contribute to the focus area.

Working to ensure a high level of security for Europeans is an objective set by the Treaties, and a common European responsibility. The importance of the Security Union agenda has been highlighted in the Commission Communication of 20 April 201613 and by the subsequent appointment of a Commissioner for the Security Union. The majority of Member States depend entirely on Horizon 2020 to cover their needs for innovative security solutions, and it represents 50% of the overall public funding for security research in the EU.

At the core of research in this area is the development of new products to meet the needs of security practitioners. Research is not just about developing new technologies or applying emerging technologies, but also requires understating phenomena such as violent radicalisation and the development of more effective policies and interventions. This means social sciences and the humanities will be involved.

To help end results correspond to real needs, research will generally require the involvement of security practitioners and those working with at-risk groups, for example fire and rescue services, police forces, border and coast guards, municipalities, social workers, educators and civil society actors.. One challenge is segmentation of civil security industry largely into national markets. Progressive development of a single market also in this area can be expected to bring benefits of economies of scale, providing incentives to businesses to develop new solutions and lowering costs for purchasers. To facilitate supply and demand for new goods and services, innovative procurement (PCP, PPI) will be used.

Mission

The mission for this Focus Area is to support implementation of the Security Union priorities. Specific issues to be covered are: reacting to and recovering from natural and man-made disasters; preventing, investigating and prosecuting crime including organised crime and terrorism; improving border entry security; protecting infrastructure against natural and man-made threats, including cyber-attacks; digital security and privacy; and space-related research.

- Reduced loss of life and reduced environmental, material and economic losses from natural and man-made disasters.
- Key infrastructure better protected against natural and man-made threats, including cyber-attacks.
- New products that meet the needs of security practitioners in the EU, including for investigating and prosecuting crime (including cybercrime) and terrorism.
- EU borders better secured against the entry of undesirable persons or goods.
- Ensuring a secure and trusted networked environment for the governments, businesses and individuals, thus positioning the EU as a world leader in building a more secure digital economy.
- Support for EU and national policies related to security, including those focusing on prevention.

13 *Delivering on the European Agenda on Security to fight against terrorism and pave the way towards an effective and genuine Security Union*, COM(2016) 230 final, 20.4.2016.

- Space-related research harnessed to support security.
- Better understanding of the complex and interrelated drivers and societal contexts of security challenges including in particular radicalisation and polarisation.

Components of the Focus Area[14]

This focus area will help to integrate security-related actions under Horizon 2020.

Leadership in Enabling and Industrial Technologies – ICT:

Activities will include assuring security and privacy in the design and management of networks, achieving a high degree of trust in EU digital networks, products and services and developing the ecosystem of skilled professionals, educators and EU-wide harmonized regulation, policies and standards. Specific research topics should be complemented by multidisciplinary research on longer term challenges, addressing non-technical aspects of cybersecurity and digital privacy such as economics and law as well as political science and international relations. These topics also contribute to the Commission's commitment under the Cybersecurity cPPP.

[Budget (tbc)]

Leadership in Enabling and Industrial Technologies – Space:

Activities will address space-related threats such as space debris and space weather: space surveillance and tracking (SST) and space traffic management aim at the protection of European infrastructure in space and a greater autonomy of Europe in its access to and use of space, for example by developing services related collision avoidance in space. Space weather research will improve modelling and enable forecasting of space weather events that could impact space and ground infrastructure such satellite systems and terrestrial as power grids and telecom networks. Satellite navigation (EGNSS) applications will foster societal resilience relevant for management of critical infrastructure, timing and synchronisation and will develop search and rescue applications, including tracking of distress situations and response management.

[Budget (tbc)]

Societal Challenge 1: 'Health, demographic change and wellbeing' (SC1):

Toolkit for assessing and reducing cyber risks in hospitals and care centres to protect data/infrastructures; Raising awareness and developing training schemes on cybersecurity in hospitals Instrument.

[Budget (tbc)]

[14] Contributions not confirmed and subject to revision

Societal Challenge 6: 'Inclusive, innovative and reflective societies' (SC6):

Activities will address the prevention of radicalisation through social inclusion, the impact of extreme ideologies on societal polarisation, and the drivers and contexts of violent extremism in the broader Middle East and North Africa (MENA) region and in the Balkans. The EU's Common Security and Defence Policy and the expanding scope of the EU's external engagement will also be addressed. In addition, the trafficking of cultural goods and its link to terrorism financing will be explored.

[Budget (tbc)]

Societal Challenge 7 'Secure Societies' (SC7): Security, Critical Infrastructure Protection:

In line with relevant EU policies, the activities will aim to reduce the loss of human life, environmental, economic and material damage from natural and man-made disasters, including from extreme weather events, industrial disasters, crime and terrorism threats (**disaster-resilient societies**); to develop new capabilities for fighting and preventing crime (including cybercrime), illegal trafficking and terrorism (including cyber-terrorism), including understanding and tackling terrorist ideas and beliefs, taking account of human factors and of the societal context whilst respecting human rights and privacy (**fight against crime and terrorism**); to develop capabilities required to enhance systems, equipment, tools, processes, and methods for rapid identification to improve border security, whilst respecting human rights and privacy; to address supply chain security in the context of the EU's customs policy; to develop capabilities and solutions required to support the Union's external security policies in civilian tasks, ranging from civil protection to humanitarian relief, border management or peace-keeping and post-crisis stabilisation, including conflict prevention, peace-building and mediation (**borders and external security**). In addition, activities will aim at **protecting the infrastructure in Europe** by developing comprehensive approaches to secure the integrity of existing or future, public or private, connected and interdependent installations against disruptions that may result from many types of hazard, including physical and/or cyber-attacks on installations and systems.

[Budget (tbc)]

Societal Challenge 7: 'Secure Societies' (SC7): Digital Security:

In line with the Commission's July 2016 Communication on strengthening cyber-resilience and fostering the cybersecurity industry, activities aim at addressing the main challenges of digital security. These topics contribute to the Commission's commitment under the Cybersecurity contractual Public Private Partnership (cPPP) established in 2016 the aims of which include engaging end-users in sectors that are important customers of cybersecurity solutions (e.g. energy, transport, health, finance) towards defining and providing to industry their sector-specific common digital security, privacy and data protection requirements.

[Budget (tbc)]

Leadership in Enabling and Industrial Technologies – ICT:

Activities will include assuring security and privacy in the design and management of networks, achieving a high degree of trust in EU digital networks, products and services and developing the ecosystem of skilled professionals, educators and EU-wide harmonized regulation, policies and standards. Specific research topics should be complemented by multidisciplinary research on longer term challenges, addressing non-technical aspects of cybersecurity and digital privacy such as economics and law as well as political science and international relations. These topics also contribute to the Commission's commitment under the Cybersecurity cPPP.

[Budget (tbc)]

In addition, related activities are financed by other parts of the Horizon 2020 Work Programme including bottom-up parts such as the European Research Council (ERC), as well as the SESAR Joint Undertaking and the ECSEL Joint Undertaking.

Annex 2:

Foresight, consultation and advice

Foresight

A programme of foresight work supported the preparations of this work programme. This work included reviewing existing foresight evidence to analyse important future trends such as globalisation, demographic change, inequalities, climate change and digitalisation as well as potential disruptions such as quantum technologies, synthetic biology and robotics.

This work highlighted eight issues as being expected to impact on society in the coming decades: i) Hyper-connectivity and big data driving change and innovation; ii) Falling cost of energy fostering innovation (e.g. separation and recycling of raw materials, drinking water from the seas on a vast scale) as one potential game changer; iii) Migration and demographic dynamics challenging European societies; iv) Pressure on health systems and health inequalities; v) Climate change, oceans and space; vi) Primary sector innovation being key for sustainability and well-being; vii) Biotechnology as the next wave of disrupting technologies; viii) Increasing instability as a new reality for societies.

Stakeholder consultation

Consultation activities were tailored to the needs and characteristics of the various parts of Horizon 2020, taking account of different R&I environments and target groups as well as the results of recent stakeholder consultations on related policy initiatives, for example in the framework of the Digital Single Market, the Energy Union, including the strategy 'Accelerating Clean Energy Innovation', or the 'call for ideas' for the European Innovation Council. Work has included open public consultations via the 'Your Voice in Europe' in areas where also citizens could directly contribute (Societal challenge 'Food' and 'Science with and for society') as well as open consultations using other platforms for ICT related issues[15]. Eight areas conducted dedicated written consultations targeted at respective stakeholder groups[16] and four organised specific consultation events[17].

The consultation also extended to the existing thematic groupings and networks like European Technology Platforms, European Innovation Partnerships, Public-Public and Public-Private Partnerships or Joint Programming Initiatives, as well as the Committee of the Regions, European Agencies (e.g. European Medicines Agency, FRONTEX, EUROPOL) and international bodies like the OECD. The work of specific expert groups (e.g. High Level Group on European Open Science Cloud), the results of FP projects like CIMULACT[18] enabling direct interaction with citizens, studies and conferences/workshops reflecting stakeholder views were also integrated in the consultation process.

[15] 'Future and Emerging Technologies', 'Research e-Infrastructures', LEIT-ICT and eHealth
[16] Future and Emerging Technologies (FET), Research Infrastructures, LEIT-NMBP, Space, Societal Challenges 'Health', 'Transport', 'Climate action' and 'Security'
[17] Space, Innovation in SME, Societal Challenge 'Secure Society', Spreading Excellence and Widening Participation
[18] http://www.cimulact.eu/

Advisory Groups

There are 19 Horizon 2020 Advisory Groups, composed of experts in R&I and across the breadth of stakeholder communities, and the membership of all of these was renewed during 2016-2017.

All of the Advisory Groups submitted a report with suggestions for priorities in the various Horizon 2020 work programme parts, or for integration of cross-cutting policy priorities. In addition, meetings were held with the chairs of the Advisory Groups to further support cross-programme integration.

This multifaceted and targeted approach allowed the capturing of opinions, latest trends and evidence that fed into the elaboration of future calls and topics in the work programme.