EN

Horizon 2020

Work Programme 2018 - 2020

1. General Introduction

Important notice on the Horizon 2020 Work Programme

This Work Programme covers 2018, 2019 and 2020. The parts that relate to 2019 and 2020 are provided at this stage on an indicative basis. Such Work Programme parts will be decided during 2018 and/or 2019.

(European Commission Decision C(2017)7124 of 27 October 2017)

Contents

1. Introduction - what is different about this work programme?

This document, the general introduction to the 2018-20 work programme for the EU's Horizon 2020 research and innovation 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 in particular at boosting its impact. These measures include highly integrated activities called focus areas (Appendix 1), market creating innovation measures, better dissemination of results and open access to data.

With a total investment of €75 billion over a seven year programme, Horizon 2020 is one of, if not the largest integrated single research and innovation programmes of its type in the world.

Horizon 2020 began in January 2014 and therefore has reached its half-way point. And even though most research and innovation activities are still either underway or yet to be started, already there is good evidence to show that the programme is on track to deliver against its ambitious aims and towards the impacts which are expected.

Horizon 2020 is implemented via multi-annual work programmes, with the first Horizon 2020 work programme (2014-15) providing an investment of around €13 billion and the second work programme around €16 billion. As of mid-September 2017 more than 126,000 eligible proposals have been submitted, with nearly 14,000 contracts signed.

During its final three years Horizon 2020 will provide further investments of around €30 billion in research and innovation. This is 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.

Horizon 2020 is at the intersection of many of the European Commission's ten policy priorities, which have been used as the basis to create a set of specific priorities for this work programme, set out in more detail in section 2 of this document.

Guiding lines for the work programme:

- **Complete the job; deliver against the objectives of the Horizon 2020 Specific Programme, taking into account the Interim Evaluation and first two work programmes;**
- **Deliver against the EU's political priorities and three O's;**
- **Maximise the potential impact notably through enhancing impact statements at call and topic level, substantial reduction of topics giving more freedom to innovators and researchers to prepare novel solutions;**
- **Put in place a bridge with the last year of the programme to enable a smooth transition to any successor to Horizon 2020.**

The result is **to provide a clear focus**: to 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 in the short, medium and long-term.

Helping to reinforce this is the commitment given in this work programme to promote the policy goals of open innovation, open science and open to the world (three O's).

Overall, 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 have attempted to draw together the maximum of the available information and intelligence.[1] 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 work began with taking stock on the progress made with Horizon 2020, using 'gap analysis' to identify the degree of coverage of the Horizon 2020 Specific Programme priorities. At the same time a foresight exercise (Appendix 2) 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, facilitating convergence and bringing in some new ideas.

Ensuring the programme has wide relevance has also been key and helping to achieve this there was an extensive programme of consultation with citizens and experts[2] from all areas of the EU's economy and across society (Appendix 2). This process of consultation has been crucial, also in helping with 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 – MAINTAINING FLEXIBILITY

The Commission takes 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 Evaluation of Horizon 2020[3]. 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

[1] This is described as 'strategic programming', in line with the requirements of the Horizon 2020 Specific Programme article 5(6) that work programmes should follow 'a multi-annual approach and strategic orientations for the following years of implementation'. It underpins the integrated approach for the work programme, ensuring work programme parts work together.

[2] The reports of Advisory Groups are at https://ec.europa.eu/programmes/horizon2020/en/experts

[3] The evaluation results can be accessed here http://ec.europa.eu/research/evaluations/index_en.cfm?pg=h2020evaluation; the Interim Evaluation of Art 185 and Art 187 initiatives are being finalised.

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, and specific information on the changes and improvements is provided in the introductions to each of the work programme parts.

We need to build on these things that are already working well, but where there is also potential to do even better. This fits with and supports the Commission's Budget for Results Initiative[4], aiming to maximise the tangible results on the ground of EU spending (e.g. innovation projects, cross-border infrastructure, and employment) 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. 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 high impact calls and broader topics,** each supporting a balanced 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 enhanced impacts, attention has been directed at the means for more effective dissemination and exploitation of results, such as specific references in the expected impact statements of the work programme topics as well as supporting actions in the part of the work programme for 'Dissemination Exploitation and Evaluation'.

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, it is important to keep sufficient flexibility to be able to 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 opportunities as well as problems still to be solved.

The increased focus on innovation is one of the standout features so far of Horizon 2020, but there is still more to do, including addressing regulatory barriers to innovation, building synergies with other EU instruments and giving **special attention to market-creating innovation**. In this vein also, the approach to support SMEs 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 require both upstream and nearer market research and innovation (R&I) activities has been important. For this reason attention has been paid to the way Technology Readiness Levels (TRL) have been expressed; making sure that TRLs

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

are used where it makes sense; and reinforcing the message during the preparation of the work programme that funded projects should typically cover a range of research and innovation activities across the innovation cycle, including projects where the centre of balance is at higher TRL levels.

There has been attention to the way important 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 integration of SSH is crucial to deliver on the 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**. (A fuller description of cross-cutting priorities in this work programme is provided in section 2.)

Other measures have been taken in all work programme parts to facilitate international cooperation including around **30 flagship initiatives of large scale and scope on topics dedicated to international** cooperation in areas of mutual benefit, comprising a total budget of over **€1 billion.**

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

Specific Lessons Learned From the Horizon 2020 Interim Evaluation for Work Programme 2018 - 2020

In line with the findings presented in the Interim Evaluation of Horizon 2020 Staff Working Document, the Horizon 2020 work programme for 2018-2020 incorporates several of the lessons learnt during the evaluation process.

In particular, the Work Programme:

- **Strengthens the programme design, structure, content, and outreach through improvements in the clarity of the impact statements and stronger links with the legal objectives, as well as better dissemination of results;**
- **Aims to tackle oversubscription by expanding the number of two stage calls;**
- **Further simplifies, through a lighter and more focussed work programme and a pilot topic on lump sum cost reimbursement;**
- **Steps up the support to breakthrough innovations through the introduction of the European Innovation Council Pilot;**
- **Rationalises the research and innovation funding landscape with a limited number of focus areas;**
- **Boosts international cooperation i.a. by launching international flagship initiatives of significant scale and scope on dedicated topics and by supporting the EU's external policies;**
- **Ramps up investments in sustainable development and climate action by identifying them as strong priorities;**
- **Continues to support the open sharing of data and publications.**

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 and the different regions of Member States, as also observed in the case of most Outermost Regions and the other regions of their mainland. For this, a new topic is included in the work programme part for Science With and for Society. This is being tackled amongst other ways through measures that reinforce and complement the actions in the Widening part of Horizon 2020 and promote synergies with the European Structural and Investment Funds (ESIF) in particular in relation to smart specialisation[5].

Ensuring **further openness of the programme by attracting newcomers, especially SMEs, is an area where major progress has been made** but 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.

For the future, this work programme, and in particular the coverage of 2020 which will be developed later, will help to bridge with the successor framework programme.

[5] See also COM(2017)376 'Strengthening Innovation in Europe's Regions: Strategies for resilient, inclusive and sustainable growth' and related SWD(2017)264

2. What are the big priorities?

For this work programme five major priorities were identified, themselves founded on the overall policy priorities for the EU, and a significant proportion of the budget has been focused on these. Attention is drawn in particular to initiatives in key areas like the Digital Single Market, (High Performance Computing, ICT, SMEs), Energy Union, Mobility (batteries) Space and the Circular Economy including work on plastics.

Priorities are described below, with examples of some of the initiatives to translate the priorities into actions in the work programme, notably the focus areas (see section 3 and Appendix 1) which **together give a combined budget of over €7 billion.** Underlining this is the delivery against the three main axes of 'openness' in this work programme, shown in the boxes.

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 proposed for this work programme and in particular the one addressing 'Building a low Carbon, Climate-resilient Future' (**budget of €3343 million**) 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 move towards decarbonisation of the energy system, as well as increasing resilience to the impacts of climate change.

Over **€2 billion** will be invested in the four strategic priorities identified

Open Innovation

Horizon 2020 marked a definite shift towards innovation, which is reinforced by the concept of Open Innovation in this work programme which includes:

- **around €2.7 billion for the EIC work programme**
- **several Open Innovation test beds (> €200 million)**
- **around 30 topics and €300 million in the Societal Challenges pillar**

The aim is to open up the innovation process to all active players so that knowledge can circulate more freely and be transformed into products and services that create new markets, fostering a stronger culture of entrepreneurship. The European Union is a research powerhouse, still the world's leading producer of scientific knowledge, ahead of the United States. However, Europe still needs to improve with turning research into innovation, in getting research results to market. Too often, new technologies that have been developed in Europe are commercialised elsewhere. Europe must get better at making the most of its innovation talent, and that's where Open Innovation comes into play.

in the Accelerating Clean Energy Innovation Communication, namely renewables, energy storage solutions (in particular batteries) energy efficiency in buildings, as well as electro mobility and more integrated urban transport systems. Work related to the circular economy and the proposed focus area on 'Connecting economic and environmental gains – the Circular Economy' (**budget of €941 million**) 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[6], 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' (**budget of €1689 million**) 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

Open Science

This work programme marks a step change in the way Open Science (OS) is promoted through Horizon 2020 with:

- **nearly 10% of the budget channelled to direct or indirect support for OS**

There are four approaches: actions addressing specific aspects of Open Science; contributions to the development of the European Open Science Cloud (EOSC); open data-driven science; explicit references to the use/experimentation of open science approaches (e.g. knowledge- or data-sharing, spreading of best practices through networks, platforms and hubs).

All parts of the work programme contribute to Open Science but 'Research Infrastructures' stands out due to the large support to the EOSC and to the European Data Infrastructure. A number of thematic clouds in various domains are foreseen and will eventually feed into the EOSC; a Blue Cloud pilot gathering data from the maritime sector and Food Cloud demonstrators hosting nutrition and agri-food scientific repositories will be early movers and set useful precedents for clouds in other pioneering sectors, such as health and transport.

To increase the uptake of open access (OA) to scientific publications in Horizon 2020 a platform for Horizon 2020 beneficiaries to publish open access is to be set up for an initial period of four years. Provisionally entitled 'EC Open Research Publishing Platform', this will provide a fast, cost efficient and high quality service, targeted towards the grantees of Horizon 2020 and its successor framework programme.

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

Open to the World

This work programme is reinforcing existing and setting up new flagship initiatives of significant scale and scope on topics dedicated to international cooperation in areas of mutual benefit:

- **in total around 30 flagship initiatives with over €1 billion budget**

For instance: collaboration with Canada for human data storage, integration and sharing to enable personalised medicine approaches; EU-Africa Research and Innovation Partnership on Food and Nutrition Security & Sustainable Agriculture; EU-China cooperation in food, agriculture and biotechnology; an All Atlantic Ocean Research Alliance Flagship; acceleration of energy innovation through the Mission Innovation Initiative; cooperation with multiple international partners on greener and safer aviation, on road transport automation and safety and on clean urban transport; climate action in support of the Paris Agreement; international cooperation on sustainable urbanisation; EU-India water co-operation; cooperation on 5G with Japan, Korea, China and Taiwan; cooperation with multiple international partners on nanosafety; and structuring cooperation with Russia in research infrastructures.

point IV.) and on addressing the societal impact, including on the workforce, 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 European Open Science Cloud (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 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, as well as supporting the EU's external policies including those on development. 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 this work programme across all areas to reverse this trend and to maximise international cooperation for mutual benefit. The Outermost Regions, due to their strategic location, have a role to play in that respect. This will 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. In addition, efforts will be

increased to attract and retain researchers in Europe as well as to enhance mobility paths for European researchers, in particular through the Marie Skłodowska-Curie actions (MSCA).

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', (**budget of €1044 million**) will address these issues. As recently highlighted[7], Europe urgently needs to reinforce its cybersecurity technology and industrial capacity. A special effort will therefore go to a pilot action for the development of a European network of cybersecurity Competence Centres. Due to its importance, the preparations for this activity will begin immediately, with a view to being launched as early as possible in 2018.

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 and decent quality work.

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 quality 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 innovative firms and entrepreneurs with the potential to scale up their businesses rapidly at the European and global levels. Moreover Horizon

[7] JOIN(2017) 450: 'Resilience, Deterrence and Defence: Building strong cybersecurity for the EU'

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. An EIC will need to ensure efficient interaction with other key players in the innovation ecosystem, notably the EIT/KICs and Eureka.

3. Implementation - new ways to focus effort

The priorities for this work programme have been translated into calls for proposals and topics. Each call has clearly defined impacts at call and topic level, 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 major actions 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, thereby also supporting better integration across work programme parts

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

Focus areas are in effect 'virtually linked 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 Appendix 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.

Another high priority is to give support to the development of electric batteries. These will play an essential role in the transformation of our societies towards less dependency on fossil fuels and radical reduction of emissions derived from anthropogenic activity. The Commission foresees a big action on electric batteries worth €200 million running until the end of Horizon 2020. Four topics with a total EC budget of €100 million are proposed in this work programme 2018-20, with the addition of a similarly large investment through additional topics in later revisions of the work programme.

Strategic interest in playing a key role in the Arctic region is another major concern. A safe, stable, sustainable and prosperous Arctic is important not just for the region itself, but for the EU and for the world. It is important to equip Europe with a better understanding of the developments the region is facing; Arctic research is a crucial cross-cutting component, not solely from a global environmental and sustainable development perspective, but also related to economic and social challenges and opportunities with great importance to the EU. Translating research results into cold-climate technologies and services, piloting and deployment of innovations and the development of sustainable Arctic Standards will further increase the impact of Horizon 2020.

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. 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 Horizon 2020 Societal Challenge 2, but also relevant topics from other parts of Horizon 2020, such as other Societal Challenges and Leadership in Enabling and Industrial Technologies, 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 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[8], and will constitute the pilot phase of a European Innovation Council.

[8] Responses to the Call for Ideas can be found at: https://ec.europa.eu/research/eic/pdf/eic_call_for_ideas-overview.pdf

4. Making research and innovation more visible - communication, open access to research results and a new emphasis on data management

This work programme continues the approach under Horizon 2020 for better 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.[9] 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 choose 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 robust possibilities for projects to partially or entirely opt-out of open access to research data before or after[10] 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 Data

[9] 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.

[10] Once the project has started, opt-outs are possible via an amendment (to remove Article 29.3. from 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.

Management Plan) 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 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 Data Management Plan 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 Horizon 2020 Participant Portal.

COMMUNICATION BY HORIZON 2020 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 2018 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-Private Partnerships (PPPs); Public-Public Partnerships (P2Ps) including the new initiative *for sustainable management of water and agro-food systems 'A new Partnership on Research and Innovation in the Mediterranean Area (PRIMA)', which has a* €220m contribution from Horizon 2020; the contractual Public Private Partnerships; the work of the European Institute of Innovation and Technology (EIT) in its efforts to build Knowledge and Innovation Communities (KICs); and other schemes.

Also to be mentioned are the synergies and complementarities, including the need to enhance these further, between Horizon 2020 and ESIF.

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 CORDIS (for research results and projects database) at http://cordis.europa.eu/
- http://cordis.europa.eu/
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Appendix 1

Focus Area - *'Building a low-carbon, climate resilient future'*

Introduction

The Paris Agreement[11] (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.

Total Budget for this Focus Area:

€3343 million

This Focus Area covers all the main 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 in the second half of the century, and to contribute substantially to similar achievements in neighbouring and development countries.

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.

Focus area impacts

This focus area 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

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

digital technologies is also needed to support the deep economic and societal transformation required. Better understanding, quantifying and valuing 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

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 crucial 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 €271 million

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.

Budget €82 million

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 contribution of the forest-based sector. Furthermore, R&I activities will allow better understanding of 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, including the development of the Arctic marine ecosystems, which are becoming increasingly crucial for harvesting fish and other marine biological resources. These ecosystems are not only affected by climate change, but also by pollution and invasive alien species. In line with the Communiqué of the G7 S&T Ministers[12], actions also focus on further developing observations of physical, biogeochemical and biological variables.

Budget €203 million

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

European climate 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 and climate resilience. Increased R&I support in this work programme part therefore targets – in line with the priorities of the 'Accelerating Clean Energy Innovation' Communication – cost reduction and performance improvement of a broad portfolio of renewable technologies (as well as their integration into the energy system); improved energy efficiency in buildings (contributing to the decarbonisation of the EU building stock by 2050) and other areas (e.g. industry, products, services etc.); and affordable and integrated energy storage solutions as a means to increase the flexibility of the EU energy system as a whole. Closely related to these objectives are activities supported by SC3 which aim at reducing the climate footprint of cities; improving the efficiency of the energy system, especially for energy islands; supporting energy consumers to play a more active role in the energy transition; enabling near-zero CO2 emissions from fossil fuel power plants and carbon intensive industries; and deepening the understanding of the Social Sciences and Humanities aspects of the energy transition. The focus on developing and demonstrating technological advances is complemented by activities facilitating the market uptake of energy technologies and services, fostering social innovation, removing non-technological barriers and promoting standards. To ensure that the EU is competitive also in the next technology generation, support is also provided for early-stage research activities aiming at breakthroughs Finally, activities are supported that foster synergies between EU and

[12] http://www.g8.utoronto.ca/science/2016-tsukuba.html

national funding thereby increasing the structural coherence of EU efforts in terms of clean energy R&I at various levels.

Budget €1 953 million

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 user-centred mobility solutions (also contributing to the relevant priority of the "Accelerating Clean Energy Innovation" Communication) and integrated services fostering a truly multi- and cross-modal approach, driving digitisation for more efficient (and safer and more secure) transport and mobility, developing disruptive and game-changing low carbon solutions, and allowing the emergence of new, socially sustainable business and operating 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 €408 million

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. Attention will be given to the Arctic's prominent role in climate change, as feedback loops are turning the Arctic into a contributor to climate change with relevance not just for the region but for the whole planet. Special consideration is also given to cooperation with strategic partner countries/regions and in particular key emitters and vulnerable regions.

Budget €426 million

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[13]. 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 PA goals.

[13] Report 'The role of ICT in reducing carbon emissions in the EU', British Telecommunications 2016, https://www.btplc.com/Purposefulbusiness/Ourapproach/Ourpolicies/ICT_Carbon_Reduction_EU.pdf

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. 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.

Total Budget for this Focus Area:

€941 million

In the circular economy, growth no longer requires increasing consumption and extraction of resources, energy, water and primary raw materials; there is less waste; and products and resources maintain their value in the economy for as long as possible. Given the increasing competition for resources, the circular economy will be a key factor in averting wars.

The European Commission has adopted an ambitious Circular Economy package, 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.

There are further links to EU policy on raw materials and upcoming Circular Economy initiatives on plastics, water and the interface between waste, products and chemical policies.

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

Focus area impacts

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 resource constraints. 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. Success will be seen in:

- A measurable improvement in the efficiency and effectiveness of the use of resources (primary and secondary), including energy;
- Measurable reductions in waste generation, environmental pollution and greenhouse gas emissions; transforming recyclable waste into a flourishing market of secondary raw materials;
- Competitive advantages for existing businesses;
- New businesses opportunities, including disruptive innovation;
- Security of raw materials supply.

Components of the focus area

This focus area entails extensive integration between the Industrial Leadership and Societal Challenges 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, 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 the circular economy

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). SPIRE is contributing to a European industrial renaissance and will make indispensable contributions to the circular economy. The same activities also contribute significantly to a low-carbon future and to energy security. The priorities for the period 2018-2020 will be in adaptable processes able to use different feedstock and alternative energy sources; recovery of industrial water and of the energy and substances it contains; making the most of mineral waste, by-products and recycled material; and new methods including digitisation for process optimisation.

In addition activities in advanced materials will catalyse the circular economy. This includes fostering innovation on plastic materials to improve the recyclability and end-of-life impacts.

Budget €370 million

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 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. Residues from agriculture, aquaculture and fisheries, and other organic waste streams, also have considerable potential. Using fertilisers efficiently and recycling nutrients are critical 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 amongst the 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 €253 million, including €100 million for access to risk finance

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

Using captured CO_2 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 in exploiting CO_2 as a chemical and fuel feedstock in a systematic manner. Highly energy-efficient technologies are needed to use CO_2 for chemical energy storage or displacement of fossil fuels, allowing for upscaling in the short to medium term. These activities are complemented by ongoing activities in SPIRE.

Budget €12 million

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, services, 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 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 €306 million

In addition to this explicit support in 2018-20, other parts of Horizon 2020, such as the European Research Council (ERC), have financed closely related activities and are expected to continue to do so.

Circular economy beyond this focus area:

Beyond the funded projects, a number of initiatives will complement the circular economy:

Innovation deals[14] have been included as a pilot in the Circular Economy Communication and in the work programme 2016-2017 under the focus area "Industry 2020 in the Circular economy". As a part of the pilot, one innovation deal has been launched, in the water reuse domain, and another one, addressing optimisation of e-vehicle battery usage, is in preparation. An evaluation of the pilot in mid-2018 may lead to ways in which innovation deals can be implemented through actions in the work programme 2018-2020.

The *Circular Economy Finance Support Platform* is a deliverable under the Circular Economy Package and was launched in January 2017. The Platform brings together the European Commission, the European Investment Bank (EIB), National Promotional Banks (NPBs), financial market participants, businesses and other stakeholders, to increase awareness of the circular economy business logic and improve the uptake of circular economy projects by investors.

An inducement prize in frugal innovation [tbc]

Open Innovation and innovative business models are included in many topics (e.g. NMBP); a main goal of these is to include all relevant stakeholders ("multi-actor approach" in SC2).

International cooperation is covered, for instance with China in industrial biotechnology and with Africa in agriculture. There are also support actions on the responsible sourcing of raw materials and the certification of waste treatment facilities.

Networking of projects and stakeholders: this will build on solid experience, e.g. in the highly relevant field of catalysis; and in EASME, involving projects on water and waste. Selected projects from different programmes may also be networked.

[14] 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, services and industrial processes in terms of wellbeing, growth and creation of jobs. Advances related to digitisation, underpinned by key enabling technologies[15] (KETs), will transform industry and 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.

Total Budget for this Focus Area:

€1689 million

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 based on smart new business 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. This also requires attention to creating the right framework conditions for societies to benefit from technological change and to promote equal opportunities with access to the labour market, fair working conditions and wages, and sustainable and adequate social protection systems.

Focus area impacts

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

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

cutting across sectorial silos. By reaching out beyond EU Programmes towards MSs and Regions, it will increase political visibility and critical mass.

- **enabling all sectors and application areas to adapt, transform and benefit from digitisation and enabling technologies,** 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

Part of the focus area will be implemented with the two following types of activities:

Innovation hubs:

With the present rapid pace of change of science and technology innovation, most industrial stakeholders, and especially SMEs, point out to the urgent need for facilities to experiment with and test digital innovations and new advances in other key enabling technologies before investing.

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. A hub is a reference at the state of the art in its technology domain. A hub is also recognized by its openness and easy access and by its ability to interface with an ecosystem. In accordance with the DEI strategy[16], more than €300 million will be invested into digital innovation hubs through this Work Programme.

For nanotechnology and advanced materials, open innovation test beds are ecosystems bringing together all the competencies and facilities required for the development, testing and upscaling in industrial environments. Each one will offer services like computational modelling; characterisation; risk-benefit assessment to ensure regulatory compliance; and market analysis. About €320 million will be invested in these open innovation test beds through this work programme.

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.

Leadership in Enabling and Industrial Technologies – ICT:

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,

[16] COM(2016)180

- 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.

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.

Budget: € 461 million

Leadership in Enabling and Industrial Technologies – Space:

Activities will include (1) new applications of space robotics for orbital and planetary use including in-orbit satellite refuelling and servicing operations, robotised in-orbit assembly of large modular structures and fundamental operations of planetary rovers. (2) In the domain of satellite communications, development and demonstration will target key enabling components and technologies which contribute to the competitiveness of European industry including secure satellite communications, high speed processing, flexible telecommunication payloads and optical communications for very high throughput systems. (3) Satellite navigation (EGNSS) applications will contribute to digitisation of products and services that will speed up the adoption of EGNOS and Galileo in mass markets and create applications that adopt EGNSS innovative features such as better multipath resistance and authentication, as well as development of applications addressing societal challenges, notably in health, citizen safety, mobility, smart cities, sustainable resources monitoring.

Budget: € 59 million

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

This part of the industrial leadership pillar will provide the key enabling technologies that underpin digitisation and will help transform industry. It will support:

- Open innovation test beds, complementing the digital innovation hubs, which will enable the upscaling and uptake of nanotechnology and advanced materials in industrial products and applications.
- To complete this ecosystem, test beds for computational modelling and characterisation will meet the needs of users, for example by reducing dramatically the need for experimental validation.
- The support for Factories of the Future will focus on the transition to a flexible, digitised, resource-efficient and demand-driven manufacturing sector reflecting the fourth industrial revolution.

Budget: € 703 million

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

Timely and meaningful information and knowledge for personalised health and care services are essential for health systems, society and citizens. Digital solutions can support prevention of health risks, self-empowerment of patients, innovative approaches

to diagnostics and treatments, and independent living. Moreover, ICT-based services have the potential to promote health and care as drivers for social and economic change.

Activities of Societal Challenges 1 in the Focus Area of "Digitising and Transforming European Industry and Services" will address the need for secure and user-driven ICT-based solutions in early risk detection and interventions with big data approaches that enable aggregation of a variety of new and existing data sources such as medical records, registries, social platforms and other environmental, physiological and behavioural data. It will aim at offering solutions for smart living environments and smart hospitals.

Budget: € 60 million

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

Information and Communication Technologies (ICT) have the potential to transform production systems in aquaculture, agriculture and the related food value chains and to contribute to healthier and more sustainable diets. They also provide considerable development opportunities for rural and coastal areas arising from better connectivity, increased social inclusiveness and openings for new business models. However the pace of technological innovation is proceeding faster than never before and it is important to ensure that EU farmers, rural communities, food processors, retailers, service outlets and citizens take fully advantage of the "digital revolution".

Through the contribution to the Focus Area "Digitising and transforming European Industry and Services", Societal Challenge 2 (SC2) will explore the conditions under which benefits of ICT applications can be maximized for those involved in the daily provision of food and nutrition security to citizens within and beyond the EU.

Activities under SC2 will look for improving knowledge and innovation systems, speeding up the rate of knowledge creation based in the potential of the use of data. Improving interoperability would allow for increased data sharing and the resulting knowledge generation in farming, food and nutrition systems, both terrestrial and aquatic.

Actions will be taken to provide researchers with services for open research data storage, management, analysis and re-use across scientific disciplines that are relevant to food, nutrition, agriculture, aquaculture and the marine.

In addition, SC2 will help the farming sector to become more competitive by building Digital Innovation Hubs (DIHs) across Europe. DIHs will facilitate the adoption and widespread transfer of ICT based solutions for agriculture

Finally, to overcome the digital divide between rural and urban areas, activities will develop the potential offered by connectivity and digitisation of rural areas supporting a plethora of cross-platform applications that can address societal changes and economic growth in rural areas.

Budget: € 107 million

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

Joint initiatives included in this section of the Focus Area 'Digitising and transforming European industry and services' build a bridge between the Digital Single Market and the Energy Union by supporting innovation to fully seize the opportunities offered by digital technologies to the energy sector.

At a time when the energy landscape is undergoing a fundamental change towards decentralisation and decarbonisation, the introduction of new and smarter technologies will make an important contribution. They will help integrate renewable energies from variable and distributed resources in the energy systems and increase efficiency through better monitoring and optimisation of assets.

These technologies can moreover provide an opportunity for the uptake of new energy services and business models enabling consumers in the active participation in the energy system and energy markets. The key issues to promote the digitisation of the energy sector are the following:

- Interoperability of communication to and from the appliance/device in a smart home to enable smart energy services, possibly combined with other services for consumers;
- The ability of the energy sector to handle much larger amounts of data than they currently do and use them to optimise the system, so that small-scale PV, demand-side response, etc. can participate in the markets for energy and network services.
- In such a market with a lot more data, and remote control actions linked to them, the reliability of the grid and of the communication channels becomes critical for a secure network operation: it is clear that none of these innovations will take off if the communication is not secure. Cybersecurity is therefore a basic condition to be taken into account in the design and testing of any of the above.

This contribution from SC3 to the focus area is complementary to the focus in the Energy Challenge part of Horizon 2020, supporting the innovation in the energy system and triggering the transformation of the energy services market.

Budget: € 30 million

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

R&I in this work programme part aims to promote a wide market introduction of highly automated driving systems (SAE level 4). Actions will focus on large-scale demonstrations to test the performance and safety of innovative highly automated driving systems for passenger cars, efficient freight transport operations and shared mobility services in urban areas. Furthermore the changing role of the driver and how to account for it by human centred design of automated vehicles will be addressed. Demonstrations will also look at testing the use of digital and connectivity technologies for optimised connected and automated driving functions. Digital technologies, such as big data, the Internet of Things and Artificial Intelligence techniques provide a great potential for developing innovative automated driving functions and mobility solutions for the future. Communication and cooperation of automated vehicles with other vehicles, infrastructure and other road users can increase the safety, comfort, productivity and the enabling of innovative business models of automated vehicles and improve the efficiency of the overall transport system.

Budget: € 103 million

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

The scope of the SC6 work programme 2018-2020 is to address the concerns of the European citizens regarding migration, the fourth industrial revolution and the problems of governance by providing objective scientific elements of assessment regarding these phenomena and formulating elaborate policy options or applicable solutions in order to help better tackle these complex issues and inform citizens objectively.

Through the contribution of eight topics to the Focus Area "Digitising and transforming European Industry and Services", Societal Challenge 6 will explore how social, cultural and ICT-based innovations as well as inclusive growth models can help to overcome the concerns of the European citizens.

Actions under these topics are aimed at developing ICT-enabled solutions for the delivery of new forms of public goods and inclusive public services, addressing the challenge of migrant integration through ICT-enabled solutions, collaborative approaches to cultural heritage for social cohesion and the curation of digital assets. They address the impact of digital transformations on governance and the delivery of public services as well as on children and youth. The consequences of digitisation on cultural diversity, access to culture and the creation of cultural value are also addressed. Finally, the creation of analytical tools that enable public administrations to reuse the European Cloud infrastructure and data sets will foster the development of better targeted and effective evidence-based policies.

Budget: € 166 million

Focus Area - *'Boosting the effectiveness of the Security Union'*

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 2016 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 understanding phenomena such as violent radicalisation and the development of more effective policies and interventions. This means social sciences and the humanities will be involved.

Total Budget for this Focus area:

€1044 million

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.

The Focus Area will support implementation of the Security Union priorities: 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.

Focus area impacts

- 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.
- 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

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 €290 million (total with Digital Security from Societal Challenge 7)

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 €95 million

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

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

Budget €36 million

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

A contribution will be made to the Digital Security Call under SC7 (see below) for improving the resilience of the Electrical Power and Energy System (EPES) against cyber and privacy attacks.

Budget €20 million

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 €32million

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, health, environmental, economic and material damage from natural and man-made disasters, including from climate-related 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; as well as to protect soft targets in the context of a smart city.

Budget €571 million

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, promoting trust and confidence, and paving the way for a competitive, trustworthy Digital Single Market. Innovative solutions and services in digital security, privacy and personal data protection will open new market opportunities for EU companies and will ensure a secure and trusted networked environment for governments, businesses and citizens. 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 €290 million (total with LEIT ICT)

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.

Appendix 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.

The foresight work fed into the work programme preparations across the board. In particular, the eight issues highlighted above were used in the process for identifying and developing focus areas e.g. 'hyper-connectivity and big data driving accelerated change and innovation' mapped to the 'digitisation' focus area; and 'a state of instability as the new norm in global society' mapped to 'Supporting the Security Union' focus area. Some of the eight issues were grouped e.g. 'Falling cost of energy: a potential game changer', 'Facing climate change, oceans and space as unifying / pacifying projects' and 'Primary sector innovation: strategic and key for sustainability and wellbeing' mapped to the two focus areas 'Building a low-carbon, climate resilient future' and 'Connecting economic and environmental gains – the Circular Economy'.

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[17]. Eight areas conducted dedicated written consultations targeted at respective stakeholder groups[18] and four organised specific consultation events[19].

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

[17] 'Future and Emerging Technologies', 'Research e-Infrastructures', LEIT-ICT and eHealth

[18] Future and Emerging Technologies (FET), Research Infrastructures, LEIT-NMBP, Space, Societal Challenges 'Health', 'Transport', 'Climate action' and 'Security'

[19] Space, Innovation in SME, Societal Challenge 'Secure Society', Spreading Excellence and Widening Participation

Level Group on European Open Science Cloud), the results of FP projects like CIMULACT[20] enabling direct interaction with citizens, studies and conferences/workshops reflecting stakeholder views were also integrated in the consultation process.

Advisory Groups

There are 19 Horizon 2020 Advisory Groups[21], 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 as part of the strategic programming process.

[20] http://www.cimulact.eu/

[21] The reports of Advisory Groups which were parts of this process are at https://ec.europa.eu/programmes/horizon2020/en/experts