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NOTE

From:	General Secretariat of the Council
To:	Delegations
No. prev. doc.:	15736/18 REV 1
Subject:	Proposal for a DECISION OF THE COUNCIL on establishing the specific programme implementing Horizon Europe – the Framework Programme for Research and Innovation

Delegations will find attached a Presidency text on the above-mentioned proposal in view of discussions in the Research Working Party.

Changes to doc. 15736/18 REV 1 are indicated in ~~Strikeout~~ and **Bold underlined**.

Please note that changes can be found mainly in articles 4a, 5, 12a, in annex I the text on pillar II, and annex Ia.

ANNEX

Proposal for a

DECISION OF THE COUNCIL

on establishing the specific programme implementing Horizon Europe – the Framework Programme for Research and Innovation

(Text with EEA relevance)

THE COUNCIL OF THE EUROPEAN UNION,

Having regard to the Treaty on the Functioning of the European Union, and in particular Article 182(4) thereof,

Having regard to the proposal from the European Commission,

After transmission of the draft legislative act to the national parliaments,

Having regard to the opinion of the European Parliament,

Having regard to the opinion of the European Economic and Social Committee[1],

Having regard to the opinion of the Committee of the Regions[2],

Acting in accordance with a special legislative procedure

Whereas:

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[1] OJ C , , p. .
[2] OJ C , , p. .

(1) In accordance with Article 182(3) of the Treaty on the Functioning of the European Union (TFEU), the Horizon Europe - Framework Programme for Research and Innovation ("Horizon Europe"), established by *FP/RfP* Regulation (EU) No … of the European Parliament and of the Council of…[3] , is to be implemented through specific programmes, which define the detailed rules for their implementation, fix their duration and provide for the means deemed necessary.

(2) *FP/RfP* Regulation (EU) No … sets out the general and specific objectives of Horizon Europe, the structure and the broad lines of activities to be carried out, while this specific programme implementing Horizon Europe - the Framework Programme for Research and Innovation (the 'Specific Programme') should define the operational objectives and the activities which are specific to parts of Horizon Europe. The provisions on implementation set out in *FP/RfP Regulation* (EU) No … apply fully to the Specific Programme, including those relating to ethical principles.

(3) In order to ensure uniform conditions for the implementation of the Specific Programme, implementing powers should be conferred on the Commission to adopt work programmes for the implementation of the Specific Programme. Those powers should be exercised in accordance with Regulation (EU) No 182/2011 of the European Parliament and of the Council[4].

(4) The Board of Governors of the Joint Research Centre (JRC), set up by Commission Decision 96/282/Euratom[5] has been consulted on the scientific and technological content of the Specific Programme on the non-nuclear direct actions of the JRC;

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[3] OJ C , , p. .

[4] Regulation (EU) No 182/2011 of the European Parliament and of the Council of 16 February 2011 laying down the rules and general principles concerning mechanisms for control by the Member States of the Commission's exercise of implementing powers (OJ L 55, 28.2.2011, p. 13)

[5] Commission Decision 96/282/Euratom of 10 April 1996 on the reorganization of the Joint Research Centre (OJ L 107, 30.4.1996, p. 12).

(5) Reflecting the importance of tackling climate change in line with the Union's commitments to implement the Paris Agreement and the United Nations Sustainable Development Goals, this Specific Programme will contribute to mainstream climate actions and to the achievement of an overall target of 25 % of the EU budget expenditures supporting climate objectives. Actions under this Specific Programme are expected to contribute 35% of the overall financial envelope of the Specific Programme to climate objectives. Relevant actions will be identified during the Specific Programme's preparation and implementation, and reassessed in the context of the relevant evaluations and review processes. Special attention will be paid to EU coal-intensive regions of the Union.

(6) The Specific Programme's actions should be used to address market failures or sub-optimal investment situations, in a proportionate manner, without duplicating or crowding out private financing and have a clear European added value.

(7) Reflecting the important contribution that research and innovation should make to address challenges in food, agriculture, rural development and the bioeconomy, and to seize the corresponding research and innovation opportunities in close synergy with Common Agricultural Policy, relevant actions under the Specific Programme will be supported with EUR 10 billion for the cluster 'Food and Natural Resources' for the period 2021-2027.

(8) The completion of the Digital Single Market and the growing opportunities from the convergence of digital and physical technologies requires a stepping up of investments. Horizon Europe will contribute to these efforts with a substantial increase of spending in main digital research and innovation activities compared to the Research and Innovation Framework Programme Horizon 2020[6]. This should ensure that Europe remains at the forefront of global research and innovation in the digital field.

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[6] The Communication from the Commission "A new, modern Multiannual Financial Framework for a European Union that deliver efficiently on its priorities post-2020" identifies EUR 13 billion spent in main digital activities under the Research and Innovation Framework Programme Horizon 2020 (https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A52018DC0098).

(9) The types of financing and the methods of implementation under this Decision shall be chosen on the basis of their ability to achieve the specific objectives of the actions and to deliver results, taking into account, in particular, the costs of controls, the administrative burden, and the expected risk of non-compliance. For grants, this shall include consideration of the use of lump sums, flat rates and scales of unit costs.

(10) It is important to involve Member States early in the process of defining missions. ~~Therefore, for each Mission Board a working group under the Committee should be established, consisting of one expert to be nominated from each Member State. Experts from Associated Countries can be invited to participate as observers. The role of the working group should be to provide feedback to the Mission Board from an early stage, including on relevant issues from the national context and opportunities to enhance alignment with activities on national level. Interactions, including possible joint meetings, between each Mission Board and working group should take place in a timely and comprehensive manner.~~

HAVE ADOPTED THIS DECISION:

CHAPTER I

GENERAL PROVISIONS

Article 1

Subject matter

This Decision establishes the specific programme implementing Horizon Europe - the Framework Programme for Research and Innovation (the 'Specific Programme'), as set out in Article 1(3)(a) of the *FP/RfP* Regulation…/…/EU.

It lays down the operational objectives of the Specific Programme, the budget for the period 2021 – 2027, the rules for implementation of the Specific Programme and activities to be carried out under the Specific Programme.

Article 2

Operational objectives

1. The Specific Programme shall contribute to the general and specific objectives set out in Article 3 of Regulation … *FP/RfP Regulation*

2. The Specific Programme has the following operational objectives:

   (a) strengthening excellent basic and frontier research; reinforcing and spreading excellence throughout the Union;

   (b) promoting complementarities with national and regional and EU research and innovation policies and activities;

   (c) promoting safe and responsible research and innovation, taking into account the precautionary principle;

   (d) increasing collaboration links in European research and innovation and across sectors and disciplines, including social sciences and humanities;

   (e) connecting, developing and providing transnational access to research infrastructures across the European Research Area,

   (f) strengthening international cooperation;

   (g) attracting talent, training and retaining researchers and innovators in the European Research Area, including through mobility;

(h) fostering open science and ensuring visibility to the public and open access to scientific publications and research data, including appropriate exceptions;

(i) actively disseminating and exploiting results, in particular for leveraging private investments and policy development;

(j) encouraging exploitation of R&I results within the Union and in the Associated Countries of the beneficiaries involved in the action;

(k) supporting the implementation of Union policy priorities;

(l) reinforcing the link between research, innovation and, where appropriate, education, and other policies, including in particular the Sustainable Development Goals;

(m) delivering, through R&I missions, on ambitious goals within a set timeframe;

(n) improving the relationship and interaction between science and society, including the visibility of science in society and the involvment of citizens and end-users in co-design and co-creation processes;

(o) improving science communication.

(p) accelerating industrial transformation;

(q) improving skills for innovation;

(r) increasing R&I activities in SMEs;

(s) stimulating the creation and scale-up of innovative companies, in particular start-ups, SMEs, and in exceptional cases small mid-caps;

(t) improving access to risk finance, including through synergies with InvestEU, in particular where the market does not provide viable financing;

(u) addressing the gender dimension across the Programme through gender equality and gender mainstreaming.

3. Within the objectives referred to in paragraph 2, account may be taken of new and unforeseen needs that arise during the period of implementation of the Specific Programme. That may, if duly justified, include responses to emerging opportunities, crises and threats, as well as responses to needs relating to the development of new Union policies.

Article 3

Structure

1. In accordance with Article 4(1) of Regulation … *FP/RfP Regulation*, the Specific Programme shall consist of the following parts:

(1) Pillar I 'Excellent Science' with the following components:

(a) the European Research Council (ERC), as described in Annex I, Pillar I, section 1;

(b) Marie Skłodowska-Curie Actions (MSCA), as described in Annex I, Pillar I, section 2;

(c) research infrastructures, as described in Annex I, Pillar I, section 3;

(2) Pillar II 'Global Challenges and European Industrial Competitiveness' with the following components:

(a) cluster 'Health', as described in Annex I, Pillar II, section 1;

(b) cluster 'Culture and Inclusive Society', as described in Annex I, Pillar II, section 2;

(c) cluster 'Civil Security for Society', as described in Annex I, Pillar II, section 3;

(d) cluster 'Digital, Industry and Space', as described in Annex I, Pillar II, section 4;

(~~e~~) cluster 'Climate and Energy ', as described in Annex I, Pillar II, section 5;

(ee) cluster ‘Mobility’, as described in Annex I, Pillar II, section 6

(f) cluster Bioeconomy, Food, Natural Resources and Environment', as described in Annex I, Pillar II, section 7;

(g) non-nuclear direct actions of the Joint Research Centre (JRC), as described in Annex I, Pillar II, section 8;

(3) Pillar III 'Innovative Europe' with the following components:

(a) the European Innovation Council (EIC), as described in Annex I, Pillar III, section 1;

(b) European innovation ecosystems, as described in Annex I, Pillar III, section 2.

(4) Part 'Widening Participation and Strengthening the European Research Area' with the following components:

(a) widening participation and sharing excellence, as described in Annex I, Part 'Strengthening the European Research Area', section 1;

(b) reforming and enhancing the European R&I system, as described in Annex I, Part 'Strengthening the European Research Area', section 2.

2. The activities to be carried out under the parts referred to in paragraph 1 are described in Annex I.

Article 4

Budget

1. In accordance with Article 9(1)of Regulation … *FP/RfP Regulation*, the financial envelope for the implementation of the Specific Programme for the period 2021 to 2027 shall be [EUR 91 100 000 000] in current prices.

2. The amount referred to in paragraph 1 of this Article shall be distributed among the components set out in Article 3(1) of this Decision in accordance with Article 9(2) of Regulation … *FP/RfP Regulation*. The arrangements of Article 9(3) to (8) of Regulation … FP/RfP Regulation shall apply.

CHAPTER II

IMPLEMENTATION AND PROGRAMMING

Article 4a

Strategic Plan

1. In accordance with Article 6 paragraph 6 of the [Framework Programme Regulation], the implementation of the Specific Programme shall be facilitated by a multiannual Strategic Plan of research and innovation activities, also promoting consistency between the work programmes and EU ~~and national~~ priorities. The result of the Strategic Planning Process shall be set out in a multiannual Strategic Plan, for preparing the content in the work programmes (as set out in Article 11) **covering a maximum period of four years**, while retaining sufficient flexibility to respond rapidly to new and emerging challenges, unexpected opportunities and crises.

2. The S~~s~~trategic P~~p~~lanning P~~p~~rocess shall focus in particular on the 'Global challenges and European industrial competitiveness' pillar and cover also relevant activities in other pillars and the Widening Participation and Strengthening the European Research Area part. ~~The strategic planning process shall ensure complementarity with the KICs of the EIT as established by Regulation 294/2008/EC~~

   The Commission shall ensure early involvement and extensive exchanges with the Member States, and as appropriate the European Parliament, complemented by consultation with stakeholders and the public at large. This will contribute to a stronger engagement with citizens and civil society.

Member States may support the strategic planning process through providing an overview of national consultations/citizens' contributions that feed into the Strategic Plan.

3. The Strategic Plan shall be adopted by the Commission, by means of an implementing act, in accordance with the examination procedure referred to in Article 12(4). The Strategic Plan shall correspond to the objectives and activities described in Annex 1. Th**is**~~e~~ Implementing Act ~~referred to in paragraph 2~~ shall contain the following elements, relating to the period covered:

   a. Key strategic orientations for R&I support, including a description of expected impacts, cross-cluster issues and intervention areas covered.

   b. Identification of European Partnerships according to Article 8(1)(a and b) of the [FP Regulation].

   c. Areas for international cooperation, actions to be aligned with Research & Innovation of other nations and regions of the world at major scale, or actions to be carried out in cooperation with organisations in third countries.

   d. Specific issues, such as the balance between research and innovation; the integration of Social Sciences and Humanities; the role of Key Enabling Technologies and strategic value chains; gender equality, including the integration of gender dimension in the R&I content; adherence to the highest ethics and integrity standards; priorities for dissemination and exploitation.

4. The Strategic Plan shall **take into account** ~~be informed by~~ an analysis covering at least the following elements:

a) Political, socio-economic and environmental drivers which are relevant for the EU and Member States' policy priorities.

b) The contribution of research and innovation to the realisation of EU policy objectives, while capitalizing on studies, other scientific evidence and relevant initiatives at EU and national level**, including institutionalised partnerships according to article 8(1)(c)of the [FP Regulation]**.

c) Evidence-base resulting from foresight activities, S&T and innovation indicators, international developments such as the implementation of the SDGs and feedback from implementation, including monitoring the implementation of specific measures with regard to widening participation and sharing excellence and participation of SMEs.

d) Priorities with the potential to be implemented in synergy with other EU programmes.

e) A description of the various approaches for stakeholder consultation and citizen engagement as part of the work to develop Work Programmes**;**~~.~~

f) Complementarity and synergies with planning of the KICs of the EIT in accordance with Regulation 294/2008/EC.

5. The strategic planning process shall be complemented by a strategic coordinating process for European Partnerships, with participation of Member States and the Commission on equal footing. It shall function as an entry point for analysis and advice on the possible setup, implementation, monitoring and phasing out of R&I partnerships and be guided by a comprehensive criteria framework, based on Annex III of the Horizon Europe Regulation.

Article 5

Missions

1. Research and Innovation Missions may be established in the mission areas identified in part 1 of Annex 1a.

2. For each mission area, a mission board shall be established, unless existing advisory structures can be used, in which case the Programme Committee shall be informed in advance. The mission board shall be composed of a maximum of 15 independent high level individuals with broad expertise from across Europe and beyond, including relevant end-users' representatives. **The members of the mission boards shall be appointed by the Commission, following a transparent procedure for their identification, including an open call for expressions of interest. The Programme Committee shall hold an exchange of views on the identification and selection procedures, including the criteria used, in a timely manner. The term of office of mission board members shall be up to five years, renewable once.**

3. The mission board shall not have decision-making powers but shall advise**, without having decision-making powers, the Commission** upon the following:

(a) identification and design of one or more missions ~~with~~in the respective mission area according to the provisions and criteria as set out in Article 7 of [Framework Programme Regulation]

(b) content of work programmes and their revision as needed for achieving the mission objectives, with input from stakeholders and, where relevant, the public;

(c) characteristics of project portfolios for missions;

(d) adjustment actions, or termination if appropriate, based on implementation assessments according to the defined objectives of the mission;

(e) selection of independent expert evaluators following the provisions of Article 44 [of the FP Regulation], briefing of expert evaluators and evaluation criteria and their weighting;

(f) framework conditions which help achieve the objectives of the mission;

(g) communication, including on the performance and the achievements of the mission;

(h) policy coordination between relevant actors at different levels**, in particular regarding synergies with other Union policies**;

(i) key performance indicators.

The advice of the mission boards shall be made public.

~~The members of the mission boards shall be appointed by the Commission, following an independent and transparent procedure for their identification, including an open call for expressions of interest and a clear set of criteria. The Member States shall be kept informed of the identification and selection procedures in a timely manner. The term of office of mission board members shall be limited to a fixed term of four years, renewable once.~~

4. For each Mission area, the Programme Committee shall give feedback on the tentative list of missions and be involved in the preparation and life cycle of the missions, taking into account relevant issues from the national context and opportunities to enhance alignment with activities on national level. Interactions with the mission boards shall take place in a timely and comprehensive manner.

~~2. Following feedback by the Strategic Configuration of the Programme Committee on the list of missions designed by Mission Boards, a limited number of missions shall be implemented through the Work Programme provided for in Article 11. A review of the first missions established under Horizon Europe shall take place in accordance with Article 7 paragraph 4 of the Framework Programme~~

~~3~~**5** The **work programme provided for in Article 11 shall include the missions, including** design of each mission, the characteristics of their project portfolios and specific provisions to enable an efficient portfolio approach shall be set out in the work programme provided for in Article 11.

Article 6

European Research Council

1. The Commission shall establish a European Research Council ("ERC"), for implementing the actions under Pillar I 'Excellent Science' which relate to the ERC. The ERC shall succeed the ERC set up by Decision C(2013) 1895[7].

2. The ERC shall be composed of the independent Scientific Council provided for in Article 7 and the dedicated implementation structure provided for in Article 8.

3. The ERC shall have a President who shall be chosen from among senior and internationally respected scientists.

   The President shall be appointed by the Commission following a transparent recruitment process involving an independent dedicated search committee, for a term of office limited to four years, renewable once. The recruitment process and the candidate selected shall have the approval of the Scientific Council.

   The President shall chair the Scientific Council and shall ensure its leadership and liaison with the dedicated implementation structure, and represent it in the world of science.

4. The ERC shall operate according to its core principles of scientific excellence, open science, autonomy, efficiency, effectiveness, transparency, accountability and research integrity. It shall ensure continuity with ERC actions conducted under Decision …/EC.

5. The activities of the ERC shall support frontier research, in a bottom-up manner, carried out across all fields by individual and transnational teams in competition at the European level, including early-stage career researchers.

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[7] OJ C 373, 20.12.2013, p. 23

6. The Commission shall act as the guarantor of the autonomy and integrity of the ERC and shall ensure the proper execution of the tasks entrusted to it.

The Commission shall ensure that the implementation of the ERC actions is in accordance with the principles set out in paragraph 4 of this Article as well as with the overall strategy for the ERC, referred to in point (a) of Article 7(2), established by the Scientific Council.

Article 7

ERC Scientific Council

1. The Scientific Council shall be composed of independent scientists, engineers and scholars of the highest repute and appropriate expertise, of both women and men in different age groups drawn from various parts of Europe, ensuring a diversity of research areas and acting in their personal capacity, independent of extraneous interests.

The members of the Scientific Council shall be appointed by the Commission, following an independent and transparent procedure for their identification agreed with the Scientific Council, including an open consultation of the scientific community and a report to the European Parliament and the Council.

Their term of office shall be limited to four years, renewable once, on the basis of a rotating system which shall ensure the continuity of the work of the Scientific Council.

2. The Scientific Council shall establish:

(a) the overall strategy for the ERC;

(b) the work programme for the implementation of the ERC activities;

(c) the methods and procedures for peer review and proposal evaluation on the basis of which the proposals to be funded are determined;

(d) its position on any matter which from a scientific perspective may enhance achievements and impact of the ERC and the quality of the research carried out;

(e) a code of conduct addressing, inter alia, the avoidance of conflict of interests.

The Commission shall depart from the positions established by the Scientific Council in accordance with points (a), (c), (d), and (e) of the first subparagraph only when it considers that the provisions of this Decision have not been respected. In that case, the Commission shall adopt measures to maintain continuity in the implementation of the specific programme and the achievements of its objectives, setting out the points of departure from the Scientific Council positions and duly motivating them.

3. The Scientific Council shall act in accordance with the mandate set out in Pillar I of Annex I, section 1.

4. The Scientific Council shall act exclusively in the interest of the ERC, according to the principles set out in Article 6. It shall act with integrity and probity and carry out its work efficiently and with the greatest possible transparency.

Article 8

Dedicated ERC implementation structure

1. The dedicated implementation structure shall be responsible for the administrative implementation and programme execution, as described in Pillar I of Annex I, section 1.3.2. It shall support the Scientific Council in the conduct of all of its tasks.

2. The Commission shall ensure that the dedicated implementation structure follows strictly, efficiently and with the necessary flexibility the objectives and requirements of the ERC alone.

Article 9

The European Innovation Council

1. The Commission shall establish a European Innovation Council (EIC) for implementing actions under Pillar III 'Innovative Europe' which relate to the EIC. The EIC shall operate according to the following principles: focus on breakthrough, market-creating and deep-tech innovation covering technological, non-technological and social aspects, clear EU added value, autonomy, ability to take risk, efficiency, effectiveness, transparency and accountability.

2. The EIC shall include the High Level Board ("EIC Board") provided for in Article 10. ~~.~~

3. The Commission shall ensure that the implementation of the EIC:

   (a) is in accordance with the principles set out in paragraph 1 of this Article, taking due account of the opinion of the EIC Board on the overall strategy for the EIC, referred to Article 10(1)(a); and

   (b) does not lead to distortions of competition contrary to the common interest.

4. For the purpose of managing EIC blended finance, the Commission shall make use of indirect management, or where this is not possible, may establish a special purpose vehicle, to be managed according to the applicable accountability rules. The Commission shall seek to ensure the participation of other public and private investors. Where this is not possible at the initial set up, the special purpose vehicle will be structured in such a way that it can attract other public or private investors in order to increase the leverage effect of the Union contribution.

Article 10

The EIC Board

1. The EIC Board shall advise the Commission upon:

   (a) the overall strategy for the EIC component under Pillar III 'Innovative Europe';

   (b) the work programme for the implementation of the EIC actions;

   (c) the criteria for assessment of the innovativeness and risk profile of the proposals and the appropriate balance of grants, equity and other forms of financing for the EIC accelerator;

   (d) the identification of strategic portfolio of projects;

   (e) the profile of programme managers.

2. The EIC Board may upon request address recommendations to the Commission on:

   (a) any matter which from an innovation perspective may enhance and foster innovation eco-systems across Europe, the achievements and impact of the objectives of the EIC component and the capacity of innovative firms to roll out their solutions;

   (b) identifying in cooperation with relevant Commission services and, where appropriate, national and regional authorities and other relevant entities, such as the EIT Governing Board, possible regulatory barriers faced by entrepreneurs, in particular those awarded support under the EIC component;

   (c) emerging technology trends from EIC's portfolio, to inform the programming in other parts of the Specific Programme;

   (d) identifying specific issues where advice from the EIC Board is needed.

The EIC Board shall act in the interest of achieving the objectives of the EIC component. It shall act with integrity and probity and carry out its work efficiently and with transparency.

The EIC Board shall act in accordance with its mandate set out in Pillar III of Annex I, section 1.

3. The EIC Board shall be composed of 15 to 20 independent high level individuals drawn from various parts of Europe's innovation ecosystem, including entrepreneurs, corporate leaders, investors, public administration experts and researchers. It shall contribute to outreach actions, with EIC Board members striving to enhance the prestige of the EIC brand.

   The members of the EIC Board shall be appointed by the Commission, following an open call for nominations or for expression of interests or both, whichever the Commission will find more appropriate, and taking into account the need for balance in expertise, gender, age and geographical distribution.

   Their term of office shall be limited to two years, renewable twice, with a rolling appointments system (members appointed every two years).

4. The EIC Board shall have a President who shall be appointed by the Commission following a transparent recruitment process. The President shall be a high profile public figure linked to the innovation world, with a solid understanding of R&D.

   The President shall be appointed for a term of office limited to four years, renewable once.

   The President shall chair the EIC Board, prepare its meetings, assign tasks to members, and may establish dedicated sub-groups, in particular to identify emerging technology trends from EIC's portfolio. He or she shall represent the EIC in the world of innovation. He or she shall also promote the EIC, act as interlocutor with the Commission ~~and~~, through the relevant programme committees, with Member States. The Commission will provide for administrative support for the President to undertake his or her duties.

5. A code of conduct addressing, inter alia, the avoidance of conflict of interests and breach of confidentiality shall be established by the Commission. Members of the EIC Board will accept the code of conduct upon assuming office.

Article 11

Work programmes

1. The Programme shall be implemented by the work programmes referred to in paragraph 2 in accordance with Article 110 of Financial Regulation. They shall set out the expected impact and be prepared following a strategic planning process as described in Annex I to this Decision. The Commission shall regularly and from an early stage inform the Committee referred to in Article 12 of the overall progress of the implementation of the indirect actions of the specific programme, including missions, also to allow the Committee to provide early appropriate input in the course of the strategic planning process and on the preparation of the work programmes, especially on missions.

   Work programmes shall set out, where applicable, the overall amount reserved for blending operations.

2. The Commission shall adopt separate work programmes, by means of implementing acts, for the implementation of actions under the following components, as set out in Article 3(1) of this Decision :

(a) the ERC, where the work programme shall be established by the Scientific Council under point (b) of Article 7(2), in accordance with the advisory procedure referred to in Article 12(3). The Commission shall depart from the work programme established by the Scientific Council only when it considers that it is not in accordance with the provisions of this Decision. In that case, the Commission shall adopt the work programme by means of an implementing act in in accordance with the examination procedure referred to in Article 12(4). The Commission shall duly motivate this measure;

(b) all clusters under the pillar 'Global Challenges and Competitiveness of European Industry', MSCA, research infrastructures, support to innovation ecosystems, sharing excellence and reforming and enhancing the European R&I System, in accordance with the examination procedure referred to in Article 12(4);

(c) the EIC, where the work programme shall be prepared following the advice of the EIC Board under point (b) of Article 10(1), in accordance with the examination procedure referred to in Article 12(4);

(d) the JRC, where the multi-annual work programme shall take into account the opinion provided by the Board of Governors of the JRC referred to in Decision 96/282/Euratom.

3. In addition to requirement in Article 110 of the Financial Regulation, the work programmes referred to in paragraph 2 of this Article shall, as appropriate, contain:

(a) an indication of the amount allocated to each action and mission and an indicative implementation timetable;

(b) for grants the priorities, the selection and award criteria and the relative weight of the different award criteria and the maximum rate of funding of the total eligible costs;

(c) the amount allocated to blended finance in accordance with Articles 41 to 43 of Regulation … *FP/RfP Regulation*:

(d) any additional obligations for beneficiaries, in accordance with Articles 35 and 37 of the *FP/RfP Regulation*.

4. The Commission shall adopt, by means of implementing acts, in accordance with the examination procedure referred to in Article 12 the following measures:

(a) the decision on the approval of the funding of indirect actions, where the estimated amount of the Union contribution under the specific programme is equal to or more than EUR 2,5 million, with the exception of actions under the specific objective "European Research Council (ERC)";

(b) the decision on the approval of the funding of actions involving the use of human embryos and human embryonic stem cells.[8]

[8] ~~*Moved from 1a to align the structure of the article with H2020.*~~

Article 12

Committee procedure

1. The Commission shall be assisted by a committee[9]. That committee shall be a committee within the meaning of Regulation (EU) No 182/2011.

2. The committee shall meet in different configurations as set out in Annex II, having regard to the subject matter to be discussed.

3. Where reference is made to this paragraph, Article 4 of Regulation (EU) No 182/2011 shall apply.

4. Where reference is made to this paragraph, Article 5 of Regulation (EU) No 182/2011 shall apply.

   Where the opinion of the committee is to be obtained by written procedure, that procedure shall be terminated without result when, within the time-limit for delivery of the opinion, the chair of the committee so decides or a simple majority of committee members so request.

   In the case of the implementing acts to be adopted under Article 4a(2), where the committee delivers no opinion, the Commission shall not adopt the draft implementing act and the third subparagraph of Article 5(4) of Regulation (EU) No 182/2011 shall apply. ~~[10]~~

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[9] With a view to facilitating the implementation of the programme, for each meeting of the Programme Committee as defined in the agenda, the Commission ~~**shall**~~~~will~~**shall** reimburse, in accordance with its established guidelines, the expenses of one representative per Member State, as well as one expert/adviser per Member State for those agenda items where a Member State requires specific expertise.

~~[10] *The subpoints 5 and 5a in a standard wording should fall under 12(4). This does not change the substance.*~~

6. The Commission shall regularly inform the Committee of the overall progress of the implementation of the specific programme and shall provide it with timely information on all actions and components proposed or funded under Horizon Europe and its externalised parts, as specified in Annex III, including detailed information/analysis of the statistics of the individual calls.

CHAPTER III

TRANSITIONAL AND FINAL PROVISIONS

Article 12 a

Review of Missions and Partnerships areas

No later than 2023 ~~and before decisions are made about launching missions other than those covered by mission areas of Annex 1a~~, the Commission shall carry out a review of Annex 1a as part of the overall monitoring of the programme, including missions and ~~all types of~~ **institutionalised European** partnerships **on the basis of article 185 TFEU or article 187 TFEU**, and present a report on the main findings to the Council and the European Parliament. That report may be accompanied, where appropriate, by a proposal for the modification of that annex.

Article 13

Repeal

Decision 2013/743/EU is repealed with effect from 1 January 2021.

Article 14

Transitional provisions

1. This Decision shall not affect the continuation or modification of the actions concerned, until their closure, under Decision 2013/743/EU, which shall continue to apply to the actions concerned until their closure.

   Where necessary, any remaining tasks of the Committee established by Decision 2013/743/EU shall be undertaken by the Committee referred to in Article 12 of this Decision.

2. The financial envelope for the Specific Programme may also cover technical and administrative assistance expenses necessary to ensure the transition between the Specific Programme and the measures adopted under its predecessor Decision 2013/743/EU.

Article 15

Entry into force

This Decision shall enter into force on the twentieth day following that of its publication in the *Official Journal of the European Union*.

This Decision is addressed to the Member States.

Done at Brussels,

For the Council
The President

ANNEX I

STRATEGIC PLANNING AND PROGRAMME ACTIVITIES

The following shall apply in the implementation of the Programme.

STRATEGIC PLANNING

As laid down in Article 4 a, the implementation of the Specific Programme shall be facilitated by a multiannual strategic planning for research and innovation activities. The strategic planning process shall focus in particular on the Global Challenges and European Industrial Competitiveness pillar, including relevant activities in other pillars and the Widening Participation and Strengthening the European Research Area part, also in close coordination and synergy with the planning of the KICs of the EIT established by Regulation 294/2008/EC.

The result of the Strategic Planning Process shall be set out in a Strategic Plan for realising content in the work programme.

The Strategic Planning process aims to:

– implement Horizon Europe's programme-level objectives in an integrated manner and provide focus on impact for the Programme overall and coherence between its different pillars.

– promote synergies between Horizon Europe and other Union Programmes, including the [cohesion funds] and the Euratom programme, thus becoming a point of reference for research and innovation in all related programmes across the EU budget and non-funding instruments.

– help to develop and realise EU policy for the relevant areas covered, and complement policy development and implementation in the Member States.

– reduce fragmentation of efforts and avoid duplication and overlaps between funding possibilities.

– provide the frame for linking the direct research actions of the Joint Research Centre and other actions supported under the Programme, including the use of results and data for support to policy.

– ensure a balanced and broad approach to research and innovation, at all stages of development, which is not only limited to fostering frontier research, the development of new products processes and services on the basis of scientific and technological knowledge and breakthroughs, but also incorporates the use of existing technologies in novel applications and continuous improvement and non-technological and social innovation.

– ensure a systemic, cross-disciplinary, cross-sectoral and cross-policy approach to research and innovation in order to tackle challenges while also giving rise to new competitive businesses and industries, fostering competition, stimulating private investments and preserving the level playing field in the internal market.

OTHER PROGRAMME ACTIVITIES

In the 'Global Challenges and ~~of~~ European Industrial Competitiveness' and the 'Innovative Europe' Pillars, research and innovation shall be complemented with activities which operate close to the end-users and the market, such as demonstration, piloting or proof-of-concept, excluding however commercialisation activities going beyond the research and innovation phase. This shall also include support to demand-side activities that help accelerate the deployment and diffusion of a broad range of innovations. Emphasis shall be put on non-prescriptive calls for proposals.

Under the 'Global Challenges and of European Industrial Competitiveness' pillar, building on experience in Horizon 2020, the social sciences and the humanities shall be fully integrated across all clusters, including specific and dedicated activities. Likewise, activities involving marine and maritime research and innovation shall be implemented in a strategic and integrated manner in line with the EU Integrated Maritime Policy, the Common Fisheries Policy Policies and international commitments.

Activities carried out within the FET Flagships on Graphene, the Human Brain Project and Quantum Technology, which are supported under Horizon 2020, will continue being supported under Horizon Europe through calls for proposals included in the work programme. Preparatory actions supported under the FET Flagships part of Horizon 2020 will feed the Strategic Planning process under Horizon Europe and inform the work on missions, co-funded/co-programmed partnerships and regular calls for proposals.

~~'FET Flagships' launched or supported under Horizon 2020 shall be eligible to be supported under this Programme. As they present substantial analogies with missions, also other 'FET flagships', if any, shall be eligible to be supported under this Framework Programme as missions, as partnerships or through regular calls geared towards future and emerging technologies.~~

Science and Technology Cooperation dialogues with the EU's international partners and policy dialogues with the main world regions shall make important contributions to the systematic identification of opportunities for cooperation which, when combined with differentiation by country/region, shall support priority setting. Strategic advice from the Strategic Forum for International Scientific and Technological Cooperation (SFIC) will continue to be sought.

DISSEMINATION AND COMMUNICATION

Horizon Europe will provide dedicated support for open access to scientific publications, to knowledge repositories and other data sources. Dissemination and knowledge diffusion actions will be supported, also from cooperation with other EU programmes, including clustering and packaging results and data in languages and formats for target audiences and networks for citizens, industry, public administrations, academia, civil society organisations, and policy makers. For this purpose, Horizon Europe may make use of advanced technologies and intelligence tools.

There will be appropriate support for mechanisms to communicate the programme to potential applicants (e.g. National Contact Points).

The Commission will also implement information and communication activities relating to Horizon Europe, to promote the fact that results were obtained with the support of EU funding. They will also seek to raise public awareness on the importance of research and innovation and the broader impact and relevance of EU funded research and innovation, by means of e.g. publications, media relations, events, knowledge repositories, databases, multi-channel platforms, websites or a targeted use of social media. Horizon Europe will also provide support to the beneficiaries to communicate their work and its impact to society at large.

EXPLOITATION AND MARKET UPTAKE

The Commission will establish comprehensive measures for exploitation of Horizon Europe results and the knowledge produced. This will accelerate exploitation towards wide market uptake and boost the impact of the Programme.

The Commission will systematically identify and record the results of the research and innovation activities under the Programme and transfer or disseminate these results and knowledge produced in a non-discriminatory fashion to industry and enterprises of all sizes, public administrations, academia, civil society organisations and policy-makers, in order to maximise the European added value of the Programme.

INTERNATIONAL COOPERATION

Greater impact will be obtained through aligning actions with other countries and regions of the world within strengthened international cooperation efforts. Based on mutual benefit, partners from across the world will be invited to join EU efforts as an integral part of initiatives in support of EU action for sustainability, reinforced research and innovation excellence, and competitiveness.

International joint action will ensure effective tackling of global societal challenges and Sustainable Development Goals, access to the world's best talents, expertise and resources, and enhanced supply and demand of innovative solutions.

WORKING METHODOLOGIES FOR EVALUATION

The use of high quality independent expertise in the evaluation process underpins the engagement of the programme across all stakeholders, communities and interests, and is a prerequisite for maintaining the excellence and relevance of the funded activities.

The Commission or funding body will ensure the impartiality of the process, and avoid conflicts of interest in line with Article 61 of the Financial Regulation. It shall also seek geographical diversity in the composition of evaluation committees, expert and advisory groups.

Exceptionally, when justified by the requirement to appoint the best available experts and/or by the limited size of the pool of qualified experts, independent experts assisting or being members of the evaluation committee may evaluate specific proposals for which they declare a potential interest. In this case, the Commission or funding body shall take all necessary remedial measures to ensure the integrity of the evaluation process. The evaluation process will be managed accordingly, including a stage involving an interaction between diverse experts. The evaluation committee will take into account the particular circumstances when identifying proposals for funding.

PILLAR I

EXCELLENT SCIENCE

The scientific, economic, social and cultural progress in all its forms depends on an adequate supply of excellent researchers; the search for breakthroughs in understanding and the acquisition of knowledge at all levels; the world class facilities needed to achieve this including physical and knowledge infrastructures for research and innovation as well as the means to openly disseminate and share knowledge (open science), methodologies and skills.

The achievement of world leading innovation is linked to the advancements of open and excellent science. Scientific and technological paradigm shifts, can be key drivers for productivity growth, competitiveness, wealth, sustainable development and social progress. Such paradigm shifts have historically tended to originate from the public-sector science base before going on to lay the foundations for whole new industries and sectors and for comprehensive societal progress.

Public investment in research, especially through universities and public research institutions (PRIs) and research facilities, often undertakes the longer-term, higher-risk research and complements the activities of the private sector. Besides this, it creates highly skilled human resources, knowhow and experience, new scientific instruments and methodologies, as well creating the networks which transmit the latest knowledge.

European science and European-based researchers have been and continue to be at the forefront in many areas. But this is not a position we can take for granted. The traditional challenge from countries such as the United States is now being joined by economic giants such as China and India, from the newly industrialising parts of the world in particular, and from all countries where governments recognise the manifold and abundant returns which derive from investing in research.

1. EUROPEAN RESEARCH COUNCIL (ERC)

1.1. Rationale

Although the EU remains the largest producer of scientific publications in the world, it has, relative to its size, comparatively few centres of excellence that standout at the world level and with large areas of average and poor performance. Compared with the US and now China to some degree, the EU still follows a 'distributed excellence model' in which resources are spread across a larger number of researchers and research institutions. Creating attractive conditions for the best researchers will help Europe to raise its attractiveness in the global competition for scientific talent.

The global research landscape is evolving dramatically and becoming increasingly multipolar as a result of a growing number of emerging countries, in particular China, expanding their scientific production. So whereas the EU and the United States accounted for nearly two-thirds of world expenditure on research and development in 2000, this share had fallen to less than half by 2013.

The ERC supports the best researchers, including talented researchers who are at an early stage of their career, with flexible, long-term funding to pursue ground breaking, high-gain/high-risk research primarily in Europe. It operates autonomously led by an independent Scientific Council made up of scientists, engineers and scholars of the highest repute and appropriate expertise and diversity. The ERC is able to draw on a wider pool of talents and ideas than would be possible for any national scheme, reinforcing excellence through the way in which the best researchers and the best ideas compete against each other.

Frontier research funded by the ERC has a proven substantial direct impact in the form of advances at the frontiers of knowledge, opening the way to new and often unexpected scientific and technological results and new areas for research. In turn, this generates radically new ideas which drive innovation and business inventiveness and tackle societal challenges. The ERC also has a significant structural impact, driving up the quality of the European research system over and above the researchers and actions it funds directly. ERC-funded actions and researchers set an inspirational target for frontier research in Europe, raising its profile and making it more attractive for the best researchers worldwide as a place to work, and work with. The prestige of hosting ERC grant- holders creates competition between Europe's universities and research organisations to offer the most attractive conditions for top researchers and can indirectly help them to assess their relative strengths and weaknesses and bring about reforms.

The ERC funds a relatively small percentage of all European research, but from this achieves a disproportionally high scientific impact. The average citation impact of the research supported by the ERC is comparable to that of the world's top elite research universities. The ERC's research performance is extremely high when compared with the world's largest research funders. The ERC funds a great deal of frontier research in many of the research areas that have received the highest numbers of citations, including those areas that are rapidly emerging. Although ERC funding is targeted to frontier research it has resulted in a substantial number of patents.

So there is clear evidence that the ERC attracts and funds excellent researchers through its calls and ERC actions are producing a substantial number of the most significant and high impact research findings worldwide in emerging areas leading to breakthroughs and major advances. The work of ERC grantees is also highly interdisciplinary and ERC grantees collaborate internationally and publish their results openly across all fields of research including the social sciences, research on the arts and the humanities.

There is also already evidence of the longer term impacts of ERC grants on careers, on training highly skilled recognised researchers and holders of doctoral degrees, on raising the global visibility and prestige of European research and on national research systems through its strong benchmarking effect. This effect is particularly valuable in the EU's distributed excellence model because ERC funded status can replace and serve as a more accurate indicator of research quality than recognition based on the status of institutions. This allows ambitious individuals, institutions, regions and countries to seize the initiative and scale up the research profiles in which they are particularly strong.

1.2. Areas of intervention

1.2.1. Frontier Science

Research funded by the ERC is expected to lead to advances at the frontier of knowledge, with scientific publications of the highest quality to achieve research results with high societal and economic potential impact and with the ERC setting a clear and inspirational target for frontier research across the EU, Europe and internationally. Aiming to make the EU a more attractive environment for the world's best scientists, the ERC will target a measurable improvement in the EU's share of the world's top 1 % most highly cited publications, and aim at a substantial increase in the number of excellent researchers from outside Europe which it funds. ERC funding shall be awarded in accordance with the following well-established principles. Scientific excellence shall be the sole criterion on which ERC grants are awarded. The ERC shall operate on a 'bottom-up' basis without predetermined priorities.

Broad Lines

– Long-term funding to support excellent ideas of investigators of any age and gender, from any country in the world, and their research teams to pursue ground-breaking, high-gain/high-risk research;

– Enabling starting and early-stage career researchers with excellent ideas to make the transition to being independent research leaders in their own right by providing adequate support at the critical stage when they are setting up or consolidating their own research team or programme;

– New ways of working in the scientific world, including the open science approach, with the potential to create breakthrough results and facilitate commercial and social innovation potential of funded research;

– Sharing experience and best practices with regional and national research funding agencies and building clear links to other parts of the Framework Programme, in particular the MSCA, to promote the support of excellent researchers;

– Raising the profile of frontier research in Europe and the visibility of ERC programmes to researchers across Europe and internationally.

1.3. Implementation

1.3.1. The Scientific Council

The Scientific Council is the guarantor of the quality of the activity from the scientific perspective and has full authority over decisions on the type of research to be funded.

In the context of the implementation of the framework programme and in order to carry out its tasks, as set out in Article 7, the Scientific Council will:

(1) Scientific strategy:

– establish the overall scientific strategy for the ERC, in the light of scientific opportunities and European scientific needs;

– establish the work programme and develop the ERC's mix of support measures in line with its scientific strategy;

– establish the necessary international cooperation initiatives including outreach activities, to increase the visibility of the ERC for the best researchers from the rest of the world, in line with its scientific strategy.

(2) Scientific management, monitoring and quality control:

– ensure a world-class peer review system based on scientific excellence of peers and on fully transparent, fair and impartial treatment of proposals by establishing positions on implementation and management of calls for proposals, evaluation criteria, peer review processes including the selection of experts, the methods for peer review and proposal evaluation and the necessary implementing rules and guidelines, on the basis of which the proposals to be funded will be determined under the supervision of the Scientific Council;

– experts shall be appointed on the basis of a proposal from the ERC Scientific Council in the case of ERC frontier research actions;

– ensure that ERC grants are implemented according to simple, transparent procedures that maintain the focus on excellence, encourage initiative and combine flexibility with accountability by continuously monitoring the quality of the operations and implementation;

– review and assess the ERC's achievements and the quality and impact of the research funded by the ERC and, accordingly, make recommendations and guidelines for corrective or future actions;

– establish positions on any other matter affecting the achievements and impact of the ERC's activities and the quality of the research carried out.

(3) Communication and dissemination:

– raise the global profile and visibility of the ERC by conducting communication and outreach activities including scientific conferences to promote the ERC's activities and achievements and the results of the projects funded by the ERC with the scientific community, key stakeholders and the general public;

– where appropriate, consult with the scientific, engineering and scholarly community, regional and national research funding agencies and other stakeholders.

– regularly report to the Commission on its own activities.

The members of the Scientific Council shall be compensated for the tasks they perform by means of an honorarium and, where appropriate, reimbursement of travel and subsistence expenses.

The President of the ERC will reside in Brussels for the duration of the appointment and devote most of his/her working time[1] to ERC business. He/she will be remunerated at a level commensurate with the Commission's top management and will be provided by the Dedicated Implementation Structure with the necessary support to carry out his or her functions.

The Scientific Council shall elect from amongst its members three Vice-Chairs who shall assist the President in its representation and the organisation of its work. They may also hold the title of Vice-President of the ERC.

Support will be provided to the three Vice-Chairs to ensure adequate local administrative assistance at their home institutes.

1.3.2. Dedicated Implementation Structure

The dedicated implementation structure will be responsible for all aspects of administrative implementation and programme execution, as provided for in the ERC work programme. It will, in particular, implement the evaluation procedures, peer review and selection process in accordance with the strategy established by the Scientific Council and will ensure the financial and scientific management of the grants. The dedicated implementation structure will support the Scientific Council in the conduct of all of its tasks as set out above including the development of its scientific strategy, its monitoring of the operations and its review and assessment of the ERC's achievements as well as its outreach and communications activities, provide access to the necessary documents and data in its possession, and keep the Scientific Council informed of its activities.

[1] In principle at least 80 %.

In order to ensure an effective liaison with the dedicated implementation structure on strategy and operational matters, the leadership of the Scientific Council and the Director of the dedicated implementation structure will hold regular coordination meetings.

The management of the ERC will be carried out by staff recruited for that purpose, including, where necessary, officials from the EU institutions, and will cover only the real administrative needs in order to assure the stability and continuity necessary for an effective administration.

1.3.3. Role of the Commission

In order to fulfil its responsibilities as set out in Articles 6, 7 and 8 and in the context of its own responsibilities for budget execution, the Commission will:

- ensure the continuity and renewal of the Scientific Council and provide support for a standing Identification Committee for the identification of future Scientific Council members;
- ensure the continuity of the dedicated implementation structure and the delegation of tasks and responsibilities to it taking into account the views of the Scientific Council;
- ensure that the dedicated implementation structure carries out the full range of its tasks and responsibilities;
- appoint the Director and the members of the management of the dedicated implementation structure taking into account the views of the Scientific Council;
- ensure the timely adoption of the work programme, the positions regarding implementing methodology and the necessary implementing rules including the ERC Rules of Submission and the ERC Model Grant Agreement, taking into account the positions of the Scientific Council;
- regularly and in a timely manner inform and consult the Programme Committee on the implementation of the ERC activities;

– as responsible for the overall implementation of the Research Framework Programme, monitor the dedicated implementation structure and evaluate its performance.

2. MARIE SKŁODOWSKA-CURIE ACTIONS (MSCA)

2.1. Rationale

Europe needs a highly-skilled and resilient human capital base in research and innovation that can easily adapt to and find sustainable solutions for current and future challenges, such as major demographic changes in Europe. To ensure excellence, researchers need to be mobile, collaborate and diffuse knowledge across countries, sectors and disciplines, with the right combination of knowledge and skills to tackle societal challenges and support innovation.

Europe is a scientific powerhouse with around 1.8 million researchers working in thousands of universities, research centres and companies. However, it is estimated that the EU will need to train and employ at least one million new researchers by 2027 in order to achieve the targets beings set for increased investment in research and innovation. This need is particularly acute beyond the academic sector (such as in industry and business, including SMEs, government, civil society organisations, cultural institutions, hospitals etc.) and requires collaboration between the different sectors to provide adequately trained new researchers. The EU must reinforce its efforts to entice more young women and men to a career in research, be more inclusive and promote better work/family life balance, attract researchers from third countries, retain its own researchers and reintegrate European researchers working elsewhere back to Europe. In addition, in order to more widely spread excellence, the conditions under which researchers perform must be further improved throughout the European Research Area (ERA). In this respect, stronger links are needed notably with the European Education Area (EEdA), the European Regional Development Fund (ERDF), and European Social Fund (ESF+).

These challenges can best be addressed at EU level due to their systemic nature and to the cross-country effort needed to solve them.

The Marie Skłodowska-Curie Actions (MSCA) focus on excellent research that is fully bottom-up, open to any field of research and innovation from basic research up to market take-up and innovation services. This includes research fields covered under the Treaty on the Functioning of the European Union and the Treaty establishing the European Atomic Energy Community (Euratom). If specific needs arise and additional funding sources become available, the MSCA may seek links to certain activities in specific challenges (incl. identified missions), types of research and innovation institutions, or geographical locations in order to respond to the evolution of Europe's requirements in terms of skills, research training, career development and knowledge sharing.

The MSCA are the main instrument at EU-level for attracting researchers from third countries to Europe, thus making a major contribution to global cooperation in research and innovation. Evidence shows that the MSCA not only have a positive impact on individuals, organisations, and at system level, but also yield high-impact and breakthrough research results while at the same time contributing significantly to societal as well as strategic challenges. Long-term investment in people pays off, as indicated by the number of Nobel Prize winners who have been either former MSCA fellows or supervisors.

Through global research competition between scientists and between host organisations from both the academic and non-academic sector, and through the creation and sharing of high-quality knowledge across countries, sectors and disciplines, the MSCA contribute notably to the goals of the 'Jobs, growth and investment' agenda, the EU Global Strategy and to the United Nations Sustainable Development Goals.

The MSCA contribute to making the ERA more effective, competitive and attractive on a global scale. This is achieved by focusing on a new generation of highly-skilled researchers and providing support for emerging talent from across the EU and beyond including fostering their transition to other programmes, such as ERC and EIT; by fostering the diffusion and application of new knowledge and ideas to European policies, the economy and society, *inter alia* through improved science communication and public outreach measures; by facilitating cooperation between research-performing organisations and by publishing following the principles of open science and FAIR data; and by having a pronounced structuring impact on the ERA, advocating an open labour market and setting standards for quality training, attractive employment conditions and open, transparent and merit-based recruitment for all researchers in line with the European Charter for Researchers and the Code of Conduct for the Recruitment of Researchers.

2.2. Areas of Intervention

2.2.1. Nurturing Excellence through Mobility of Researchers across Borders, Sectors and Disciplines

The EU must remain a reference point for excellent research and thus attractive for the most promising researchers, European and non-European alike, at all stages of their careers. This can be achieved by enabling researchers and research-related staff to move and collaborate between countries, sectors and disciplines and thus benefit from high-quality training and career opportunities. This will facilitate career moves between academia and other sectors as well as stimulate entrepreneurial activity.

Broad Lines

– Mobility experiences within or outside Europe for the best or most promising researchers regardless of nationality to undertake excellent research and develop their skills as well as career and broaden their network in academia and other sectors (including research infrastructures).

2.2.2. Fostering new Skills through Excellent Training of Researchers

The EU needs a strong, resilient and creative human resource base, with the right combination of skills to match the future needs of the labour market, to innovate and to convert knowledge and ideas into products and services for economic and social benefit. This can be achieved through training researchers to further develop their core research competences as well as enhance their transferable skills such as a creative, responsible, open-to-society and entrepreneurial mindset and awareness of sustainable development. This will allow them to face current and future global challenges, and improve their career prospects and innovation potential.

Broad Lines

– Training programmes to equip researchers with a diversity of skills relevant to current and future global challenges.

2.2.3. Strengthening Human Resources and Skills Development across the European Research Area, including, if appropriate and justified by a study, support for reserachers to return to their country of origin within and to the Union[2]

In order to foster excellence, promote cooperation between research-performing organisations and create a positive structuring effect, high-quality training and mentoring standards, good working conditions and effective career development of researchers need to be introduced across the ERA. This will help modernise or enhance research training programmes and systems as well as increasing institutions' attractiveness worldwide.

[2] ~~*1 to 1 alignment with PGA text*~~

Broad Lines

- Training programmes to foster excellence and spread best practices across institutions, research infrastructures and research and innovation systems, and to foster the transition to other programmes, such as ERC and EIT;

- Inter- and transdisciplinary cooperation, production and diffusion of knowledge within the EU and with third countries.

2.2.4. Improving and Facilitating Synergies

Synergies between research and innovation systems and programmes at EU, regional and national level need to be further developed. This can be achieved in particular through synergies, complementarities with other parts of Horizon Europe such as the European Institute of Innovation and Technology (EIT) and other EU programmes, notably Erasmus and the ESF+, including via a Seal of Excellence.

Broad Lines

- Training programmes and similar research career development initiatives supported through complementary public or private funding sources at regional, national or EU level.

2.2.5. Promoting Public Outreach

The awareness of the programme's activities and the public recognition of researchers need to be enhanced across the EU and beyond, to raise the global profile of the MSCA and to develop a better understanding of the impact of researchers' work on citizens' daily lives, and to encourage young people to embark on research careers. This can be achieved by working according to the open science principle which leads to better dissemination, exploitation and diffusion of knowledge and practices. Citizen science could play a valuable role as well.

Broad Lines

- Public outreach initiatives to stimulate interest in research careers, especially amongst young people of all backgrounds;
- Promotion activities to raise the global profile, visibility and awareness of the MSCA;
- Diffusion and clustering of knowledge through cross-project collaboration, national contact points (NCP) projects and other networking activities such as an alumni service.

3. RESEARCH INFRASTRUCTURES

3.1. Rationale

State of the art research infrastructures provide key services to research and innovation communities, playing an essential role in extending the frontiers of knowledge and laying the basis for research and innovation contributions to tackle the global challenges and industrial competitiveness. Supporting research infrastructures at the EU level helps to mitigate what in many cases is the reality of scattered national and regional research infrastructures and pockets of scientific excellence, and so strengthening the ERA as well as increasing the circulation of knowledge across silos. Scientific progress is increasingly dependent on the collaborations of research infrastructures and industry that develop the necessary instruments based on new key enabling technologies and other new technologies.

The overall aim is to endow Europe with world-class sustainable research infrastructures open and accessible to all researchers in Europe and beyond, which fully exploit their potential for scientific advance and innovation. Key objectives are to reduce the fragmentation of the research and innovation ecosystem, avoiding duplication of effort, and better coordinate the design, development, accessibility and use of research infrastructures, including those financed from ERDF. It is crucial to support open access to research infrastructures for all European researchers as well as, inter alia through the European Open Science Cloud (hereafter 'EOSC'), increased access to digital research resources, specifically stimulating the up-take of open science and open data practises.

It is also important to improve the long-term sustainability of research infrastructures as they are typically operational for several decades and therefore should produce plans to secure continuous and stable support.

Equally, the EU needs to tackle the rapid increase of global competition for talent by attracting third country researchers to work with European world-class research infrastructures. Increasing the competitiveness and innovation capabilities of European industry is also a major objective, supporting key technologies and services relevant for research infrastructures and their users, thus improving the conditions for supply of innovative solutions.

Past framework programmes have made a significant contribution towards the more efficient and effective use of national research infrastructures as well as developed with the European Strategy Forum on Research Infrastructures (ESFRI) a coherent and strategy-led approach to policy making on pan-European research infrastructures. This strategic approach has generated clear advantages, including reducing duplication of effort with more efficient overall use of resources, as well as standardising processes and procedures. Research mobility plays an important role in facilitating the use of research infrastructures.

EU supported activity will provide added value through: consolidating and optimising the existing research infrastructure landscape in Europe alongside efforts to develop new research infrastructures of pan-European importance and impact; ensuring similar sets of research infrastructures work together to address strategic issues affecting user communities; establishing the European Open Science Cloud (EOSC) as an effective scalable and sustainable environment for data-driven research; the interconnection of national and regional research and education networks, enhancing and securing high-capacity network infrastructure for massive amounts of data and access to digital resources across borders and domain boundaries; fostering the interoperability of research infrastructures; enhancing and reinforcing knowledge transfer and training of high-skilled human resources; overcoming barriers preventing the best research teams from accessing the best research infrastructures services in Europe; fostering the innovation potential of research infrastructures, focused on technology development and co-innovation as well as increased use of research infrastructures by industry.

And the international dimension of EU research infrastructures must be reinforced, fostering stronger cooperation with international counterparts and international participation in European research infrastructures for mutual benefit.

Activities will contribute to different Sustainable Development Goals (SDGs) such as: SDG 3 – Good Health and Well-Being for People; SDG 7 – Affordable and Clean Energy; SDG 9 – Industry Innovation and Infrastructure; SDG 13 – Climate Action.

3.2. Areas of intervention

3.2.1. Consolidating and Developing the Landscape of European Research Infrastructures

The establishment, operation and long-term sustainability of research infrastructures~~,~~ identified by ESFRI and other world-class research infrastructures of pan-European relevance is essential for the EU to ensure a leading position in frontier research, training and upskilling of researchers, the creation and use of knowledge and the competitiveness of its industries.

The European Open Science Cloud (EOSC) should become an effective and comprehensive delivery channel for research infrastructures services and should provide Europe's research communities with the next generation of data services for harvesting, storing, processing (e.g. analytics, simulation, visualisation services) and sharing big science data according to the FAIR principles. The EOSC should also provide researchers in Europe with access to the majority of data generated and collected by research infrastructures as well as to HPC and exascale resources, including those deployed under the European Data Infrastructure (EDI)[3].

The pan-European research and education network will link together and enable remote access to research infrastructures and research resources, by providing interconnectivity between universities, research institutes and research and innovation communities at EU level as well as international connections to other partner networks worldwide.

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[3] The European Data Infrastructure will underpin the European Open Science cloud by providing world-class High Performance Computing capability, high speed connectivity and leading-edge data and software services.

Broad Lines

- The life-cycle of pan-European research infrastructures through the design of new research infrastructures; their preparatory and implementation phase, their early-phase operation in complementarity with other funding sources, as well as the consolidation and optimisation of the research infrastructure ecosystem by monitoring the ESFRI landmarks and facilitating service agreements, evolutions, mergers or decommissioning of pan-European research infrastructures;

- The European Open Science Cloud, including:- scalability and sustainability of the access channel; in cooperation with the Member States and the associated countries effective federation of European, national, regional and institutional resources; its technical and policy evolution to cope with new research needs and requirements (e.g. usage of sensitive data sets, privacy by design); data inter-operability and compliance with the FAIR principles; and a wide user base;

- The pan-European research and education network underpinning the EOSC and EDI as well as enabling the delivery of HPC/data services in a cloud based environment capable of coping with extreme large data sets and computational processes.

3.2.2. Opening, Integrating and Interconnecting Research Infrastructures

The research landscape will be improved through ensuring openness of key international, national and regional research infrastructures for all European researchers and integrating their services when necessary so as to harmonise access conditions, improve and enlarge service provision and encourage common development strategy of high tech components and advanced services through innovation actions.

Broad Lines

- Networks that bring together national and regional funders of research infrastructures for the co-funding of trans-national access of researchers;

– Networks of pan-European, national and regional research infrastructures addressing global challenges for the provision of access to researchers as well as for the harmonisation and improvement of the research infrastructures' services.

3.2.2a. The innovation potential of European Research Infrastructures and activities for Innovation and Training

To stimulate innovation both in the research infrastructures themselves and in industries, R&D cooperation with industry will be fostered to develop Union capacities and industrial supply in high-tech areas such as scientific instrumentation. In addition, the use of research infrastructures by industry, e.g. as experimental test facilities or knowledge-based centres, will be stimulated. The development and exploitation of research infrastructures will require adequate skills for their managers, researchers, engineers and technicians, as well as users. For this purpose, Union funding will support the training of staff managing and operating research infrastructures of pan-European interest, the exchange of staff and best practices between facilities, and the adequate supply of human resources in key disciplines, including the emergence of specific education curricula. Synergies with the Marie Skłodowska-Curie actions will be encouraged.

Broad lines

- Integrated networks of research infrastructures for the preparation and implementation of a common strategy/roadmap for technological development and instrumentation;

- training of staff managing and operating research infrastructures of pan-European interest.

3.2.2b Reinforcing European Research Infrastructure policy and International Cooperation

Support is needed so that policy makers, funding bodies or advisory groups such as ESFRI are well-aligned towards developing and implementing a coherent and sustainable long-term European strategy on research infrastructures.

Similarly, support to strategic international cooperation will strengthen of the position of European research infrastructures at international level, ensuring their global networking, interoperability and reach.

Broad Lines

- Survey, monitoring and assessment of research infrastructures at EU level, as well as policy studies, communication and training actions, strategic international cooperation actions for research infrastructures, and specific activities of relevant policy and advisory bodies.

PILLAR II

GLOBAL CHALLENGES AND EUROPEAN INDUSTRIAL COMPETITIVENESS

The EU is confronted by many challenges, some of which are also global challenges. The scale and complexity of the problems are vast, need to be tackled jointly and matched by adequate, properly trained and skilled human resources, by the appropriate amount of financial resources and a proportionate effort in order to find solutions. These are precisely the areas where the EU must work together; smart, flexible and joined-up for the benefit and well-being of all our citizens.

Greater impact can be obtained through aligning actions with other nations and regions of the world within international cooperation along the lines indicated by the United Nations 2030 Agenda for Sustainable Development and the Sustainable Development Goals and the Paris climate agreement. Based on mutual benefit, partners from across the world will be invited to join EU efforts as an integral part of research and innovation for sustainable development.

Research and innovation are key drivers of sustainable and inclusive growth and technological and industrial competitiveness. They will contribute to finding solutions to today's problems, and the problems of tomorrow, in order to reverse as quickly as possible, the negative and dangerous trend that currently links economic development~~,~~ with the growing use of natural resources and growing social challenges. This will turn the challenges into new business opportunities and into rapid benefits for society.

The EU will benefit as user and producer of knowledge, technologies and industries showcasing how modern industrialised, sustainable inclusive, creative, resilient, open and democratic society and economy can function and develop. The growing economic-environmental-social examples of the sustainable economy of the future will be fostered and boosted, be they for: health and well-being for all; or resilient, creative and inclusive societies; or societies strengthened by civil security; or available clean energy and mobility; or a digitised economy and society; or a transdisciplinary and creative industry; or space-related, marine or land-based solutions; or a well-functioning bioeconomy, including food and nutrition solutions; sustainable use of natural resources, protection of the environment, climate change mitigation and adaptation, all generating wealth in Europe and offering higher quality jobs. Industrial transformation will be crucial, as well as developing EU innovative industrial value chains.

New technologies affect virtually all policy areas. For each separate technology there is often a combination of social and economic opportunities, opportunities for efficiency and quality and improvement of the government, consequences for employment and education, but also possible risks for safety, privacy and ethics.Technology policy therefore necessarily requires an integral weighing of interests, and cross-sectoral cooperation and strategy formulation.

Research and innovation under this pillar of Horizon Europe is grouped into integrated, non-siloed broad clusters of activities. Rather than addressing sectors, the investments aim at systemic changes for our society and economy along a sustainability vector. These will only be achieved if all actors, both private and public, engage in co-designing and co-creating research and innovation; bringing together end-users, scientists, technologists, producers, innovators, businesses, educators, policy-makers, citizens and civil society organisations. Therefore, none of the clusters is intended for only one set of actors and all activities will be implemented primarily by collaborative research and innovation projects selected on the basis of competitive calls for proposals.

In addition to addressing global challenges, activities in the clusters will also develop and apply, key enabling and emerging technologies (either or not digital-based) as part of a common strategy to promote the EU's industrial and social leadership. Where appropriate this will use EU space-enabled data and services. All TRL levels up to 8 will be covered in this pillar of Horizon Europe without prejudice to Union competition law.

Actions will generate new knowledge and develop technological and non-technological solutions, bring technology from lab to market and to develop applications including pilot lines and demonstrators, and include measures to stimulate market uptake and to boost private sector commitment and incentives to standardisation activities within the Union. Technologies require critical mass of European researchers and industry to establish world leading eco-systems, that include state of the art technology infrastrucres e.g. for testing. Synergies with other parts of Horizon Europe and the EIT, as well as other programmes will be maximised.

The clusters will boost the quick introduction of first-of-its-kind innovation in the EU through a broad range of embedded activities, including communication, dissemination and exploitation, standardisation as well as support to non-technological innovation and innovative delivery mechanisms, helping create innovation friendly societal, regulatory and market conditions such as the innovation deals. Pipelines of innovative solutions originating from research and innovation actions will be established and targeted to public and private investors as well as other relevant EU and national or regional programmes. Synergies will be developed with the third pillar of Horizon Europe in that perspective.

Gender equality is a crucial factor in order to obtain sustainable economic growth. It is therefore important to integrate a gender perspective in all global challenges.

1. CLUSTER 'HEALTH'

1.1. Rationale

The EU Pillar of Social Rights asserts that everyone has the right to timely access to affordable, preventive and curative health care that is safe and of good quality. This underlines the EU's commitment to the UN's Sustainable Development Goals calling for universal health coverage for all **and** at all ages by 2030, leaving no one behind, and ending preventable deaths.

A healthy population is vital for a stable, sustainable and inclusive society, and improvements in health are crucial in reducing poverty, **in dealing with an ageing European society,** in fostering social progress and prosperity, and in increasing economic growth. According to the OECD a 10% improvement in life expectancy is associated with a rise in economic growth of 0.3-0.4% a year. Life expectancy in the EU increased by 12 years since its establishment as a result of tremendous improvements achieved in the quality of life, environment, education, health and care of its people. In 2015, overall life expectancy at birth was 80.6 years in the EU compared to 71.4 years globally. In the past years, it increased in the EU on average by 3 months annually. Besides these improvements social and gender-specific differences in life expectancy can be observed between specific groups and across European countries.

Health research and innovation have played a significant part in this achievement but also in improving productivity and quality in the health and care industry. However, the EU continues to face novel, newly emerging or persisting challenges that are threatening citizens and public health, the sustainability of its health care and social protection systems, as well as the competitiveness of its health and care industry. Major health challenges in the EU include: **accessibility and** affordability of health and care; the lack of effective health promotion and disease prevention; the rise of non-communicable diseases; the increase of mental illness; the spread of antimicrobial drug resistance and the emergence of infectious epidemics; increased environmental pollution; the persistence of health inequalities among and within countries **disproportionally** affecting ~~disproportionally~~ people that are disadvantaged or in vulnerable stages of life; the detection, understanding, control, prevention and mitigation of health risks, including poverty-related aspects, in a rapidly changing social, urban, rural and natural environment; demographic change**, including ageing-related issues,** and the increasing costs for European health care systems~~ and taking full advantage of the progressive introduction of personalised medicine approaches and digitalisation in health and care~~; and the increasing pressure on the European health and care industry to remain competitive in and by developing health innovation vis-a-vis emerging global players. **In addition, vaccine hesitancy may decrease immunisation coverage among certain population groups.**

These health challenges are complex, interlinked and global in nature and require multidisciplinary, **technical and non-technical,** cross-sectorial and transnational collaborations. Research and innovation activities will build close linkages between discovery, clinical, **translational** epidemiological, ethical, environmental and socio-economic research as well as with regulatory sciences. **They will address areas of unmet clinical needs such as for example rare or hard to treat cancers, notably in paediatry.** They will harness the combined skills of academia**, practitioners** and industry and foster their collaboration with health services, **social services,** patients, policy-makers and citizens in order to leverage on public funding and ensure the uptake of results in clinical practice as well as in health care systems taking into account the competencies of Member States regarding the organisation and financing of their health systems. **Full advantage will be taken of genomic frontier research, as well as the progressive introduction of personalised medicine approaches, relevant for addressing a variet of non-communicable diseases and the digitalisation in health and care.** Research and innovation will foster strategic collaboration at EU and international level in order to pool the expertise, capacities and resources needed to create scope, speed and economies of scale, as well as to exploit synergies, avoid duplication of effort and share the expected benefits and financial risks involved. **Synergies in h**~~H~~ealth research and innovation in Horizon Europe shall be ~~coordinated~~ **promoted, in particular** with the Health ~~Programme~~ **Strand** within the European Social Fund Plus.

The research and innovation activities of this global challenge will develop the knowledge base, **exploit existing knowledge and technologies, consolidate and create** ~~build~~ the research and innovation capacity and develop the solutions needed for a more effective promotion of health and the **integrated** prevention, diagnosis, monitoring, treatment, rehabilitation and cure of diseases and (long-term **and palliative**) care. Results of research will be translated as recommendations for action and communicated with the relevant stakeholders. Improving health outcomes will in turn result in increased well-being and life expectancy, healthy active lives, improved quality of life and productivity, **more healthy life years** and sustainability of health and care systems. Ethics, protection of human dignity, gender and ethnical aspects and the needs of disadvantaged and vulnerable people will receive special attention.

Addressing major health challenges will support the EU's commitment to the United Nation's 2030 Agenda for Sustainable Development and those in the context of other UN organisations and international initiatives, including the global strategies and plans of action of the World Health Organization (WHO). It will contribute to the EU's policy goals and strategies, notably to the EU Pillar of Social Rights, the EU Digital Single Market, the EU Directive on cross-border healthcare, and the European One Health Action Plan against antimicrobial resistance (AMR), and to the implementation of the relevant EU regulatory frameworks.

Activities will contribute directly to the following Sustainable Development Goal (SDGs) in particular: SDG 3 – Good Health and Well-Being for People; ~~SDG11 - Make cities and human settlements inclusive, safe, resilient and sustainable;~~ SDG13 – Climate Action.

1.2. Areas of Intervention

1.2.1. Health throughout the Life Course

People in vulnerable stages of life (perinatal, birth, infancy, childhood, adolescence, pregnancy, mature and late adulthood), including people with disabilities or injuries, have specific health needs that require better understanding and tailored solutions, **taking** ~~eg.~~ gender **and ethical aspects into consideration** ~~related issues~~. This will allow reducing related health inequalities and improving health outcomes to the benefit of active and healthy ageing throughout the life course, including through a healthy start of life reducing the risk of mental and physical diseases later in life. **Prevention and communication will consider characteristics of specific audiences:**

Broad Lines

- **Understanding the e**~~E~~arly development and the aging process throughout the life course;
- **pre- and neo-natal, m**~~M~~aternal, paternal, infant and child health as well as the role of parents**,** ~~and~~ family **and educators**;
- Health needs of adolescents**, including factors influencing mental health**;
- Health consequences of disabilities and injuries;
- **Healthy ageing, i**~~I~~ndependent and active life, including social participation for the elderly and/or disabled people;
- Health education and ~~digital~~ health literacy**, including digital**.

1.2.2. Environmental and Social Health Determinants

Improved understanding of health drivers and risk factors determined by the social, **culture,** economic and physical environment in people's everyday life and at the workplace, including the health impact of digitalisation, **human mobility (such as** migration **and travel)**, pollution, **nutrition,** climate change and other environmental issues, will contribute to identify, prevent and mitigate health risks and threats; to reducing death and illness from exposure to chemicals and environmental pollution; to supporting safe, environmental-friendly, healthy, resilient and sustainable living and working environments; to promoting healthy lifestyles and consumption behaviour; and to developing an equitable, inclusive and trusted society. **This will also be based on population based cohorts and epidemiological studies.**

Broad Lines

- Technologies and methodologies for assessing hazards, exposures and health impact of chemicals, pollutants and other stressors **related to** ~~such as~~ climate **change,** ~~related,~~ workplace, lifestyle ~~or and~~ **the** environment~~al stressors,~~ and combined effects of several stressors;

- Environmental, occupational, ~~soci~~**socioeconomic** ~~al~~**, cultural,** and behavioural factors impacting physical and mental health and well-being of people and their interaction, with special attention to vulnerable and disadvantaged people, **age-specific** and gender-specific issues where relevant;

- Risk assessment, management and communication, supported by transdisciplinary approaches, where relevant, and improved tools for evidence-based decision-making, including alternatives to animal testing;

- Capacity and infrastructures to securely collect, share, use and re-use and combine data on all health determinants, including exposure **and connection with environmental conditions databases**, **lifestyles,** health **status** and diseases at EU and international level;

- Health promotion and primary prevention interventions, including occupational aspects.

1.2.3. Non-Communicable and Rare Diseases

Non-communicable diseases (NCDs), including rare diseases, pose a major health and societal challenge and call for **improved understanding and** **taxonomy, as well as** more effective approaches**, including personalised medicine approaches,** in prevention, diagnosis, monitoring, treatment, rehabilitation and cure as well as understanding of multimorbidities~~, including personalised medicine approaches~~.

Broad Lines

- **Understanding the mechanisms underlying the development of non-communicable diseases;**

- **Longitudinal population studies to support understanding health and disease parameters and help stratifying populations in support of the development of preventive medicine;**

- Diagnostic **tool**s **and techniques** for earlier and more accurate diagnosis and for **timely** patient-adapted treatment, enabling delay **and/or reversal of the progression of disease**~~of the first symptoms~~;

- Prevention and screening programmes, in line with or going beyond WHO, UN and EU recommendations;

- Integrated solutions for self-monitoring, health promotion, disease prevention, and management of chronic conditions and multi-morbidities;

- Treatments**,** ~~or~~ cures **or other therapeutic interventions**, including both pharmacological and nonpharmacological treatments~~ or interventions~~;

- Palliative care;

- **Areas of high unmet clinical need, such as rare cancers, including paediatric cancers**

- Assessment of comparative effectiveness of interventions and solutions**, including based on Real World Data (RWD)**;

- Implementation research to scale up health interventions and support their uptake in health policies and systems**;**~~.~~

- **Development of research and improvement of information, care and treatment for rare diseases.**

1.2.4. Infectious Diseases, including poverty-related and neglected diseases

Protecting people against cross-border health threats is a major challenge for public and global health, calling for effective international cooperation at EU and global level. This will involve **understanding and** prevention of, preparedness for, early detection of and research response to outbreaks, treatment and cure of infectious diseases, including poverty-related and neglected diseases, and also tackling antimicrobial resistance (AMR) following a 'One Health approach'.

Broad Lines

- **Understanding infection-related mechanisms;**
- Drivers for the emergence or re-emergence of infectious diseases and their spread, including transmission from animals to humans (zoonosis), or from other parts of the environment (water, soil, plants, food) to humans**, as well as impact of climate change and ecosystems evolutions on the dynamics of infectious diseases** ;
- Prediction, early and rapid detection**, control** and surveillance of infectious diseases~~,~~ ~~combatting antimicrobial resistance~~, healthcare-associated infections and environmental related factors;
- **Combatting antimicrobial resistance, including epidemiology, prevention, diagnosis, as well as the development of new antimicrobials and vaccines;**
- Vaccines, including vaccine platform technologies, diagnostics, treatments and cures for infectious diseases, including co-morbidities and co-infections;
- **Addressing low vaccine uptake, understanding vaccine hesitancy and building vaccine confidence;**
- Effective health emergency preparedness, response and recovery measures and strategies, involving communities**, and their coordination at regional, national and EU level**;

– Barriers to the implementation and uptake of medical interventions in clinical practice as well as in the health**care** system;

– Trans-border aspects of infectious diseases and specific challenges in low- and middle-income countries (LMICs), such as tropical diseases, also in relation to migratory flows and, in general, to increased human mobility.

1.2.5. Tools, Technologies and Digital Solutions for Health and Care, including personalised medicine

Health technologies and tools are vital for public health and contributed to a large extent to the important improvements achieved in the quality of life, health and care of people, in the EU. It is thus a key strategic challenge to design, develop, deliver, implement and evaluate suitable, trustable, safe, user-friendly and cost-effective tools and technologies for health and care, taking due account of the needs of people with disabilities and the aging society. These include **key enabling technologies from new biomaterials to biotechnology as well as** artificial intelligence and other digital technologies, offering significant improvements over existing ones, as well as stimulating a competitive and sustainable health-related industry that creates high-value jobs. The European health-related industry is one of the critical economic sectors in the EU, accounting for 3% of GDP and 1.5 million employees. Relevant stakeholders need to be involved as early as possible**, and the non technological dimension will be taken into account,** in order to ensure acceptability of new technologies**, methodologies** and tools. **This includes citizens, health care providers and professionals.**

Broad Lines

– Tools and technologies for applications across the health spectrum~~, including medical imaging,~~ and any relevant medical indication, including functional impairment;

– Integrated tools, technologies, medical devices**, biotechnology, nanomedicine and advanced therapies (including cellular and gene therapy),** and digital solutions for human health and care, including artificial intelligence, ~~mobile and digital solutions for human health,~~ mobile **solutions** and telehealth**, while addressing, when relevant, cost-efficiency production aspects at an early stage (in order to optimize the industrialisation stage and the potential of innovation to become an affordable medicinal product)**;

– Piloting, large-scale deployment, optimisation, and innovation procurement of health and care technologies and tools in real-life settings including clinical trials**,** ~~and~~ implementation research;

– Innovative processes and services for the development, manufacturing and rapid delivery of tools and technologies for health and care;

– The safety, efficacy, cost-effectiveness**, interoperability** and quality of tools and technologies for health and care as well as their ethical legal and social impact, including social acceptance issues;

– Regulatory science **and standards** for health **and care** technologies and tools**;**~~.~~

– Health data management, including data interoperability, integration, analytical and visualisation methods, decision making processes, building on artificial intelligence, data mining, big data technologies, bioinformatics and high performance computing technologies to foster personalised healthcare, including prevention, and to to optimise the health journey.

1.2.6. Health Care Systems

Health systems are a key asset of the EU social systems, accounting for 24 million employees in the health and social work sector in 2017. It is a main priority of Member States to render health systems **safe and** secure, accessible for all, integrated, cost-effective, resilient, sustainable and trusted with timely and relevant services, as well as to reduce inequalities, including by unleashing the potential of data-driven and digital innovation for better health and person-centred care building on open and safe European data infrastructures. **New opportunities such as 5G deployment, the concept of 'digital twins' and the Internet of Things** ~~This~~ will advance the digital transformation of health and care.

Broad Lines

- Supporting the knowledge base for reforms in ~~public~~ health systems and policies in Europe and beyond;
- New models and approaches for health and care**, including personalised medicine approaches, management and organisational aspects,** and their transferability or adaptation from one country/region to another;
- Improving health technology assessment;
- Evolution of health inequality and effective policy response;
- Future health workforce and its needs**, including digital skills**;
- Improving timely, reliable**, safe** and trustworthy health information and use/reuse of health data, including electronic health records, with due attention to data protection, including the misuse of personal life style and health information, security, accessibility, interoperability, standards, comparability and integrity;

- Health systems resilience in absorbing the impact of crises and to accommodate disruptive innovation;

- Solutions for citizen and patient empowerment, self-monitoring, and interaction with health and social care professionals, for more integrated care and a user-centred approach**, while considering equal access**;

- Data, information, knowledge and best practice from health systems research at EU-level and globally building on existing knowledge and databases.

2. CLUSTER CULTURE AND INCLUSIVE SOCIETY'

2.1. Rationale

The EU stands for a unique way of combining economic growth with sustainable development goals and social policies, with high levels of social inclusion, shared values embracing democracy, human rights, gender equality and the richness of diversity. This model is constantly evolving and needs to deal with the challenges from amongst other things, globalisation and technological change and rising inequalities.

The EU must promote a model of inclusive and sustainable growth while reaping the benefits of technological advancements, enhancing trust in and promoting innovation of democratic governance, **fostering education,** combatting inequalities, unemployment, marginalisation, discrimination and radicalisation, guaranteeing human rights, fostering cultural diversity and European cultural heritage and empowering citizens through social innovation. The management of migration and the integration of migrants will also continue to be priority issues. The ~~reciprocal~~ role of research and innovation in the social sciences, the arts and the humanities**, as well as in the cultural and creative sectors,** in responding to these challenges and achieving the EU's goals is fundamental.

The magnitude, complexity**, intergenerational** and trans-national character of the challenges call **for** multi-layered EU action. Addressing such critical social, political, cultural and economic issues only at national level would carry the danger of inefficient use of resources, fragmented approaches and dissimilar standards of knowledge and capacity.

Research and Innovation activities in this Global Challenge will be overall aligned with the ~~Commission's~~ **EU's** priorities on Democratic Change; Jobs, Growth and Investment; Justice and Fundamental Rights; Migration; A Deeper and Fairer European Monetary Union; Digital Single Market. It will respond to the commitment of the Rome Agenda to work towards: "a social Europe" and "a Union which preserves our cultural heritage and promotes cultural diversity". It will also support the European Pillar of Social Rights, and the Global Compact for safe, orderly and regular migration. Synergies with the Justice Programme and with the Rights and Values Programme, which support activities in the area of access to justice, victims' rights, gender equality, non-discrimination, data protection and promotion of the European citizenship, as well as with the Creative Europe and Digital Europe programme, Erasmus**, Erasmus+** and European Social Fund Plus, will be exploited.

Activities will contribute directly to the following Sustainable Development Goals (SDGs) in particular: SDG 1 - No Poverty; SDG 3 – **G**~~g~~ood **H**~~h~~ealth and **W**~~w~~ell-**B**~~b~~eing **for People**; SDG 4 - Quality Education; SDG 5 - Gender Equality; SDG 8 – Decent Work and Economic Growth; SDG 9 – Industry, Innovation and Infrastructure; SDG 10 - Reducing Inequalities; SDG 11- Sustainable Cities and Communities; SDG 16 – Peace, Justice and Strong Institutions.

2.2. Areas of Intervention

2.2.1. ***Democracy and*** *Governance* ~~*and Democracy*~~

Trust in democracy and established political institutions seems to be receding. Disenchantment with politics is increasingly articulated by anti-establishment and populist parties and a resurgent nativism. This is compounded by socio-economic inequalities, high migration flows and security concerns, among others. Responding to present and future challenges requires new thinking on how democratic institutions at all levels must adapt in a context of greater diversity, global economic competition, rapid technological advancements and digitisation, with citizens' experience of democratic discourses, practices and institutions being crucial.

Broad Lines

- The history, evolution and efficacy of democracies, at different levels and in different forms; the role of education**, cultural** and youth policies as cornerstones of democratic citizenship;

- **The role of social capital and access to culture in strengthening democratic dialogue and civic participation, open and trusting societies.**

- Innovative and responsible approaches to support the transparency, accessibility, responsiveness, accountability, trustworthiness, resilience, effectiveness and legitimacy of democratic governance in full respect of fundamental **and human** rights and of the rule of law;

- Strategies to address populism, **racism,** polarisation, corruption, extremism, radicalisation, terrorism and to include**, empower** and engage citizens;

- Better understand the role of journalistic standards and user-generated content in a hyper-connected society and develop tools to combat disinformation;

- The role of multi-cultural ~~citizenship and~~ identities in relation to democratic citizenship and political engagement, as well as EU founding values such as respect, tolerance, **gender equality,** cooperation **and**~~or~~ dialogue;

- The impact of technological and scientific advancements, including big data, online social networks and artificial intelligence on democracy;

- Deliberative**,** ~~and~~ participatory **and direct** democracy **and governance** and active and inclusive citizenship, including the digital dimension;

- The impact of economic and social inequalities on political participation and democracies, **while considering** ~~demonstrating~~ how reversing inequalities and combatting all forms of discrimination including gender~~,~~ can sustain democracy;

– Human**,** ~~and~~ social **and political** dimensions of criminality, dogmatism and radicalisation, in relation to those engaged or potentially engaged in such behaviour as well as to those affected or potentially affected;

– Combatting disinformation**,** ~~and~~ fake news **and hate speech,** and their impact in shaping the public sphere**;**

– **The EU as an international and regional actor in multilateral governance**.

– **Efficiency of justice systems and improved access to justice based on judiciary independence and rule of law principles and human rights, with fair, efficient and transparent procedural methods both in civil and criminal matters.**

2.2.2. Cultural Heritage

The European cultural and creative sectors build bridges between arts, culture, cultural heritage, business and technology. Furthermore, Cultural and Creative Industries (CCIs) play a key role in reindustrialising Europe, are a driver for growth and are in a strategic position to trigger innovative spill-overs in other industrial sectors, such as tourism, retail, media and digital technologies and engineering . Cultural heritage **forms an integral part of the cultural and creative sectors and** is the fabric of our lives, meaningful to communities, groups and societies, giving a sense of belonging. It is the bridge between the past and the future of our societies. A better understanding of our cultural heritage and how it is perceived and interpreted are vital to creating an inclusive society **in Europe and worldwide**. It is also a driving force of **European, national, regional and** local economies and a powerful source of inspiration for creative and cultural industries. Accessing, conserving, safeguarding and restoring, interpreting and harnessing the full potential of our cultural heritage are crucial challenges now and for future generations. Cultural heritage, tangible **and**~~,~~ intangible ~~and digital~~, is the major input and inspiration for the arts, traditional craftsmanship, the cultural, **creative and** entrepreneurial ~~and creative~~ sectors that are drivers of sustainable economic growth, new job creation and external trade. In this sense, both innovation and resilience of cultural heritage need to be considered in collaboration with local communities and relevant stakeholders. It also may serve as an agent of cultural diplomacy and as a factor of identity building and cultural and social cohesion.

Broad Lines

- Heritage studies and sciences, with cutting edge technologies **and innovative methodologies,** including digital ones;

- Access to and sharing of cultural heritage, with innovative patterns and uses and participatory management models;

- **Establish a research and innovation collaboration space granting accessibility of cultural heritage through new technologies as well as encouraging and facilitating transmission of know-how and skills, providing the opportunity to set up individual workgroups and project structures, and constituting a European cultural counterpart to commercially driven cloud services. This will be preceeded by an impact assessment;**

- **Sustainable business models to strengthen the financial foundation of the heritage sector;**

- Connect cultural heritage with emerging creative sectors and social innovation;

- The contribution of cultural heritage to sustainable development through conservation, safeguarding, developing, and regeneration of cultural landscapes, with the EU as a laboratory for heritage-based innovation and **sustainable** cultural tourism;

- Conservation, safeguarding, enhancement, restoration and sustainable management of cultural heritage and languages including the use of **traditional skills and crafts or** cutting edge technologies including digital;

- Influence of **cultural memories,** traditions, behavioural patterns, perceptions, beliefs, values, sense of belonging and identities. The role of culture and cultural heritage in multi-cultural societies and patterns of cultural inclusion and exclusion.

2.2.3. Social and Economic Transformations

European societies are undergoing profound socio-economic **and cultural** transformations, especially as a result of globalisation and technological innovations. At the same time there has been an increase in income inequality in most European countries[4]. Forward-looking policies are needed, with a view to promoting inclusive growth and well-being and reversing inequalities, boosting productivity (including advancements in its measurement)**, social-spacial inequalities** and human capital, understanding and responding to migration and integration challenges and supporting intergenerational solidarity, intercultural dialogue and social mobility. **Accessible, inclusive and high quality e**Education and training systems are needed for a more equitable and prosperous future.

Broad Lines

- Knowledge base for advice on investments and policies especially education and training, for high value added skills, productivity, social mobility, growth, social innovation and job creation. The role of education and training to tackle inequalities and underpin inclusion**, including school-failure prevention**;
- Social sustainability beyond GDP**-**only indicators especially new economic and business models and new financial technologies;
- Statistical and other economic tools for a better understanding of growth and innovation in a context of sluggish productivity gains- and/or structural economic changes;
- **New governance models in emerging economic areas and market institutions;**

[4] OECD Understanding The Socio-Economic Divide in Europe, 26 January 2017.

– New types of work, the role of work, **upskilling,** trends and changes in labour markets and income in contemporary societies, and their impacts on income distribution, **work-life balance,** working environments, non-discrimination including gender equality and social inclusion;

– The effects of social**, technological** and economic transformations on access to safe, healthy, and sustainable housing~~ and work environments~~;

– Tax and benefits systems together with social security and social investment policies with a view to reversing inequalities and addressing the ~~negative~~ impacts of technology, demographics and diversity;

– Inclusive and sustainable growth models for urban, semi-urban and rural environments;

– Understanding human mobility and its impacts in the context of social and economic transformations, considered in the global and local scales for better migration governance, respect of differences, long-term integration of migrants including refugees and impact of related policy interventions; respect of international commitments and human rights and issues of development aid and cooperation; greater, improved access to quality education, training, **labour market,** culture, support services, active and inclusive citizenship especially for the vulnerable, including migrants;

– Education and training systems to foster and make the best use of the EU's digital transformation, also to manage the risks from global interconnectedness and technological innovations, especially emerging online risks, ethical concerns, socio-economic inequalities and radical changes in markets;

– Modernisation of public authorities **governance and management systems** to **engage citizens and** meet **their**~~citizens'~~ expectation regarding service provision, transparency, accessibility, openness, accountability and user centricity.

– ~~Efficiency of justice systems and improved access to justice based on judiciary independence and rule of law principles and human rights, with fair, efficient and transparent procedural methods both in civil and criminal matters.~~

3. CLUSTER 'CIVIL SECURITY FOR SOCIETY'

3.1. Rationale

European cooperation has contributed to an era of unprecedented peace, stability and prosperity on the European continent. **However,** Europe has to respond to the challenges arising from persistent threats to the security of our **increasingly complex and digitalised** society. Terrorist attacks and radicalisation, as well as cyber-attacks and hybrid threats, raise major security concerns and put particular strain on societies. New, emerging security threats caused by new technologies in the near future, also require ~~our~~ attention. **Future security and prosperity depend on improving the abilities to protect Europe against such threats.** These cannot be dealt with purely by technological means but require knowledge about people, their history**, culture** and behaviour**, and include ethical considerations regarding the balance between security and freedom**. **Moreover, Europe has to ensure its non-dependence on security-critical technologies and support the development of breakthrough security technologies.**

European citizens, state institutions, EU bodies and the economy need to be protected from the continued threats of **terrorism and** organised crime, including firearms trafficking, drug trafficking and trafficking in human beings **and trafficking of cultural goods**. Human and social dimensions of criminality and violent radicalisation require better understanding so as to improve public policies in terms of security. Strengthening protection and security through better border management**, including maritime and land borders,** is also key. Cybercrime is on the increase and related risks are diversifying as the economy and society digitalise. Europe needs to continue its efforts to improve cybersecurity, digital privacy, personal data protection and combat the spread of false and harmful information in order to safeguard democratic**, social** and economic stability. Further efforts are required to limit the effects on lives and livelihoods of extreme weather events which are intensifying due to climate change, such as floods, storms, heat waves or droughts leading to forest fires, land degradation and other natural disasters, e.g. earthquakes. Disasters, whether natural or human-made, can put at risk important societal functions **and critical infrastructures**, such as **communication,** health, food, drinking water, energy supply**, transport, security** and government. This requires both technical research and research into the human factors involved to improve disaster resilience**, including, where appropriate, testing applications, training and cyber hygiene and education**. **More efforts are needed to evaluate the results of security research and promote their uptake.** ~~Lastly, further efforts are required to limit the effects on lives and livelihoods of extreme weather events which are intensifying due to climate change, such as floods, storms or droughts leading to forest fires, land degradation and other natural disasters, e.g. earthquakes. Disasters, whether natural or man-made, can put at risk important societal functions, such as communication, health, energy supply and government.~~

This cluster will seek synergies, in particular with the following Programmes: Internal Security Fund, Integrated Border Management Fund and Digital Europe as well as improved research and innovation cooperation between intergovernmental agencies, including through exchange and consultation mechanisms.

Security research is part of the wider comprehensive EU response to security threats. It contributes to the capability development process by enabling the future availability of technologies**, techniques** and applications to fill capability gaps identified by policy-makers and practitioners **and civil society organisations**. Already, funding to research through the EU's framework programme has represented around 50% of total public funding for security research in the EU. Full use will be made of available instruments, including the European space programme (Galileo and EGNOS, Copernicus, Space Situational Awareness and Governmental Satellite Communications). ~~Security research shall also take into account general requirements, resilience and security capabilities of existing infrastructures in the member states, building on them where feasible and considering interoperability issues where applicable.~~ **However, where dual use opportunities arise, s**~~S~~ynergies are sought with the activities supported by EU-funded defence research and duplication of funding is avoided. Cross-border collaboration contributes to developing a European single security market and improving industrial performance, underpinning the EU's autonomy. **Due attention will be given to the human understanding and perception of security.**

Security research responds to the commitment of the Rome Agenda to work towards "a safe and secure Europe", contributing to a genuine and effective Security Union.

Activities will contribute directly to the following Sustainable Development Goals (SDGs) in particular: SDG 16 – Peace, Justice and Strong Institutions.

3.1.1. Disaster-Resilient Societies

Disasters may arise from multiple sources, whether natural or human-made, including those from terrorist attacks, climate-related and other extreme events (including from sea level rises), from forest fires, heat waves, floods, droughts, desertification, earthquakes, tsunamis and volcanic events, from water crises, from space weather events, from industrial and transport disasters, from CBRN events, as well as those from resulting cascading risks. The aim is to prevent and reduce the loss of life, harm to health and the environment, **trauma as well as** economic and material damage from disasters, ensure food**, medicine supply and services** and water security as well as to improve the understanding and reduction of disaster risks and **enhance** post-disaster ~~lesson learning~~**recovery**. This implies covering the full spectrum of crisis management: from prevention and training, to crisis management and post-crisis management and resilience.

Broad Lines

- Technologies, capabilities and governance for first responders for emergency operations in crisis, disaster and post-disaster situations **and the initial phase of recovery**;

- The capacities of society to better prevent, manage and reduce disaster risk, including through nature-based solutions, by enhancing **forecasting capabilities,** prevention, preparedness and response to existing and new risks and domino effects, impact assessment and a better understanding of the human factor in risk management **and risk communication strategies**;

- More effectively support the build-back-better philosophy of the Sendai Framework through better understanding of post-disaster recovery and research into more effective post-disaster risk assessment.

- Interoperability of equipment and procedures to facilitate cross-border operational cooperation and an integrated EU market.

3.1.2. Protection and Security

There is a need to protect citizens from and to respond to security threats from criminal including terrorist activities and hybrid threats; to protect people, public spaces and critical infrastructure, from both physical (including CBRN-E) attacks and cyber-attacks; to fight terrorism and **violent** radicalisation, including understanding and tackling terrorist ideas and beliefs; to prevent and fight serious crime, including cybercrime, and organised crime; to support victims; to trace criminal financial flows; **to develop new forensic capabilities;** to support the use of data for law enforcement and to ensure the protection of personal data in law enforcement activities; **to strengthen border protection capabilities,** to support air, land and sea EU border management, for flows of people and goods and to understand the human factor in all these security threats **and in their prevention and mitigation**. It is essential to maintain flexibility **to** rapidly ~~to~~ address new **and unforeseen** security challenges that may arise.

Broad Lines

– Innovative approaches and technologies for security practitioners (such as police forces, fire brigades, medical services, border and coast guards, customs offices), in particular in the context of digital transformation and interoperability of security forces, ~~public health practitioners,~~ operators of infrastructure**, civil society organisations,** and those managing open spaces;

~~Advanced methods of fast, reliable and privacy enhanced data-sharing for law-enforcement purposes~~

– Analysis of cross-border crime phenomena, **advanced methods of fast, reliable, standardised and privacy enhanced data sharing and** ~~international data~~ collection ~~and sharing a~~s well as best practices;

– Human and soci**o-economic**~~al~~ dimensions of criminality and violent radicalisation, in relation to those engaged or potentially engaged in such behaviour as well as to those affected or potentially affected, including understanding and tackling terrorist ideas and beliefs **and crimes based on gender, sexual orientation or racial discrimination**;

– Analysis of security aspects of new technologies such as DNA-sequencing, genome editing, **nanomaterials and functional materials,** Artificial Intelligence, autonomous systems, **drones,** robotics, quantum computing, cryptocurrencies, 3D printing and wearables**, blockchain**, as well as improving awareness of citizens, public authorities and industry to prevent the creation of new security risks and to reduce existing risks, including from those new technologies;

– Improved foresight and analysis capabilities for policy making and ~~in~~at strategic level on security threats**;**

– **Monitoring and c**Combatting disinformation and fake news with implications for security**, including developing capabilities to detect the sources of manipulation**;

– **Technological development in the area of dual-use technologies to enhance interoperability between civil protection and military forces;**

– Interoperability of equipment and procedures to facilitate cross-border and inter-agency operational cooperation**,** and develop an integrated EU market.

– **Protection of critical infrastructures as well as open and public spaces against physical, digital and hybrid threats.**

– **Developing tools and methods for an effective and efficient Integrated Border Management, in particular to increase reaction capability and improved capacity to monitor movements across external borders to enhance risk detection, incident responding and crime prevention;**

– **Detection of fraudulent activities at border crossing points and throughout the supply chain, including identifying forged or otherwise manipulated documents and detecting trafficking in human beings and illicit goods;**

– Ensuring the protection of personal data in law enforcement activities, in particular in view of rapid technological developments.

3.1.3. Cybersecurity

Malicious cyber activities not only threaten our economies but also the very functioning of our democracies, our freedoms and our values. Cyber threats are often criminal, motivated by profit, but they can also be political and strategic. Our future security, freedom**, democracy** and prosperity depend on improving our ability to protect the EU against cyber threats. The digital transformation requires improving cybersecurity substantially, to ensure the protection of the huge number of IoT devices expected to be connected to the internet, **and the safe operation of network and information systems,** including ~~those controlling~~ **for** power grids, **drinking water supply and distribution,** ~~cars~~ **vehicles** and transport ~~networks~~**systems**, hospitals, finances, public institutions, factories, homes. Europe must build resilience to cyber-attacks and create effective cyber deterrence, while making sure that data protection and ~~our~~ **the** freedom **of citizens** are respected. **It is in the Union's interest to ensure that it develops and retains essential cybersecurity strategic capacities in order to secure the Digital Single Market, and, in particular, to ensure the protection of critical networks and of information systems and to provide key cybersecurity services. The Union must be in a position to autonomously secure its digital assets and to compete on the global cybersecurity market.**

Broad Lines

- Technologies across the digital value chain (from secure components **and quantum-resistant** ~~and~~ cryptography to self-healing software and networks);
- Technologies, methods**, standards** and best practices to address ~~current~~ cybersecurity threats, anticipating future needs, and sustaining a competitive European industry**, including tools for electronic identification, threat detection, as well as training and education resources**;
- A ~~European cybersecurity competence network and competence centre.~~ **European Cybersecurity Industrial, Technology and Research Competence Centre and a Network of National Coordination Centres.**

4. CLUSTER 'DIGITAL, INDUSTRY AND SPACE'

4.1. Rationale

To ensure industrial competitiveness and the capacity to address the global challenges ahead, the EU must increase its technological **sovereignty**~~non-dependence~~ and its **scientific,** technological and industrial capacities in the key areas that underpin the transformation of our economy**, the work place** and society.

EU industry provides one out of five jobs and two thirds of private sector R&D investments and generates 80% of EU exports. A new wave of innovation, involving a merging of physical and digital technologies, will trigger huge opportunities for EU industry and improve the quality of life for EU citizens.

Digitisation is a major driver. As it continues at a rapid pace across all sectors, investment in priority areas ranging from **trustworthy** artificial intelligence to next generation internet, high performance computing, **(bio)**photonics, quantum technologies and micro-/nano-electronics, becomes essential for the strength of our economy and the sustainability of our society. Investing, producing and using **digital technologies**~~ICT~~ provides a major boost to EU economic growth, amounting to an increase of 30% between 2001 and 2011 alone. In this context, the role of SMEs remains fundamental in the EU, both in terms of growth and jobs. ~~The efforts for supporting d~~**D**igital uptake among SMEs ~~must be strengthened in order to avoid market and technological segmentation and to provide for~~ **promotes competitiveness and** sustainability~~ of our societies~~.

Key enabling technologies[5] underpin the blending of the digital and the physical worlds, central to this new global wave of innovation. Investing in research, development, demonstration and deployment of key enabling technologies, and ensuring a secure, sustainable and affordable supply of raw and advanced materials, will secure EU strategic autonomy and help EU industry to significantly reduce its carbon and environmental footprints.

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[5] The Key Enabling Technologies of the future include advanced materials and nanotechnology, photonics and micro- and nano-electronics, life science technologies, advanced manufacturing and processing, artificial intelligence and digital security and connectivity

Specific future and emerging technologies will also be pursued as appropriate.

Space is of strategic importance; around 10% of the EU's GDP depends on the use of space services. The EU has a world-class space sector, with a strong satellite manufacturing industry and a dynamic downstream services sector. Space provides important tools for monitoring, communication, navigation, and surveillance and opens up many business opportunities especially in combination with digital technologies and other sources of data. The EU must make the most of these opportunities by fully exploiting the potential of its space programmes Copernicus, EGNOS and Galileo, and by protecting space and ground infrastructures against threats from space.

The EU has the unique chance of being a global leader and increase its share of world markets, by showcasing how digital transformation, leadership in key enabling and space technologies, the transition to a low-carbon, circular economy and competitiveness can reinforce each other through scientific and technological excellence. ~~Societal understanding of these technologies and evolutions is crucial.~~

To make the digitised, circular, low-carbon and low-emission economy a reality, action is needed at EU level because of the complexity of value chains, the systemic and multi-disciplinary nature of the technologies and their high development costs, and the cross-sectoral nature of the problems to be addressed. The EU must ensure that all industrial players, and society at large, can benefit from advanced and clean technologies and digit**al**isation. Developing technologies alone will not suffice. **Crucial elements include a societal understanding of these technologies and evolutions, engaging end-users, and behavioural change.**

~~Other EU-Programmes will facilitate i~~**I**ndustrially-oriented infrastructures, including pilot lines, will help ~~set up~~ EU businesses**,** and in particular SMEs**,** deploy these technologies and improve their innovation performance **and may be facilitated also by other EU programmes**.

A strong engagement of industry **and civil society** ~~in the process~~ is essential for setting priorities and developing research and innovation agendas, increasing the leverage of public funding **through private and public investments**, and ensuring the better uptake of results. Societal understanding and acceptance, including consideration of the design of products, goods and services, are key ingredients for success, as well as a new agenda for industry-relevant skills and standardisation.

Bringing together activities on digital, key enabling and space technologies, as well as a sustainable supply of raw materials, will allow for a more systemic approach, and a faster and more profound digital and industrial transformation. It will ensure that research and innovation in these areas feed into, and contribute to the implementation of, the EU's policies for industry, digitisation, environment, energy and climate, circular economy, raw and advanced materials and space.

Complementarity will be ensured with activities in particular under the Digital Europe Programme **and** ~~,~~ **the Space Programme, while** ~~to~~ respect**ing** the delineation between ~~both~~ Programmes and avoid**ing** ~~any~~ overlaps.

Activities will contribute directly to the following Sustainable Development Goals (SDGs) in particular: SDG 8 - Decent Work and Economic Growth; SDG 9 - Industry, Innovation and Infrastructure; SDG 12 - Responsible Consumption and Production; SDG-13 Climate Action.

4.2. Areas of Intervention

4.2.1. Manufacturing Technologies

Manufacturing is a key driver of employment and prosperity in the EU, producing over three quarters of the EU's global exports and providing over a 100 million direct and indirect jobs. The key challenge for EU manufacturing is to remain competitive at a global level with smarter and more customised products of high added value, produced at much lower energy **and material resource** costs **as well as with** ~~and with~~ a reduced environmental footprint. Creative and cultural inputs as well as perspectives from social sciences and humanities on the relation between technology and people in production will be vital to help generate added value. **The impact on work life and employment will be studied as well.**

Broad Lines

- Breakthrough manufacturing technologies such as additive manufacturing, industrial, collaborative**, flexible** and intelligent robotics, human integrated manufacturing systems, also promoted via an EU network of industrially-oriented infrastructures, which provide services to accelerate technological transformation and uptake by EU industry;

- Breakthrough innovations using different enabling technologies **across the value chain. Examples are** ~~e.g.~~ converging technologies, artificial intelligence, digital twin, data analytics, control technologies, sensor technologies, industrial, collaborative and intelligent robotics, human-cantered systems, bio-manufacturing, advanced batteries and hydrogen and fuel cell technologies, advanced plasma and laser technologies**.** ~~across the value chain~~;

- Skills**,** ~~and~~ workspaces **and businesses** fully adapted to the new technologies, in line with European social values;

- Flexible, high-precision, zero-defect, low-pollution and -waste, sustainable and climate-neutral cognitive plants**, in line with the circular economy approach,** -and smart manufacturing systems meeting customer needs;

- Breakthrough innovations in techniques for exploring construction sites, for full automation for on-site assembly and prefabricated components.

4.2.2. Key Digital Technologies

Maintaining and autonomously developing strong design and production capacities in essential digital technologies such as micro- and nano-electronics, microsystems, photonics, software and **cyber-physical** systems, and their integration as well as advanced materials for these applications will be essential for a competitive **citizen-centered and social** EU.

Broad Lines

- Micro- and nano-electronics, including design and processing concepts**, components and manufacturing equipment** responding to the specific requirements of digital transformation and global challenges, in terms of performance functionality, energy consumption and integration;

- Efficient and secure sensing and actuating technologies and their co-integration with computational units as the enabler of industry and the Internet of Things, including innovative solutions on flexible and conformable materials for human-friendly interacting objects~~, new medical technologies or automated driving~~;

- Technologies as complements or alternatives to nano-electronics~~, or integrated quantum computing~~;

- **Quantum computing and simulation, quantum networks for secure transmission of data and quantum sensors;**

- Computing architectures and low-power processors for a wide range of applications including **open source** neuromorphic computing powering artificial intelligence applications, edge computing, digitisation of industry, big data and cloud **computing**, smart energy and connected and automated driving;

- Computing hardware designs delivering strong guarantees of trusted execution, with built-in privacy and security protection measures for input/output data, quantum computing as well as processing instructions **and adequate human machine interfaces**;

- Photonics technologies enabling applications with breakthrough advances in functionality, integration and performance;

– System and control engineering technologies to support **flexible, evolvable and** fully autonomous systems for trustworthy applications interacting with the physical world **and humans**, including in industrial and safety critical domains;

– Software technologies enhancing software quality, **cyber**security and reliability with improved service life, increasing development productivity, and introducing built-in artificial intelligence and resilience in software and their architecture;

– Emerging technologies expanding digital technologies~~ and bridging the gap from proofs of concept in research to industrial feasibility for relevant markets~~.

*4.2.**3**~~2.a~~ Emerging enabling technologies*

Key Enabling Technologies have demonstrated their potential to stimulate innovation in and across many sectors[6]. To facilitate the development of new enabling technologies and feed the innovation pipeline, transformative research themes must be identified and supported from an early exploratory stage to demonstrations in pilot applications. Furthermore, emerging, often interdisciplinary, communities need to be assisted to reach the critical mass enabling them to systematically develop and mature promising technologies. The goal is to bring ermerging enabling technologies to levels of maturity that allow inclusion into industrial research and innovation roadmaps.

Broad lines

– support for future and emerging trends in key enabling technologies;

– support for emerging communities **involving a human centered-approach from the outset**;

– assessing the disruptive potential of new emerging industrial technologies, and their impact on people, industry, society and the environment, building interfaces with industrial roadmaps;

[6] "Re-finding industry - defining innovation" Report of the High-Level Strategy Group on Industrial Technologies, Brussels April 2018.

– broaden the industrial basis for adopting technologies and innovation with breakthrough potential, including development of human resources and in the global context.

4.2.4~~3~~. Advanced Materials

The EU is a global leader in advanced materials and associated processes, which make up 20% of its industry base and form the root of nearly all value chains through the transformation of raw materials. To remain competitive and meet citizens' needs for sustainable, safe and advanced materials, the EU must **invest in research for novel materials, including bio-based ones, and must** improve the recyclability of materials, reduce the carbon and environmental footprint, and drive cross-sectoral industrial innovation by supporting new applications in all industry sectors. Furthermore Advanced Materials have a tremendous impact regarding citizens' needs.

Broad Lines

– Materials (including ~~plastic~~ **polymers**, bio-, nano-, two-dimensional, smart and multi-materials, **composites,** metals and alloys) and advanced materials (e.g. quantum, responsive**,** ~~and~~ photonic **and superconducting** materials) designed with new properties and functionalisation and meeting regulatory requirements (while not leading to increased environmental pressures during their whole life-cycle, from production to use or end-of-life);

– Integrated materials processes and production following a customer-oriented and ethical approach, including pre-normative activities and life-cycle assessment, sourcing and management of raw materials, durability, reusability and recyclability, safety, risk assessment for human health and environment and risk management;

– Advanced materials enablers like characterisation (e.g. for quality assurance), modelling and simulation, piloting and upscaling;

– An EU innovation ecosystem of technology infrastructures[7], **networked and** accessible to all relevant stakeholders, identified and prioritised in agreement with Member States, which provide services to accelerate technological transformation and uptake by EU industry, notably by SMEs; this will cover all key technologies necessary to enable innovations in the field of materials;

– Solutions based on advanced materials for **cultural heritage,** design, architecture and general creativity, with a strong user orientation, for adding value to industrial sectors and the creative industries.

*4.2.**5**~~4~~. Artificial Intelligence and Robotics*

Making any object and device intelligent and connected is one of the megatrends. Researchers and innovators developing Artificial Intelligence (AI) and offering applications in Robotics and other areas will be key drivers of future economic and productivity growth. Many sectors including health, manufacturing, **ship-building,** construction, **service industries** and farming will use and further develop this key enabling technology, in other parts of the Framework Programme. Developments must ensure the safety**, the societal** and environmental soundness of AI-based applications, consider ethical aspects **from the outset**, assess the risks and mitigate its potential for malicious use and unintended discrimination such as gender**,** ~~or~~ racial **or disability** bias. It must also be ensured that AI is developed within a well-coordinated framework which respects the EU's values**,** ~~and~~ **ethical principles** **and** the Charter of Fundamental Rights of the European Union. This Programme will **be** complement**ed by** activities ~~foreseen~~ **set out** under the Digital Europe Programme.

[7] These are public or private facilities that provide resources and services primarily for the European industry to test**,** ~~and~~ validate **and demonstrate** key enabling technologies and products. Such infrastructures may be single sited, virtual or distributed, and must be registered in a Member State or a third country associated to the Programme.

Broad Lines

- Enabling AI technologies such as explainable AI, ethical AI, **human-controlled AI,** unsupervised machine learning and data efficiency and advanced human-machine **and machine-machine** interactions;

- Safe, smart, collaborative and efficient robotics and complex embodied **and autonomous** systems;

- **Human-centric**~~User-driven~~ AI technologies for AI-based solutions;

- Developing and networking the research competences **in the area** of AI ~~competence centres~~ across Europe under an open collaborative perspective **while also developing the capacity for closed testing**;

- **The employment of AI and robotics to support people affected by disability, and inclusion of marginalised individuals;**

- Technologies for open AI platforms including software algorithms, data repositories, **agent-based systems,** robotics and autonomous systems platforms.

*4.2.**6**~~5~~. Next Generation Internet*

The Internet has become a key enabler of the digital transformation of all sectors of our economy and society. The EU needs to take the lead in driving the next generation Internet towards a human-centric ecosystem in line with our social and ethical values. Investing in technologies and software for the Next Generation Internet will improve EU industrial competitiveness in the global economy. Optimising EU wide take up will require large-scale cooperation across stakeholders. **Ethical norms regulating next-generation internet should be also considered.**

Broad Lines

– Technologies and systems for trusted and energy-efficient smart network and service infrastructures (connectivity beyond 5G, software defined infrastructures, Internet of things, cloud infrastructures, next generation optical networks, quantum, cognitive clouds and quantum internet), enabling real-time capabilities, virtualisation and decentralised management (ultrafast and flexible radio, edge computing, shared contexts and knowledge) **to ensure scalable, efficient, reliable and trustworthy network performance suited for massive service deployment**;

– Next Generation Internet applications and services for consumers, industry and society building on trust, **fairness,** interoperability, better user control of data, transparent language access, new multi modal interaction concepts, inclusive and highly personalised access to objects, information and content, including immersive and trustworthy media, social media and social networking as well as business models for transactions and services over shared infrastructures;

– Software-based middleware, including distributed ledger technologies such as blockchains, working in highly distributed environments, facilitating data mapping and data transfer across hybrid infrastructures with inherent data protection, embedding artificial intelligence, data analytics, security and control in Internet applications and services predicated on the free flow of data and knowledge**;**~~.~~

– Technologies for System of Systems integration for societal and industrial applications.

4.2.~~6~~7. Advanced Computing and Big Data

High Performance Computing and Big Data have become indispensable in the new global data economy, where to out-compute is to out-compete. High Performance Computing and Big Data analytics **shall be encouraged throughout the EU and** are critical to support policy making, scientific leadership, innovation and industrial competitiveness, and to maintain national sovereignty **while respecting ethical issues**. **These activities will be complemented by activities under the Digital Europe Programme.**

Broad Lines

- High Performance Computing (HPC): next generation of key exascale and post-exascale technologies and systems (e.g. low-power microprocessors, software, system integration); algorithms, codes and applications, and analytic tools and test-beds; industrial pilot test-beds and services; supporting research and innovation for a world-class HPC infrastructure, including the first hybrid HPC**, business models for shared HPC infrastructures and services;** ~~/~~ Quantum computing infrastructure in the EU;

- Big Data: Extreme-performance data analytics; "Privacy by design" in the analysis of personal and confidential Big Data; technologies for full-scale data platforms for re-use of industrial, personal and open data; data management, interoperability and linking tools; data applications for global challenges**; methods for data science**;

- Reduced carbon footprint of ICT processes, covering hardware, architecture, communication protocols, software, sensors, networks, storage and data centres, and including standardised assessments.

*4.2.**8**~~7~~. Circular Industries*

Europe is at the forefront of the global transition towards a circular economy. Europe's industry should become a circular industry: the value of resources, materials and products should be maintained much longer compared to today, even opening up new value chains. Engagement of citizens is crucial.

Primary raw materials will continue to play an important role in the circular economy and attention must be paid to their sustainable production. **Safe and sustainable materials cycles shall be ensured.** In addition, entirely new materials, **including bio-based materials,** products and processes should be designed for circularity. Building a circular industry will have several advantages for Europe: It will lead to a secure, sustainable and affordable supply of raw materials, which will in turn protect the industry against scarcity of resources and price volatility. It will also create new business opportunities and innovative, more **resource and energy** efficient ways of produc**tion**~~ng~~. Research and development focused on developing less hazardous substances will be encouraged and stimulated.

The objective is to develop affordable breakthrough innovations and deploy a combination of advanced technologies and processes so as to extract maximum value from all resources.

Broad Lines

- Industrial symbiosis with resource flows between plants across sectors and urban communities; processes and materials, to transport, transform, re-use and store resources, combining the valorisation of by-products, waste**, wate-water** and CO2;

- Valorisation and life-cycle assessment of materials and product streams with use of new alternative feedstocks, resource control, material tracking and sorting **(including tools for risk assessment for human health and environment)**;

- **Eco-designed p**~~P~~roducts**, services and new business models** for enhanced life-cycle performance, durability, upgradeability and ease of repair, dismantling, reuse and recycling;

- Recycling industry, maximising potential and safety of secondary materials and minimising pollution, quality downgrading, and quantity dropouts after treatment;

- Elimination or**, if no alternative,** safe handling of substances of concern in the production and end-of-life phases; safe substitutes, and safe and cost-efficient production technologies;;

- Sustainable supply **and** ~~or~~ substitution of raw materials, including critical raw materials, covering the whole value chain.

*4.2.**9**~~8~~. Low-Carbon and Clean Industries*

Industrial sectors, including energy-intensive industries **and steel**, contribute millions of jobs and their competitiveness is key for the prosperity of our societies. However, they account for 20% of the global greenhouse gas emissions and have a high environmental impact (particularly in terms of air, water and soil pollutants).

Breakthrough technologies to achieve significant reductions in greenhouse gases and pollutants, often combined with the technologies for circular industry above, will lead to strong industrial value chains, revolutionise manufacturing capacities and improve the global competitiveness of industry; and at the same time make key contributions to our targets for climate action and environmental quality.

Broad Lines

- Process technologies, including heating and cooling, digital tools, automation and large-scale demonstrations for process performance and **resource and energy** efficiency; substantial reductions or avoidance of industrial emissions of greenhouse gases and pollutants, including particulate matter;

- Industrial CO2 valorisation;

- Electrification and use of unconventional energy sources within industrial plants, and energy and resource exchanges between industrial plants (for instance via industrial symbiosis);

– Industrial products that require low or zero carbon emissions production processes through the life cycle.

*4.2.**10**~~9~~. Space, including Earth Observation*

EU space systems and services reduce costs and improve efficiency, offer solutions to societal challenges, increase societal resilience**, help monitoring and fighting climate change** and foster a competitive and sustainable economy. EU support has been instrumental in helping to realise these benefits and impacts. **The** EU space programme~~s~~ must evolve to remain at the forefront. **Research and innovation activities should also support the evolution of the Union Space Programme.**

The EU will support synergies between space and key enabling technologies (advanced manufacturing, Internet of Things, big data, photonics, quantum technologies, robotics and artificial intelligence); foster a thriving and entrepreneurial and competitive **upstream and downstream** space sector**, including industry and SMEs**; boost application of space technologies**, data** and services in other sectors and help secure **technological** non-dependence in accessing and using space in a strategic, safe and secure manner**; and will promote capacity building measures**. Activities will be **generally** roadmap-based, taking account of the ESA harmonisation process and relevant Member States initiatives, and will be implemented with ESA, as appropriate.

There is a need for a wider deployment, exploitation and update of new technologies and continued research and innovation to address gaps in Earth Observation (EO) on land and sea and in the atmosphere, **benefiting from Copernicus as an essential source and** ~~collaborating in particular~~ **coordinating** through the Global Earth Observation System of Systems (GEOSS) and its European component EuroGEOSS.

Broad Lines

– European Global Navigation Satellite Systems (Galileo and EGNOS): innovative applications, global uptake including international partners, solutions improving robustness, authentication, integrity of services, development of fundamental elements such as chipsets, receivers and antennas, sustainability of supply chains, **at cost-effective and affordable conditions,** new technologies (e.g. quantum technologies, optical links, reprogrammable payloads), towards sustained exploitation of services for impact on societal challenges. Next generation systems development for new challenges such as security or autonomous driving;

– **European Earth Observation system (**Copernicus**)**: **leveraging the full, free and open data policy, develop** innovative applications, **European and** global uptake and international partners**hips**, research needed to maintain**, improve and expand** core services and research for space data assimilation **and exploitation**, robustness and evolution of services, ~~**and maintain the full, free and open data policy**~~, sustainability of supply chains, sensors, systems and mission concepts (e.g. High Altitude Platforms, drones, light satellites); calibration and validation; sustained exploitation of services and impact on societal challenges; Earth observation data **processing** techniques, **including** big data, computing resources and algorithmic tools. Next generation systems development for ~~new~~ challenges**,** such as climate change, **polar** and security; extension of the Copernicus product and service portfolio;

– Space Situational Awareness: **developments to support** robust EU capacity to monitor and forecast **the** state of the space environment e.g. space weather**, including radiation**, **space hazards,** space debris and near Earth objects**.** ~~;~~**Developments of** sensors **technologies** and new service concepts, such as space traffic management, applications and services to secure critical infrastructure in space and on Earth;

– Secure Satellite Communications for EU governmental actors: solutions **supporting the EU's autonomy** for ~~the widest possible range of~~ governmental users ~~and~~ **including** associated user equipment ~~in~~ **and** architectural, technological and system solutions for space **and ground** infrastructure~~, supporting the EU's autonomy~~;

– ~~End-to-end s~~**S**atellite Communications for citizens and businesses: **integration of** cost-effective, advanced satellite communications **in the terrestrial networks** to connect assets and people in underserved areas, as part of 5G-enabled ubiquitous connectivity**,** ~~and development of the~~ Internet of Things (IoT), and contributing to the Next Generation Internet (NGI) infrastructure. Enhanc**ing the**~~ed~~ ground segment and user equipment, standardisation and interoperability**, and preparation of quantum key communication by satellite** to ensure EU industrial leadership;

– Non-dependence and sustainability of the supply chain: increased technology readiness levels in satellites and launchers; associated space and ground segments, and production and testing facilities ~~in complementarity with ESA~~. To secure EU technological leadership and autonomy, improved supply chain sustainability **at cost-effective and affordable conditions**, reduced dependence on non-EU critical space technologies and improved knowledge of how space technologies can offer solutions to other industrial sectors;

– **Space** ~~eco~~system**s**: in-orbit validation and demonstration services, including rideshare services for light satellites; space demonstrators in areas such as hybrid, smart or reconfigurable satellites, in-orbit **servicing,** manufacturing and assembly, **energy supply using diversified sources,** ~~launcher reusability~~ ~~**concepts leading to cost reductions**, in-orbit servicing and **new commercial space transportation solutions (e.g.** micro-launchers)~~; **new industrial processes and production tools; ground systems;** breakthrough innovations, and technology transfer, in areas such as recycling, green space, artificial intelligence, robotics, digitisation, cost-efficiency, miniaturisation;

~~1.~~ **Access to space: innovative technologies for increasing the technical compatibility and economic efficiency of European space launch systems, with regard to the launch of European Union satellites: low cost production processes, launcher reusability technologies and concepts for cost reduction; concepts for future launcher ground segments and adaptations of existing ground infrastructures (e.g. digitalisation, advanced data management); innovative space transportation services/concepts, including launch systems dedicated to light satellites (e.g. micro launchers).**

– Space science: exploitation of scientific data delivered by scientific and exploration missions, combined with the development of innovative instruments in an international **and interdisciplinary** environment; contribution to precursor scientific missions for the evolution of the Space Programme.

5. CLUSTER 'CLIMATE AND ENERGY'

5.1. Rationale

The intersection of research and innovation on climate and energy will address in a highly integrated and effective way, one of the most important global challenges for the sustainability and future of our environment**, economy** and way of life.

To meet the objectives of the Paris Agreement the EU will need to transition to ~~carbon~~ **climate** neutral, resource-efficient and resilient economies and societies. This will ~~be based~~**entail** on profound changes in technology, processes, products and services, to the ways in which businesses and consumers behave**.** ~~,~~ **The transformation of the energy market will take place through interaction of technology, infrastructure, the market as well as policy and regulatory frameworks, including** ~~as well as involving~~ new forms of governance. Limiting the increase of global average temperature to well below 2°C, and pursuing efforts to limit the temperature increase to 1.5°C, requires rapid progress in decarbonising the energy system**, transport, buildings, industrial systems and agriculture**. ~~It will also need~~ **N**~~n~~ew impetus **is needed** to accelerate the pace of developing next-generation breakthroughs as well as demonstrating and deploying innovative technologies and solutions, using also the opportunities provided by digital, ~~**advanced materials**~~ bio and space technologies**, as well as key enabling technologies and advanced materials**~~.~~ This will be pursued through an integrated approach encompassing decarbonisation, resource efficiency, **improved recovery, reuse and** ~~waste disposal and improved~~ recycling, reduction of air pollution, access to raw materials and circular economy **in Horizon Europe**.

Progress in these sectors - but also across the spectrum of EU industry including **energy infrastructures, transport,** agriculture **and forestry**, tourism, -buildings, industrial processes and product use, ~~and~~ waste management **and recycling**[8] - will require continued efforts to better understand the mechanisms and dynamics of climate change and the associated impacts across the economy and society, exploiting synergies with regional and national activities, other EU types of actions and international cooperation**, including through Mission Innovation**.

Over the past decade**s**, considerable advances have been made in climate science, in particular in observations and data assimilation and climate modelling. However, the complexity of the climate-system and the need to support implementation of the Paris Agreement, the Sustainable Development Goals and EU policies necessitate a reinforced effort to fill the remaining knowledge gaps, **further enhance spatial and~~/~~ temporal granularity of climate science** while ensuring adequate interaction with citizens and other stakeholders.

The EU has established a comprehensive policy framework in the Energy Union strategy, with binding targets, legislative acts and research and innovation activities aiming to lead in developing and deploying efficient energy production systems based on renewables. A better coordination between national and European research and innovation efforts by promoting cooperation among EU countries, industries and research institutions will build on the achievements of e.g. **the** SET-**P**plan~~ and strategic transport research and innovation agenda (STRIA)~~. **Complementarity between this cluster and the EU ETS Innovation Fund will be ensured.**

The energy sector is a major driver of Europe's economic competitiveness and growth. The EU has upwards of ~~1.6~~**2** million people working in the field of renewables and energy efficiency. ~~Transportation and the storage sectors employ more than 11 million in the EU, accounting for around 5% of GDP and 20% of exports.~~

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8 **Substantial reduction of greenhouse gas emissions in other sectors is addressed in other Parts of Pillar II and Horizon Europe in general**

Finding new ways to accelerate the deployment of ~~clean~~ **renewable-based and energy efficient** technologies and **other non-technological** solutions for the decarbonisation of the European economy requires also increased demand for innovation. This can be stimulated through the empowerment of citizens**, public procurement** as well as socio-economic and public sector innovation and will lead to approaches broader than technology-driven innovation. Socio-economic research covering inter alia user needs and patterns, foresight activities, environmental, **regulatory,** economic, social**, cultural** and behavioural aspects, business cases and models and pre-normative research for standard setting **and market uptake innovation**, will also facilitate actions fostering regulatory, financing and social innovation, skills, as well as engagement and empowerment of market players**,** ~~and~~ consumers **and citizens**.

Activities under this Cluster contribute in particular to the goals of the Energy Union, **the Paris Agreement commitments** as well as to those of the Digital Single Market, the Jobs, Growth and Investment agenda, the strengthening of the EU as a global actor, the new EU Industrial Policy Strategy, **the Bioeconomy Strategy,** the Circular Economy **Action Plan**, **the European Battery Alliance Initiative,** the Raw Materials Initiative, the Security Union and the Urban Agenda, as well as the Common Agricultural Policy of the EU as well as EU legal provisions to reduce noise and air pollution.

Activities will contribute directly to the following Sustainable Development Goals (SDGs) in particular: SDG 6 - Clean water and sanitation; SDG 7 - Affordable and Clean Energy; **~~SDG8 Decent work and economic growth;~~**SDG 9 - Industry, Innovation and Infrastructure; SDG 11 - Sustainable Cities and Communities; **~~SDG 12 responsible Production and consumption;~~** SDG 13 - Climate Action.

5.2. Areas of Intervention

5.2.1. Climate Science and Solutions

Effective implementation of the Paris Agreement has to be based on science, requiring continuously ~~updating~~ **improving** of our knowledge on the climate-earth system, as well as the mitigation and adaptations options available, allowing for a systemic and comprehensive picture of challenges and climate-responsible opportunities for the EU's economy **and society**. On this basis, science-based solutions for a cost-effective transition to a ~~low-carbon~~**climate neutral**, climate-resilient and resource-efficient society will be developed~~.~~**, considering behavioural, regulatory, socio-economic and governance aspects.**

Broad Lines

- Knowledge base on the **current** functioning and future evolution of the earth-climate and living system, as well as associated impacts, risks, and climate-responsible opportunities; effectiveness of different climate mitigation and adaptation solutions;

- Integrated carbon neutral pathways, mitigation actions and policies covering all sectors of the economy, compatible with **Earth system analyses,** the Paris Agreement and the United Nations Sustainable Development Goals;

- Climate **models,** projections and techniques **aiming to improve** ~~for~~ predict**ive capacity**~~ability~~ and climate services for businesses, public authorities and citizens, including cross-cutting aspects with air quality improvement;

– Adaptation pathways and support policies for vulnerable ecosystems, **urban areas,** critical economic sectors and infrastructure in the EU (local/regional/national), including improved risk assessment tools; water cycle and adaptation to climate change**, such as flooding and water scarcity**.

5.2.2. Energy Supply

The EU aims to be world leader in affordable, secure and sustainable energy technologies improving its competitiveness in global value chains and its position in growth markets. Diverse climatic, geographical, environmental and socio-economic conditions in the EU as well as the need to ensure **climate resilience,** energy security and access to raw materials, dictate a broad portfolio of energy solutions, including of non-technical nature. As regards renewable energy technologies, costs need to decrease further, performance must improve, integration into the energy system must be improved and breakthrough technologies need to be developed. As regards fossil fuels, decarbonising their usage ~~will be~~**is** essential to meet the climate objectives.

Broad Lines

– Renewable energy ~~and energy conservation~~ technologies and solutions for power generation, heating and cooling, sustainable transport fuels and intermediate carriers, at various scales and development stages, adapted to geographic **and socio-economic** conditions and markets, both within the EU and worldwide;

– Disruptive renewable energy technologies for both existing and new applications and for breakthrough solutions;

– Technologies and solutions to reduce greenhouse gas emissions from fossil fuel-based as well as from bio**-** and waste**-** ~~-~~to**-** ~~-~~energy**-** ~~-~~based ~~solutions~~ **approaches** producing power, heating, cooling or biofuels **including** via CO2 capture, utilisation and storage (CCUS~~).~~) ~~including~~ **and** studies of economic and ecologic**al** feasibility;

– ~~Technology and solutions enabling optimal use of space for the generation of renewable energy.~~

5.2.3. Energy Systems and Grids

The expected growth of variable electricity production and shift towards more electric heating, cooling and transport dictates the need for new approaches to manage energy grids. Next to decarbonisation, the goal is to ensure energy affordability, security**, climate resilience,** ~~-~~and stability of supply, achieved through investments in innovative network infrastructure technologies and innovative system management. Energy storage in different forms will play a key role in providing services to the grid, also improving and reinforcing network capacities **and system flexibility**. Exploiting synergies between different networks (e.g. electricity grids, heating and cooling networks, gas networks, transport recharging and refuelling infrastructure, hydrogen, including its infrastructure, and telecom networks) and actors (e.g. industrial sites, data centres, self-producers**, consumers, renewable energy communities**) **as well as demand-response and developing and integrating European and international standards** will be crucial for enabling the smart, integrated operation of the relevant infrastructures.

Broad Lines

- Technologies and tools for ~~electricity~~ networks to integrate renewables, storage solutions and new loads such as electro-mobility and heat pumps as well as the electrification of industrial processes;
- Pan-European energy network approaches to ~~management~~**reliable energy supply, transmission and distribution**;
- Integrated approaches to match renewable energy production and consumption at local level including on islands or remote regions, based on new services and community initiatives;
- Network flexibility**, interoperability** and synergies between the different energy sources, networks, infrastructures and actors**, also exploiting specific technologies**;
- **Technologies, services and solutions empowering consumer to be an active market player.**

5.2.4. Buildings and Industrial Facilities in Energy Transition

Buildings and industry installations play an increasingly active role in their interaction with the energy system. Therefore, they are crucial elements in the transition to a carbon-neutral society based on renewable energy and increased energy efficiency.

Buildings are an important factor for quality of life of citizens. Integrating different technologies, appliances and systems and linking various energy uses, buildings as well as their inhabitants and users represent a very high potential for climate change mitigation, energy generation, **energy savings,** storage**, system flexibility** and efficiency improvements.

Industries, and especially those that are energy-intensive, could further improve energy efficiency, **reduce their energy consumption** and favour the integration of renewable energy sources. **Industrial facilities' role in the energy system is changing, due to the need to reduce emissions, based on direct or indirect electrification, also a source of materials for production processes (e.g. hydrogen). Industrial and manufacturing complexes where many different processes take place near to each other can optimise the exchange of flows of energy and other resources (raw materials) between them.**

Broad Lines

- **Improve sector coupling : Processes, systems and business models supporting flexibility and efficiency of e**~~E~~lectricity and heat **flows** between an industrial plant **or industrial clusters** and ~~an~~ **the** energy system~~ operator~~;
- Tools and infrastructure for process control of production plants to optimise energy flows in interaction with the energy system;
- Relevant processes, design and materials;
- **Improved or new processes, design and materials to efficiently use, produce or store energy (including heat and cold) in sectors not covered by the "Digital, Industry and Space" cluster;**
- **Strategies and technologies for revitalising coal regions in transition;**

- Smart buildings and large mobility hubs (ports, airports, logistic centres) as active elements of wider energy networks and of innovative mobility solutions;

- Buildings life-cycle design, construction, operation, including heating and cooling, and dismantling, taking into account circularity, energy and environmental performance, **as well as indoor environmental quality,** for energy and resource efficiency, for well-being and health impact on the inhabitants, climate resilience, carbon footprint and recycling; **development and optimization of novel advanced materials to increase the energy, carbon and environmental performances of buildings over the life cycle**

- New business models, approaches and services for renovation financing, enhancement of construction skills, engagement of buildings occupants and other market actors, **addressing energy poverty and**~~including~~ **prenormative activities**~~ definition of standards~~;

- Energy performance of buildings monitoring and **control** technologies for optimising **energy consumption and production of building as well as their interaction with the overall energy** system~~s~~;

- Tools and smart appliances for energy efficiency gains in buildings;

- Renovation processes of existing buildings towards 'Nearly Zero Energy Buildings' **and innovative technologies**;

5.2.5. *Communities and Cities*

It is estimated that by 2050, more than 80% of the EU's population will live in urban areas, consuming the lion's share of available resources, including energy, and being areas particularly vulnerable to the adverse meteorological change impacts worsen by climate change and natural disasters already now and increasingly in the future. A key challenge is to significantly increase the overall energy and resource efficiency as well as climate-resilience of Europe's **communities and** cities in a **systematic and** holistic approach, targeting the building stock, energy systems, mobility, climate change, **migration,** as well as water, soil, air quality, waste and noise**, taking into account Europe's cultural heritage, sustainable tourism management and social sciences and humanities aspects, including lifestyle.**. Synergies with ERDF-funded urban policy and actions should be investigated and exploited.

Broad Lines

- City/district energy/mobility systems towards the EU-wide deployment of carbon neutral, Positive Energy Districts and zero-emission mobility and logistics by 2050, boosting the global competitiveness of integrated EU solutions;

- Systemic urban planning, infrastructures ~~and~~ systems **and services** including mutual interfaces and interoperability, **standardisation,** nature-based solutions and the use of digital technologies and space based services and data, taking into account the effects of projected climate change and integrate climate resilience **and the influence on air and water quality**;

- Quality of life for the citizens, safe**,** flexible, accessible and affordable energy and **multi-modal** mobility, urban social innovation **and citizen engagement**, cities' circular and regenerative capacity, **urban metabolism and** reduced environmental footprint and pollution;

- Global cities research agenda; resilience strategy development, ~~including~~ spatial planning and other relevant planning processes.

5.2.6. Energy Storage

Massive, **smart,** concentrated and decentralised storage solutions (comprising chemical, electrochemical, electrical, mechanical and thermal **and new disruptive technologies**) for the energy system will increase efficiency, flexibility, technology independence and accessibility as well as the security of supply. Low-emission, decarbonised transport will require a growing share of electrical and/or other alternatively fuelled vehicles, with better-performing and cheaper, **lighter, highly** recyclable and reusable batteries **with a low environmental impact**, as well as local provision of synthetic/renewable fuels such as hydrogen and innovative solutions for on-site storage. Options for sustainable and cost efficient large scale energy storage are essential to optimize and balance the energy system in all sectors of production, infrastructure up to end-user applications. Attention should be paid to the risks of energy storage and other unwanted side effects.

Broad Lines

- Technologies including liquid and gaseous renewable fuels and their associated value chains, for daily to seasonal energy storage needs;
- Smart, sustainable and durable batteries and the EU value chain, including the use of advanced material solutions, design, large-scale battery cell production technologies, reuse and recycling methods **as well as standardisation needs**;
- Low carbon hydrogen including fuel cells, and the EU value chain from design to end use across various applications.

6. CLUSTER 'MOBILITY'

6.1. Rationale

Transport is a fundamental sector for and of the economy with the EU being a world leader in vehicle, rail, aircraft and vessel design and manufacturing. It embraces a complex network of around 1.2 million private and public companies in the EU, employing around 10.5 million people. The sector is also important for the EU's international trade: in 2016, 17.2% of the EU's total exports of services were transport related.

Transport, including vehicles, ensures the mobility of people and goods necessary for an integrated European single market, territorial cohesion and an open and inclusive society. At the same time, transport ~~has~~ **can have** significant ~~negative~~ effects on human health, congestion, land, water, **climate,** air quality and noise, as well as safety resulting in numerous premature deaths and increased socio-economic costs. Therefore, sustainable mobility and transport ~~networks~~ **systems** need to be~~come~~ clean, safe, smart, secure, silent, reliable**, accessible** and affordable, offering a seamless integrated door-to-door service **to all**.

The issues faced by the transport sector go however beyond the need for emission reduction. **In order to address the various challenges posed, it is necessary to take into consideration the ever-changing landscape and trends of the sector. Notably, effective solutions are needed** ~~There are several challenges to be tackled, including~~ **to respond to** the increasing penetration of digital and space-based technologies, changes in user behaviour and mobility patterns, new market entrants and disruptive business models, globalisation, increasing international competition and an older, more urban and increasingly diverse, population

A rapid growing world population, growing urbanisation, changes in consumption patterns, the need to reduce greenhouse gas emissions, accelerated innovation in automation, digitalisation, AI and robotics bring substantive transformation to transport and create additional challenges for the competitiveness of the European transport sector. Internet of things, ~~/P~~physical internet developments, Big Data and ~~huge p~~Platforms will stimulate hyper connectivity, increase seamlessness and will change the way in which we access and use mobility, how we organise, manage, operate and plan transport, how we deliver goods, and how we include walking, cycling and other innovative, non fuel-consuming transport means into our mobility systems. Interpenetration between the virtual and the physical world might soon become the norm and cause new challenges for infrastructure providers and ~~proper~~ amortisation of investments. The move towards automated vehicles, non carbon fuels, innovative materials, smarter logistics and changing habits of people and industries will have severe repercussions on transport modes, interfaces and hubs, vehicles and infrastructure and on building infrastructure as well as system resilience against multifaceted hazards (including cyber threats). Demand for goods and mobility will continue to grow. Innovation will have to bridge growing demand with cleaner and more efficient mobility systems, modes and patterns.

Cities' ability to function will become dependent on technology and the liveability of cities will evolve around mobility, spatial planning and competition in space use. Migration to the cities from rural areas, and regional connectivity issues, will change the nature of cities and their surroundings. Developments will also be posing a challenge to the sustainability of existing social models and social participation, aspects of inclusion and accessibility as well as affordability.

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Finding new ways to accelerate the deployment of clean technologies and solutions for the decarbonisation of the European transport sector requires also increased demand for innovation. This can be stimulated also through the empowerment of citizens as well as socio-economic and public sector innovation and will lead to approaches broader than technology-driven innovation. Socio-economic research covering inter alia user needs and patterns, foresight activities, environmental, economic, social and behavioural aspects, business cases and models and pre-normative research for standard setting, will also facilitate actions fostering regulatory, financing and social innovation, skills, as well as engagement and empowerment of market players and consumers. **A better coordination and complementarity between national and European research and innovation efforts by promoting information exchange and cooperation among EU countries, industries and research institutions will build on the achievements of e.g. the strategic transport research and innovation agenda (STRIA).**

~~Transport is a fundamental sector for and of the economy with the EU being a world leader in vehicle, aircraft and vessel design and manufacturing. It embraces a complex network of around 1.2 million private and public companies in the EU, employing around 10.5 million people. The sector is also important for the EU's international trade: in 2016, 17.2% of the EU's total exports of services were transport related.~~

Activities will contribute directly to the following Sustainable Development Goals (SDGs) in particular: SDG 9 - Industry, Innovation and Infrastructure; SDG 11 - Sustainable Cities and Communities; SDG 13 - Climate Action.

6.2. Areas of Intervention

6.2.1. Industrial Competitiveness in Transport

The shift towards clean technologies, connectivity and automation will depend on the timely design and manufacture of aircraft, vehicles**,** ~~-~~and vessels **developing new breakthrough technologies and concepts,** integrating different technologies and accelerating their introduction and marketability. Increasing comfort, efficiency, affordability, while minimising lifecycle impact on the environment, human health and on energy use remain objectives of paramount importance. Innovative, highly capable transport infrastructure is essential for the proper functioning of all transport modes in view of increased mobility demand and rapidly changing technology regimes. An integrated approach to infrastructure and vehicle/vessel/aircraft development deserves particular attention also in order to minimise energy ~~and~~ environmental**, economic and social** impact.

Broad Lines

- Merging of physical and digital vehicle/vessel/aircraft design, development and demonstration, manufacturing, operations, standardisation, certification and regulations and integration (including integration between digital design and digital manufacturing);
- Vehicle/vessel/aircraft concepts and designs, including their spare parts and software **and technology** updates, software solutions; using improved materials and structures, recycling/reusing materials; efficiency, energy storage and recovery, safety and security features **considering users' needs,** with less **impact on climate,** environment and health ~~impact~~, including noise and air quality**,**.
- On-board technologies and sub-systems, including automated functions, for all modes of transport taking account of relevant infrastructure interface needs and exploring; technological synergies between modes; safety/accidence avoidance systems and enhancing cybersecurity; leveraging progress **in information technologies, and** in artificial intelligence; developing the human-machine interface;
- New materials, techniques and methods of construction, operations and maintenance of infrastructures, ensuring reliable network availability, **intermodal interfaces and multimodal interoperability,** workforce safety, and full life-cycle approach;

– **Addressing issues of merging physical and digital infrastructure design and development, i**~~I~~nfrastructure maintenance, regeneration and upgrading transport integration, interoperability and intermodality, resilience to extreme weather events.

6.2.2. Clean, Safe and Accessible Transport and Mobility

For the EU to reach its air quality, climate, and energy goals, including **reaching net-zero emissions** ~~a 60% reduction in green-house gas emissions~~ by 2050 as well as noise reduction, will require rethinking the whole mobility system including users**' needs and behaviours**, vehicles, fuels, infrastructures as well as ~~transport~~**new**-**mobility** solutions. It will also require the deployment of low-emission alternative energies and market uptake of zero-emission vehicles/vessels/aircrafts. In addition to the ~~harmful~~ effects of greenhouse gas emissions, transport contributes significantly to poor air quality and noise in Europe with negative consequences for the health of citizens and ecosystems. Building on progress with electrification and the use of **batteries and** fuel cells for cars, buses and light duty vehicles, accompanied by adequate standards, it is essential to accelerate research and innovation solutions for other road applications (long distance coaches, heavy freight vehicles and lorries) and other transport sectors such as aviation, rail, maritime and inland navigation. **Transport safety research aims at reducing accident rates, fatalities and casualties in each mode and in the whole transport system by furthering knowledge and awareness and by developing technologies, products services and solutions that reconcile safety, efficiency, user-friendliness and climate change.**

Broad Lines

– Electrification of all transport modes ~~(e.g. batteries, fuel cells, hybridisation, etc.)~~ including new **battery, fuel cell and hybrid** technologies for vehicle/vessel/aircraft powertrains and auxiliary systems, fast charging/refuelling, energy harvesting and user-friendly and **easily** accessible interfaces with the charging**/refuelling** infrastructure, ensuring interoperability and seamless services provision; development and deployment of competitive, safe, high-performing and sustainable batteries for low and zero-emission vehicles considering all the conditions of using and during the different phases of its life cycle; development and deployment of competitive, safe, high-performing and sustainable batteries for low and zero-emission vehicles;

– Use of ~~sustainable~~ new **and alternative sustainable** fuels, including advanced bio-fuels and new, safe and smart vehicles/vessels/aircraft for existing and future mobility patterns and supporting infrastructure **with reduced impact on the environment and public health**; technologies and user-based solutions for interoperability and seamless services provision;

– Safe, accessible**, inclusive** and affordable mobility, reducing the harmful whilst enhancing the positive impact of mobility on **social cohesion,** the environment and human health, including shift to less polluting modes of transport **and sharing schemes**; **Quality of life for the citizens, urban social innovation;** ~~significantly reducing~~ reaching nearly zero accidents and injuries in road transport.

6.2.3. Smart Mobility

Smart mobility will help ensure the efficiency, safety and resilience of door-to-door mobility and all its components, in particular by using digital technologies, advanced satellite navigation (EGNOS/Galileo), and artificial intelligence. New technologies will help to optimise the use and efficiency of transport infrastructure and networks, improving multi-modality and connectivity, increasing reliability, optimising traffic management and enable innovative transport solutions and services, thus reducing congestion and negative environmental impacts, providing better mobility and logistics services for citizens and businesses **improving accessibility and social inclusion**. Connected and automated mobility together with the enabling infrastructure will improve efficiency and safety in all transport modes.

Broad Lines

– Digital network-and traffic management: advanced decision support systems; next generation traffic management (including multi-modal network and traffic management); contributing to seamless, multimodal and interconnected mobility for passengers and freight; use and limitations of big data; use of innovative satellite positioning/navigation (EGNOS/Galileo);

– Single European Sky: on-board and on-the-ground solutions for **simultaneously** higher degrees of automation, connectivity, safety, interoperability, performance, emission reduction and service;

- Rail technologies and operations for a high-capacity, silent, interoperable, and automated railway system;
- **Large mobility hubs (e.g railway stations, ports, airports, logistic centres) as active elements of innovative mobility solutions**
- **Waterborne technologies and operations for safe and automated transport systems seizing the opportunities provided by waterborne transport**
- Connected, cooperative, interoperable and automated mobility systems and services, including technological solutions and non-technological issues, such as changes in user behaviour and mobility patterns .

7. CLUSTER 'BIOECONOMY, FOOD NATURAL RESOURCES AND ENVIRONMENT'

7.1. Rationale

Human activities are exerting increasing pressure on soils, seas and oceans, water, air, biodiversity and other natural resources. Nourishing the planet's growing **human** population is directly dependent on the health of natural systems and resources. **Beyond its intrinsic value, a** ~~A~~ functioning and prosperous ecosystem is the very basis for all resources utilisation. However, combined with climate change, human**kind**~~ity~~'s growing demand for natural resources creates environmental pressures that go far beyond sustainable levels, affecting ecosystems and their capacity to provide services for human well-being. The concepts of the circular economy, the sustainable bioeconomy[9] and the blue economy[10] provide an opportunity to balance environmental, social and economic goals and to set human activities on a path to sustainability.

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[9] The bioeconomy covers all sectors and systems that rely on biological resources (animals, plants, micro-organisms and derived biomass, including organic waste), their functions and principles. It includes and interlinks: land and marine ecosystems and the services they provide; all primary production sectors that use and produce biological resources (agriculture, forestry, fisheries and aquaculture); and all economic and industrial sectors that use biological resources and processes to produce food, feed, bio-based products, energy and services. Biomedicines and health biotechnology are excluded.

[10] 'Sustainable blue economy' means all sectoral and cross-sectoral economic activities throughout the single market related to oceans, seas, coasts and inland waters, covering the Union's outermost regions and landlocked countries, including emerging sectors and non-market goods and services and being consistent with Union environmental legislation.'

Meeting the goals of sustainable development, guaranteeing the production and consumption of safe and healthy food, promoting sustainable practices in agriculture, aquaculture, fisheries and forestry, ensuring access to clean water, soil and air for all, cleaning up ~~the~~ seas**,** ~~and~~ oceans **and inland waters**~~,~~ preserving and restoring the planet's vital natural systems and environment requires that we harness the potential of research and innovation. But the pathways for the transition to sustainability and ways to overcome resilient barriers are hardly understood. Making the transition to sustainable consumption and production and restoring planetary health requires ~~investing~~ **investment** in **research and** technologies, novel**, high quality** -products **and services**, new business models, and social**, territorial** -and environmental innovation**s**. This creates new opportunities for a sustainable, resilient, innovative and responsible European bioeconomy, boosting resource efficiency, productivity and competitiveness, ~~and~~ generating jobs and growth **and increasing social inclusion**.

Activities will build a knowledge base and deliver solutions to: protect, sustainably manage and use natural resources from land and sea[11] - and enhance the role of terrestrial and aquatic systems as carbon sinks; **protect biodiversity,** ensure food and nutrition security, providing safe, healthy and nutritious diets; accelerate the transition from a fossil-based linear economy to a resource efficient, resilient, low emission, low-carbon circular economy, and supporting the development of a sustainable bioeconomy and the blue economy; and develop resilient and vibrant rural, mountain, coastal and urban areas.

~~They~~ **These activities** will help to maintain and enhance ~~the provision of~~ biodiversity and secure the long-term provision of ecosystem services, **such as** climate change adaptation and mitigation and carbon sequestration (both on land and sea). They will help reduce greenhouse gas (GHG) and other emissions, waste and pollution from primary production (both terrestrial and aquatic), **the use of hazardous substances,** processing, consumption and other human activities. They will trigger investments, supporting the shift towards a circular economy, sustainable bioeconomy and blue economy, whilst protecting environmental health and integrity.

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[11] The expression 'land and sea' includes 'inland waters' throughout the text of Cluster 6.

~~They~~ **Activities** will also foster participatory approaches to research and innovation, including the multi-actor approach and develop knowledge and innovation systems at local, regional, national and European levels. Social innovation with citizens' engagement and trust in innovation will be crucial to encourage new governance, production**,** ~~and~~ consumption patterns **and skills**.

As these challenges are complex, interlinked and global in nature, activities will follow a systemic approach, cooperating with Member States and international partners, with other funding sources and with other policy initiatives. This will involve user-driven exploitation of environmental big data sources, such as those from Copernicus, EGNOS/Galileo, INSPIRE, EOSC, GEOSS, CEOS, EMODnet.

Research and innovation activities under this Cluster contribute in particular to the implementation of the goals of: the Environment~~al~~ Action Programme, the Common Agricultural Policy, the Common Fisheries policy, the Food Law legislation, the Maritime policy, the Circular Economy Action Plan, the EU Bioeconomy Strategy, **the Biodiversity Strategy,** ~~and~~ the 2030 climate and energy framework **and the EU 2050 long term** ~~**strategy**~~**vision for carbon neutrality**~~**climate action**~~[12], **EU Arctic Policy** as well as EU legal provisions to reduce air pollution.

Activities will contribute directly to the following Sustainable Development Goals (SDGs) in particular: SDG 2 – Zero Hunger; SDG 3 – Good Health and Well-Being; SDG 6 - Clean Water and Sanitation; SDG 8 – Decent Work and Economic Growth; SDG 9 – Industry, Innovation, and Infrastructure; SDG 11 – Sustainable Cities and Communities; SDG 12 - Responsible Consumption and Production; SDG 13 – Climate Action; SDG 14 – Life Below Water; SDG 15 - Life on Land.

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[12] **COM(2018) 773 final: A Clean Planet for all. A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy**

7.2. Areas of intervention

7.2.1. Environmental Observation

The capacity to observe the environment[13], including space-based, in-situ-based (air, sea, land) observation, and citizen observations underpins research and innovation[14]-for the sustainable use and monitoring of food and natural resources, biomonitoring and environmental monitoring. Improved spatio-temporal coverage and sampling intervals at reduced cost, as well as big data access and integration from multiple sources provide new ways to monitor, understand and predict the Earth system. **Research and innovation is needed to develop methods and technologies to improve quality as well as facilitate access and use of data.**

Broad Lines

- User driven and systemic approaches including open data, to environmental data and information for complex modelling and predictive systems**, business opportunities from exploitation and valorisation of existing and new data**;
- **Further development of products and services portfolio for environmental observations;**

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[13] **Environmental Observation accessible *e.g.* through the Copernicus component of the Union Space programme and the GEO initiative will support research and innovation under other intervention areas within this Global Challenge as well as other relevant parts of Horizon Europe.**

[14] ~~Earth Observation will support research and innovation under other intervention areas within this Global Challenge as well as other relevant parts of Horizon Europe.~~

– Biodiversity status, ecosystem protection, climate change mitigation and adaptation, food security, agriculture and forestry, land use and land use change, urban and peri-urban development, natural resources management, **sea and** ocean **resources management** ~~exploitation~~ and conservation, maritime security, **long term** ~~decadal~~ environmental trends, changes in seasonal variability, ambient air and atmospheric changes and other relevant domains;

– User oriented applications**, to be delivered through the EuroGEOSS initiative,** including their **up** scaling ~~up~~, to contribute to the preservation and management of European natural resources (including exploration of raw materials) and ecosystems services and their related value chain.

– Implementation of the Global Earth Observation System of Systems of the GEO (Group on Earth Observations) initiative

7.2.2. Biodiversity and Natural Resources

Improved understanding**,** ~~and~~ preservation **and management** of biodiversity and ecosystems, the multiple services they provide (in a context of combatting climate change and mitigating its impacts) and planetary 'boundaries' as well as solutions harnessing nature's power and complexity is needed to address societal challenges, to enhance sustainability and to attain the EU objective of 'Living well within the limits of our planet' by 2050 as laid down in the 7th EU Environmental Action Programme. Due account must be taken of potential upstream impacts throughout whole value chains. International cooperation and contribution to international efforts and initiatives, such as the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services **(IPBES)**, are essential to achieve the objectives in this area. There is a need to better understand the governance of the transition to sustainability in the economic, social and natural system, from the local to the global level.

Broad Lines

- The state and value of biodiversity, terrestrial, freshwater and marine ecosystems, natural capital and ecosystem services, including agro-ecosystems **and the microbiome**;

- Holistic and systemic approaches within a socio-ecological framework for the links between biodiversity, ecosystems and ecosystems services and their causality relationships with drivers of change, across different scales and economic activities, including the **socio economic aspects and** governance of transition processes to sustainability;

- Modelling of trends and integrated scenarios for biodiversity, ecosystem services and good quality of life at different scales and horizons; the potential contribution of biotopes and ecosystems as carbon sinks under various climate change scenarios; **potential conflicts of interests in utilization of natural resources and services;**

- Ecotoxicology of compounds and new pollutants, their interactions**, including combination effects,** and environmental behaviour, and altered biochemical loops under changing climate**, restoration of degraded areas**;

- Mainstreaming biodiversity and ecosystem services in decision-making frameworks and accounting systems of governments and businesses, as well as quantification of ~~their~~ **societal** benefits;

- Adaptable and multi-functional nature-based solutions, addressing challenges in ~~cities and other~~ urban ~~(~~and peri-urban~~)~~ areas, rural and coastal and mountain areas related to climate change, natural disasters, biodiversity loss, ecosystem degradation, pollution, social cohesion and citizens' health and well-being;

– Multi-actor living labs approaches engaging authorities, stakeholders, business and civil society in co-designing and co-creating systemic solutions for the preservation, restoration and sustainable use of natural capital, and the governance of the transition to sustainability and sustainable management options in economic activities throughout whole value loops in different environmental, economic and social conditions.

7.2.3. Agriculture, Forestry and Rural Areas

Resilient and sustainable **agriculture** ~~farming~~ and forestry ~~systems~~ provide economic, environmental and social benefits ~~in a changing context for primary production~~. In addition to contributing to food and nutrition security, they feed into dynamic value chains, manage land and natural resources as well as deliver a range of vital public goods including carbon sequestration, biodiversity preservation, pollination and public health. Integrated and place-based approaches are needed to promote the multiple functions of agro- and forest (eco)systems taking into account the changing context for primary production, notably in relation to climate change and environment, resource availability, demography and consumption patterns. It is also necessary to address the spatial**,** ~~and~~ socio-economic **and cultural** dimension of agriculture and forestry activities and mobilise the potential of rural **and coastal** areas.

Broad Lines

– Methods, technologies and tools for sustainable**,** ~~and~~ resilient **and productive** ~~production in farming~~ **agriculture** and forestry, ~~including adaptation to climate change~~;

– Sustainable management and efficient use of natural resources (e.g. soils, water, nutrients and biodiversity including genetic resources)~~-~~ in agriculture and forestry; alternatives to non-renewable resources and adoption of circular economy principles**, including through the recycling of waste and by-products**;

– Climate and environmental impact of activities in the primary sector; potential of agriculture and forestry as carbon sinks and for mitigation of greenhouse gas emissions including negative emission~~s~~ approaches; **increasing adaptability of primary production to climate change**

- **Integrated approaches to tackling** ~~P~~**p**lant pests and diseases **as well as** ~~and~~ animal health and welfare; **prevention strategies, control and diagnostic and** alternatives to the use of contentious pesticides, antibiotics and other substances **also to tackle resistance**;

- Antimicrobial resistance and threats from biological and agrochemical hazards**, including pesticides,** as well as chemical contaminants tackling the links between plant, animal , ecosystems and public health from One-Health and Global-Health perspectives;

- The use and delivery of ecosystem~~s~~ services in agriculture and forestry systems applying ecological approaches and testing nature-based solutions from farm to landscape levels for an environmentally friendly agriculture; **support to organic farming;**

- Agricultural and forestry systems from farm to landscape levels ~~for optimising local conditions~~; the use and delivery of ecosystem services in primary production, e.g. through agro-ecology;

- Innovations in farming at the interfaces between agriculture, aquaculture**,** ~~and~~ forestry and in urban **and peri-urban** areas;

- **Support to EU plant protein production for food, feed and environmental services**

- **Sustainable** ~~L~~**l**and use, rural development and territorial linkages; capitalising on the social, cultural, economic and environmental assets of rural areas for new services, business models, value chains and public goods;

- Digital innovations in farming, forestry and across value chains and rural areas through the use of data and development of infrastructures, **technologies (such as AI, robotics, precision farming and remote sensing)** ~~**technologies**~~ and governance models;

- Agricultural and forestry knowledge and innovation systems and their interconnection at various scales; advice, building skills**, participatory approaches** and information sharing.

– **Fostering international partnerships for sustainable agriculture for food and nutrition security:**

7.2.4. Seas, Oceans and Inland Waters

The natural capital and ecosystem services of seas, oceans', inland waters and ~~the wider~~ coastal ~~zones~~ **areas** offer significant socio-economic and welfare benefits. This potential is at risk because of the severe pressure from human and natural stressors such as pollution, overfishing, climate change, sea-level rise, other water-use and extreme weather events. To prevent seas**,** ~~and~~ oceans ~~**and to restore a good status of inland waters and inland waters**~~ from reaching a point of no return, **and to restore a good status of inland waters ;** it is necessary to strengthen our knowledge and understanding in order to ~~sustainably manage~~, protect ~~and~~ **,**restore **and sustainably manage** marine**, inland**- and coastal ecosystems and prevent ~~marine~~ pollution, in a context of an improved and responsible ~~ocean~~ governance framework. This will also include research to sustainably unlock the vast and unexploited economic potential of seas, oceans and inland waters aiming at producing more food, bio-based ingredients and raw material without increasing pressures on them, as well as the potential of aquaculture in all forms to alleviate pressure on land, freshwater and ocean resources. There is a need for partnering approaches, including sea basin and macro-regional strategies, extending beyond the EU (e.g. in **the Atlantic,** the Mediterranean, the Baltic, the North Sea, ~~**and**~~ the Black Sea, **the Caribbean Sea and the Indian Ocean**~~the Atlantic, the Caribbean Sea and in the Indian Ocean~~); and for contributing to International Ocean Governance commitments, initiatives like the United Nations Decade of Ocean Science for Sustainable Development and commitments linked to the conservation of marine biological diversity in areas beyond national jurisdiction.

Broad Lines

– Sustainable fisheries and aquaculture in all forms, including alternative sources of protein with increased food security, food sovereignty and climate resilience; **monitoring and management tools.**

– Strengthened resilience of marine ecosystems thereby ensuring seas and ocean health, combating and mitigating the effects of natural and ~~human~~ **anthropic** pressures like contaminants and marine litter **(including plastics~~-~~)**, eutrophication, invasive species, physical damage to the sea floor, **overexplotation,** underwater noise, acidification, seas and oceans warming, sea level rise, considering the intersection between land and sea**, the cumulative impact of these issues** and fostering a circular approach and a better understanding of ocean-human interactions;

– ~~Ocean g~~**G**overnance at global and regional levels to ensure conservation and sustainable use of the ~~seas and oceans~~ resources **of seas, oceans and inland waters**;

– Technologies for the digital ocean (seafloor, water column and water surface) connecting services and communities in land-based, atmosphere, climate, space and weather related activities, and promoted through the Blue Cloud as part of the European Open Science Cloud;

– Monitoring**, risk-based assessment** and predictive/forecasting capacities including sea-level rise and other natural hazards e.g. storms surges, **floods and droughts,** tsunamis as well as cumulative impact of human activities**;** ~~and risk-based assessment (monitoring);~~

– Blue value-chains, ~~including the sustainable exploitation of deep sea resources~~, the multiple-use of marine space and growth of the renewable energy sector from seas and oceans, including sustainable **use of** micro- and macro- algae;

– Integrated approaches to sustainable management of inland and coastal waters which will contribute to environmental protection and adaptation to climate change;

– Nature-based solutions ~~based on~~**derived from** marine and coastal ecosystem dynamics, biodiversity and multiple ecosystem services, which will enable systemic approaches to sustainably use the resources of seas and oceans, contribute to environmental protection and restoration, coastal management, and adaptation to climate change;

– Blue innovation including in the blue and digital economies, across coastline areas, coastal cities and ports in order to strengthen resilience of coastal areas and increase citizens' benefits;

– Better understanding of the role of oceans ~~for~~ **in** climate change mitigation and adaptation.

7.2.5. Food Systems

The combined effects of population growth, **evolution of diets,** resource scarcity and overexploitation, environmental degradation, climate change and migration create unprecedented challenges which require food system transformation (FOOD 2030).[15] Current food production and consumption are largely unsustainable while we are confronted with the double burden of malnutrition, characterised by the coexistence of undernutrition, obesity and other ~~emerging eating~~**diet imbalances and metabolic** ~~-~~disorders. Future food systems need to deliver **on food security, and ensure** sufficient safe, healthy and quality food for all, underpinned by resource efficiency, sustainability (including the reduction of GHG emissions, pollution**, water and energy consumption as well as**~~and~~ waste production), **transparency,** linking land and sea, reducing food waste, enhancing food production from inland waters, seas and oceans and encompassing the entire 'food value chain' from producers to consumers – and back again **–**~~,~~ ensuring resilience. This needs to go hand in hand with development of the food safety system of the future and the design, development and delivery of tools, technologies and digital solutions that provide significant benefits for consumers and improve the competitiveness and sustainability of the food value chain. Furthermore, there is a need to foster behavioural changes in food consumption and production patterns**, taking into account cultural and social aspects,** as well as to engage primary producers, industry (including SMEs), retailers, food service sectors, consumers, and public services.

[15] SWD(2016) 319 final: European Research and Innovation for Food and Nutrition Security

Broad Lines

- Sustainable and healthy diets for people's well-being across their lifespan**, including dietary patterns, improved nutritional quality of food and advances in understanding the impact of nutrition on health and well-being**;

- Personalised nutrition especially for vulnerable groups, to mitigate the risk factors for diet-related and non-communicable diseases;

- Consumers' behaviour, lifestyle and motivations**, including social and cultural aspects of food**, promoting social innovation and societal engagement for better health and environmental sustainability throughout the entire food value chain, including retail patterns;

- Modern food safety and authenticity systems**, including traceability**, **improving food quality and** enhancing consumer confidence in the food system;

- Food system mitigation of and adaptation to climate change, including the exploration of the potential and use of the microbiome, ~~-~~of food crop diversity, and of alternative **to animal** proteins;

- Environmentally sustainable, circular, resource efficient and resilient food systems**, ~~,~~** from land and sea, towards safe drinking water and maritime issues, zero food waste throughout the entire food system, through reuse of food and biomass, recycling of food waste, new food packaging, demand for tailored and local food;

- ~~Innovation~~ **Novel approaches, including digital tools** and food systems for place-based innovation and empowerment of communities, fostering fair trade and pricing **along the value chain**, inclusiveness and sustainability through partnerships between industry **(including SMEs and smallholders)**, local authorities, researchers and society.

7.2.6. Bio-based Innovation Systems in the EU Bioeconomy

Innovation in the bioeconomy lays the foundations for the transition away from a fossil-based economy. Bio-based innovation is an important segment and enabler of the overall bioeconomy and encompasses the sustainable sourcing, industrial processing and conversion of biomass from land and sea into bio-based materials and products. **Sustainability includes all its dimensions: ecological, social, economic and cultural aspects).** It also capitalises on the potential of living resources, life sciences**, digitalisation** and biotechnologies for new discoveries, products**, services** and processes. Bio-based innovation, including **(bio)processes and** technologies, can bring new economic activities and employment to regions and cities, contribute to revitalising rural and coastal economies **and communities** and strengthen the circularity of the bioeconomy.

Broad Lines

- Sustainable biomass sourcing, logistics and production systems, focusing on high-value applications and uses, social and environmental sustainability, impact on climate and biodiversity**, circularity** and overall resource efficiency**, including water**;

- Life sciences and their convergence with digital technologies for understanding, prospecting and sustainably using biological resources;

- Bio-based value chains, bio-based materials, including bio-inspired materials, chemicals, products**, services** and processes with novel qualities, functionalities and improved sustainability (including reducing ~~greenhouse gases~~ emissions **of greenhouse gases**), fostering the development of **(small and large scale)** advanced biorefineries using a wider range of biomass; **replacing current production of unsustainable products by outperforming biobased solutions for innovative market applications;**

- Biotechnology, including cross sectoral cutting-edge biotechnology, for application in competitive, sustainable and novel industrial processes, environmental services and consumer products[16];

[16] Health biotechnology applications will be addressed by the Health cluster under this pillar.

– Circularity of the bio-based sector within the bioeconomy through technological, systemic, social and business model innovation to radically increase the value generated per unit of biological resource~~s~~, keeping the value of such resources in the economy for longer**, preserving and enhancing natural capital, designing out waste and pollution** ~~and~~**,** supporting the principle of the cascading use of sustainable biomass through research and innovation **and taking into account the waste hierarchy**;

– Inclusive bioeconomy patterns with different actors participating in the creation of value, maximising societal impact **and public engagement**.

– Increased understanding of the boundaries, metrics and indicators of the bioeconomy and its synergies and trade-offs with a healthy environment, ~~such as~~**and** trade-offs between food and ~~non-food~~**other** applications.

7.2.7. Circular Systems

Circular production and consumption systems will provide benefits to the European economy and global environment by reducing **use and dependency on** resource~~ dependencys~~, decreasing greenhouse gas **emissions and other negative environmental impacts** and increasing the competitiveness of enterprises, and to European citizens by creating new job opportunities and reducing pressures on the environment and climate. Beyond industrial transformation, the transition to a low-emission, resource efficient, bio-based and circular economy**, avoiding the use of hazardous substances** will also need a broader system shift that requires systemic eco-innovative solutions, new business models, markets and investments, enabling infrastructure, social innovation changes in consumer behaviour, and governance models stimulating multi-stakeholder collaboration through the whole value chain to ensure that the intended system change achieves better economic, environmental and social outcomes[17]. Opening for international cooperation will be important for comparability, generating and sharing knowledge and avoiding duplication of efforts, e.g. through international initiatives such as the International Resource Panel. ~~Attention will be given to possible adverse effects due to the various transitions for developing countries and other resource generating countries, including social, economic and trade effects.~~ Also, attention will be given to the social context of new knowledge and technology in this area and for its uptake **and acceptance** in society.

Broad Lines

– Systemic transition to a resource-efficient, bio-based and circular economy, with new paradigms in consumer interaction, new business models for resource efficiency and environmental performance; products and services stimulating resource efficiency **and substitution of hazardous substances** during the whole lifecycle; systems for sharing, reuse, repair, remanufacturing, recycling and composting; economic, social, behavioural, regulatory and financial conditions **and incentives** for such transitions.

[17] The activities in Circular Systems Area of Intervention are complementary to those of Low-Carbon and Clean Industry in the Digital and Industry cluster.

– Metrics and indicators, based on a systemic approach, for measuring the circular economy and life cycle performance **and enhancing social responsibility**; -governance systems which accelerate expansion of the circular economy, the bioeconomy and resource efficiency while creating markets for secondary materials; multi-stakeholder and cross-value chain collaboration; instruments for investment in the circular economy and bioeconomy;

– Solutions for sustainable and regenerative development of cities, peri-urban areas and regions, integrating the circular economy transformation with nature-based solutions, technological, digital, social, cultural and territorial governance innovations;

– Eco-innovation for prevention and remediation of environmental pollution from **and exposure to** hazardous substances and chemicals of emerging concern; looking also at the interface between chemicals, products and waste, and at sustainable solutions for primary and secondary raw materials production;

– Circular use of water resources, including reduction of water demand, prevention of losses, water reuse, recycling and valorisation of wastewater**. New** ~~and~~ governance models **and economic instruments** for smart water allocation, addressing **conflicts in water use,** sources of pollution **including emerging pollutants** and tackling other pressures on water resources; tackling the water-food-energy nexus.

8. NON-NUCLEAR DIRECT ACTIONS OF THE JOINT RESEARCH CENTRE

8.1. Rationale

High-quality and trusted scientific evidence is essential for good public policies. New initiatives and proposals for EU legislation need transparent, comprehensive and balanced evidence, whereas implementation of policies needs evidence to measure and monitor their impact and progress.

The JRC adds value to EU policies because its science is excellent, multi-disciplinary and independent of national, private and other external interests. Serving all areas of EU policy, it provides the cross-sectoral support that policymakers need to tackle increasingly complex societal challenges. The JRC's independence from special interests combined with its scientific-technical reference role enable it to facilitate consensus building between stakeholders and policy makers. With its capacity to respond rapidly to policy needs, the JRC's activities are complementary with indirect actions aiming at supporting longer term policy objectives.

The JRC performs its own research and is a strategic manager of knowledge, information, data and competences to deliver high quality and relevant evidence for smarter policies. To achieve this, the JRC works together with the best organisations world-wide, and with international, national and regional **experts and** stakeholders. Its research contributes to the general objectives and priorities of Horizon Europe, provides independent scientific knowledge, advice and technical support for EU policies throughout the policy cycle, and is focussed on European policy priorities, supporting a Europe that is safe and secure, prosperous and sustainable, social and stronger on the global scene.

8.2. Areas of intervention

8.2.1. Strengthening the knowledge base for policy making

Knowledge and data are growing exponentially. If policy makers are to make sense and use of them they must be reviewed and filtered. There is also a need for cross-cutting scientific methods and analytical tools for use by all Commission services, especially to anticipate upcoming societal challenges and support better regulation. This includes innovative processes to engage stakeholders and citizens in policy-making issues **and various tools of impact and implementation assessment**.

Broad Lines

- Modelling, micro-economic evaluation, risk assessment methodologies, quality assurance tools for measurements, design of monitoring schemes, indicators and scoreboards, sensitivity analysis and auditing, lifecycle assessment, data and text mining, (big) data analytics and applications, design thinking, horizon scanning, anticipation and foresight studies, behavioural research, and stakeholders and citizen engagement;
- Knowledge and competence centres;
- Communities of practice and knowledge sharing platforms;
- Data management, data sharing and coherence.

8.2.2. Global Challenges

The JRC will contribute to the specific EU policies and commitments addressed by the seven Global Challenges clusters, notably the EU's commitment to the Sustainable Development Goals.

Broad Lines

1. Health

- Scientific and technical policy support for improved public health and health care systems, including medical devices and health technology assessments, databases, digitisation ~~with particular attention~~**including** for accelerating interoperability~~ between health and care providers, allowing patients to manage their own health related data~~;
- Safety assessment methods for potential health and environmental risks posed by chemical substances and pollutants;
- EU Reference Laboratory for Alternatives to Animal Testing;
- Quality assurance tools such as certified reference materials for health biomarkers;

– Research on newly emerging health issues and health threats.

~~– Research on societal, medical, public health and ethical possibilities and consenquences of the development from classical vaccinology (isolate, inactivate, inject) and vaccine development into individalization, often based on novel data resulting from high throughput "omics" technologies.~~

2. Culture and inclusive society

– Research on inequality, poverty and exclusion, social mobility, cultural diversity, and skills; **migration,** assessment of social, demographic and technological transformations on the economy and on society;

– Research on good governance and democracy;

– Support to the **safeguarding,** preservation **and management** of cultural heritage;

– Knowledge centre for migration and demography

3. Civil security for society

~~– Knowledge centre for migration and demography~~;

– Knowledge centre for disaster risk management;

– Support to security policies in the areas of protection of critical infrastructures and public spaces, CBRN-E (Chemical, Biological, Radiological, Nuclear, and Explosive materials) and hybrid threats, border protection and document security, and information and intelligence for countering terrorism;

– Technologies for CBRN-E materials detection, biometric systems, and intelligence-gathering techniques;

– Support to the EU's security position in the world; assessment of competitiveness and innovation of the Union defence industry; exploitation of security-defence synergies;

– Research for reinforced Cybersecurity capabilities, cyber-resilience, and cyber-deterrence.

4. Digital, Industry and Space

– Implications of digitisation, with a focus on new and emerging ICT technologies such as machine learning and artificial computing, distributed ledgers, Internet of Things, and High-Performance Computing;

– Digitisation in individual sectors, such as energy, transport, construction, **service industry,** health and care and government;

– Industrial metrology and quality assurance tools for smart manufacturing;

– Research on ~~nanotechnology and other~~ Key Enabling Technologies;

– Research on best available techniques and environmental management practices, techno-economic analyses and life cycle assessment of industrial processes,chemicals management, waste management, water reuse, raw materials, critical raw materials and quality criteria for recovered materials, all supporting circular economy;

– Analysis of security of supply of raw materials, including the critical raw materials, in relation to primary and secondary resources information and data update of the Raw Materials Information System;

– Implementation of Copernicus actions;

– Technical and scientific support for applications of the EU Global Navigation Satellite System Programmes.

5. Climate and Energy

- Support to implementation of the EU climate, energy and transport policies, transition to a low-carbon economy and strategies for decarbonisation towards 2050; analysis of integrated national climate~~, environmental protection~~ and energy plans; assessment of decarbonisation pathway in all sectors, including agriculture and Land Use Land Use Change and Forestry;

- Assessment of risks in vulnerable ecosystems and critical economic sectors and infrastructure, with focus on adaptation strategies;

- Analysis of the R&I dimension of Energy Union; assessment of EU competitiveness in the global clean energy market;

- Assessment of deployment potential of smart energy technologies and sector coupling solutions to enable smooth and cost efficient energy transition.

- Assessment of deploying renewables and clean energy production technologies;

- Analysis of energy use of buildings, smart and sustainable cities, and industries;

- Technical and socio-economic analysis of energy storage, particularly sector coupling and batteries;

- Analysis of the EU's energy security of supply, including energy infrastructure, and energy markets;

- Support to energy transition, including the Covenant of Mayors, clean energy for EU Islands, sensitive regions, and Africa.

6. Mobility

- Integrated analysis for deployment of ~~Cooperative,~~ Connected**, Cooperative, Automated** and ~~Automated~~ **Autonomous** Mobility;
- Integrated analysis for development and deployment of **electric driving, including** the next generation of battery technologies;
- Harmonised test procedures and market surveillance for CO2 and air pollutant emissions from vehicles, assessment of innovative technologies;
- Assessment of smart transport, traffic management systems and congestion indicators;
- Analyses of alternative fuels and related infrastructure needs.

7. Bioeconomy, food, natural resources and environment

- Research on land, soil, forests, air, water, marine resources, raw materials and biodiversity to support the effective preservation, restoration and sustainable use of natural capital, including sustainable resources management in Africa ;
- Knowledge centre for global food nutrition security;
- Assessment of climate change and potential mitigation and adaptation measures for agricultural and fisheries policies, including food security;
- Monitoring and forecasting of agricultural resources in EU**, enlargement** and neighbourhood countries;
- Research for sustainable and economically thriving aquaculture and fisheries, and for Blue Growth and the Blue Economy;
- Validated methods, laboratory proficiency tests and new analytical tools for implementing food safety policies;

- EU Reference Laboratories on Feed Additives, Genetically Modified Organisms and Food Contact Materials;
- Knowledge centre for food fraud and quality;
- Knowledge centre for bioeconomy.

8.2.3. Innovation, economic development, and competitiveness

The JRC will contribute to **knowledge-based** innovation and technology transfer.. It will support the functioning of the internal market and the economic governance of the Union. It will contribute to development and monitoring of policies targeting a more social and sustainable Europe. It will support the EU's external dimension and international goals and help in promoting good governance. A well-functioning internal market with a strong economic governance and fair social system will foster **knowledge-based** innovation and competitiveness.

Broad Lines

- Analysis of **EU and national research and** innovation policies**, including the ERA**;
- Economic, **trade,** financial and fiscal analysis;
- Pre-normative research and testing for harmonisation and standardisation;
- Production of certified reference materials;
- Market surveillances activities;
- Management of intellectual property rights;
- **Competence Centre for Technology Transfer**~~Promotion of technology transfer cooperation~~.

8.2.4. Scientific Excellence

The JRC shall pursue excellence **and integrity** in research and extensive collaboration with top level research institutions worldwide. It will carry out research in emerging fields of science and technology and promote open science and open data as well as knowledge transfer.

Broad Lines

- Exploratory research programmes;
- Dedicated collaborative and exchange programmes with research institutions and scientists;
- Access to JRC research infrastructures;
- Training of scientists and national experts;
- Open science and open data.

8.2.5. Territorial development and support for Member States and Regions

The JRC will contribute to regional and urban policies, with focus on innovation-led territorial development, and with a view to reducing disparities between regions. It will also offer technical assistance to Member States and third countries and support the implementation of European legislation and actions.

Broad Lines

- Implementation of regional and urban policies, smart specialisation strategies, strategies for economic transformation of regions in transition, integrated urban development strategies and data;
- Capacity building of local and regional actors for implementation of macro-regional strategies;

- Knowledge centre for territorial policies;
- 'On demand' advice and tailored support to Member States, regions or cities, including through a virtual network of Science4Policy Platforms.

PILLAR III

INNOVATIVE EUROPE

Innovation in all its forms is a key driver for the EU to continue delivering prosperity to its citizens and meeting challenges of the future. Implementing it requires a systemic, cross-cutting and multifaceted approach. Europe's economic progress, social welfare and quality of life rely on its ability to boost productivity and growth, which, in turn, depends heavily on its ability to innovate. Innovation is also key to solving the major challenges that lie ahead for the EU. Innovation has to be responsible, ethical and sustainable.

Like in the case of its predecessor, innovation is at the heart of Horizon Europe. The quest for acceleration of knowledge transfer and new ideas, products and processes is driving Horizon Europe objectives and implementing modalities, from strategic programming to calls, and is present from the onset to the end of any project supported, from 'blue-sky' research to industrial or technological roadmaps and missions.

Yet, innovation deserves specific measures, as the EU must decisively enhance the conditions and environment for European innovation to thrive, so that ideas are quickly shared between actors in the innovation ecosystem, and new ideas and technologies swiftly transformed into the products and services needed for the EU to deliver.

Recent decades have seen the emergence of major and global new markets in health care, media, entertainment, communication and retail, based on breakthrough innovations in ICT, biotech, green-tech, internet and the platform economy. These market-creating innovations, which impact the EU economy as a whole, are deployed by fast growing and often new companies which, however, seldom originate and scale-up in the EU.

A new global wave of breakthrough innovation is coming up, one that will be based on more 'deep-tech' technologies such as block-chain, artificial intelligence, genomics and robotics, and other technologies, which may also emerge from individual innovators and communities of citizens. They have in common that they are taking shape at the intersection between different technologies, industry sectors and scientific disciplines, offering radically new combinations of products, processes, services and business models, and have the potential to open up new markets worldwide. Additional sectors such as manufacturing, financial services, transport or energy will also be impacted.

Europe has to ride that wave. It is well positioned as the new wave comes in 'deep-tech' areas, such as artificial intelligence, quantum technologies, clean energy sources, smart and sustainable cities, where Europe has some competitive advantages regarding science and knowledge, and can build on close public-private cooperation (e.g. in health care or energy).

For Europe to lead that new wave of breakthrough innovation, the following underlying challenges need to be met:

– Increase risk finance to overcome financing gaps: Europe's innovators suffer from a low supply of risk finance. Private venture capital is key to turning breakthrough innovations into world-leading companies but, in Europe, it is less than a quarter of the amounts raised in the US and in Asia. Europe must bridge the 'Valleys of death', whereby ideas and innovations fail to reach the market due to the gap between public support and private investment, in particular with regard to high-risk breakthrough innovations and long-term investments;

– Facilitate the access to research results, improve the transformation of science into innovationand accelerate the transfer of ideas, technologies and talent from the research base into start-ups and industry;

– Further develop all forms of innovation, including user-driven, service and social innovation;

– Speed up industrial transformation: European industry is lagging behind in embracing new technologies and scaling up: 77% of the young and big R&D companies are in US or Asia and only 16% are based in Europe;

– Enhance and simplify the European landscape for funding and supporting research and innovation: the multitude of funding sources provides a complex landscape for innovators. EU intervention has to cooperate and coordinate with other initiatives at European, national and regional level, public and private, to better enhance and align supporting capacities, avoid duplication of activities and provide for an easy-to-navigate landscape for any European innovator;

– Overcome fragmentation to the innovation ecosystem. While Europe is home to a growing number of hotspots, these are not well connected. Companies with international growth potential have to cope with fragmentation of national markets with their diverse languages, business cultures and regulations. The EU has a role to play in supporting effective collaboration between national and regional ecosystems, so that companies, and SMEs in particular, can access the best knowledge, expertise and services across Europe. The EU supports that collaboration between ecosystems will improve, for example, in the field of interoperability of technologies and solutions.

In order to cope with that new global wave of breakthrough innovation, EU support to breakthrough innovators requires an agile, simple, seamless and tailored approach. Policy to develop and deploy breakthrough innovations and scale-up companies has to be bold in taking risks and must take into account the above-mentioned challenges and add value to related innovation activities implemented by individual Member States or regions.

Horizon Europe's Innovative Europe pillar, in cooperation with other EU policies and in particular the InvestEU Programme, is designed to deliver such tangible results. It builds on lessons learned and on experience gained under the previous framework programmes, in particular from activities such as Future Emerging Technologies (FET), Fast Track to Innovation (FTI) and the SME Instrument, but also private and corporate finance (such as FP7 RSFF, Horizon 2020 InnovFin), all part of the 'EIC pilot' activities launched for the period 2018-2020.

Based on these experiences, this Pillar provides for the launch of the European Innovation Council (EIC), which will promote breakthrough innovation with rapid scale-up potential at EU and global level and with dedicated types of actions and activities:

– Supporting the development of future and emerging breakthrough innovations;

– Bridging financing gaps in the development, deployment and scaling up of market-creating innovations;

– Leverage private capital and investment;

– Increasing the impact and visibility of EU innovation support.

Whilst the EIC will directly support breakthrough innovations across the EU, the overall environment from which European innovations nurture and emerge must be further developed and enhanced: findings in fundamental research are seeds for market-creating innovations. It must be a common European endeavour to support innovation all across Europe, and in all dimensions and forms, including through complementary EU and national and regional policies (including through effective synergies with ERDF and smart specialisation strategies) and resources whenever possible. Hence, this Pillar provides also for:

– Renewed and reinforced coordination and cooperation mechanisms with Member States and Associated Countries, but also with private initiatives, in order to support all types of European innovation ecosystems, including at regional and local level, and their actors;

– Synergies with the European Institute of Innovation and Technology (EIT) and Knowledge and Innovation Communities (KICs).

Additionally, as a continued effort to enhance risk-finance capacities for research and innovation in Europe and where necessary, this pillar will link with the InvestEU programme. Building on the successes and the experiences gained under Horizon 2020 InnovFin, as well as under EFSI, the InvestEU Programme will enhance access to risk finance for bankable research organisations, innovators and entrepreneurs, in particular for SMEs and small midcaps, as well as for investors.

1 THE EUROPEAN INNOVATION COUNCIL (EIC)

1.1. Areas of Intervention

The objectives of the EIC are:

– to identify, develop and deploy high risk innovations of all kinds with a strong focus on breakthrough, market-creating and/or deep-tech innovations, and

– to support the rapid scale-up of innovative firms (mainly start-ups and SMEs) at EU and international levels along the pathway from ideas to market.

Where relevant, the EIC shall contribute to the activities supported under other parts of Horizon Europe, in particular in Pillar II.

The EIC will be implemented primarily through two complementary types of action, namely *the Pathfinder for advanced research*, for the early stages of technology development, and *the Accelerator* for innovation and market deployment actions, including the pre-mass commercialisation stages and company growth. With the idea to offer a single one-stop shop and a single process of support for high risk innovations carried out by start-ups, SMEs and, in exceptional cases, small midcaps, the *Accelerator* will mainly award blended finance, combining grants with equity investments. It will in addition also channel access to loans and guarantees, notably those provided under the InvestEU programme. Under certain conditions, it will also propose grant-only and equity-only supports.

These two complementary types of actions will share common characteristics. They will:

– Focus on high-risk breakthrough, market creating and/or deep-tech innovations, that have the potential to create new markets or contribute to resolving global challenges;

– Be mainly bottom-up, open to innovations from all fields of science, technology and applications in any sector of Horizon Europe, while also enabling targeted support for emerging breakthrough, market-creating and/or deep-tech technologies of potential strategic significance;

– Encourage innovations that cut across different scientific, technological (e.g. combining physical and digital) fields and sectors;

– Be centred on innovators, simplifying procedures and administrative requirements, making use of interviews to help assess applications, and ensuring fast decision making;

– Support high-risk innovations where the risks, whether financial, technological/scientific, market and/or regulatory, cannot be borne by the market alone or exclusively supported by financial instruments under InvestEU.

– They will be managed pro-actively with milestones to gauge progress and the possibility to reorient or terminate the projects where needed.

As well as financial support, innovators will have access to EIC business advisory services providing to projects coaching, mentoring and technical assistance, and pairing innovators with peers, industrial partners and investors. Innovators will also have facilitated access to expertise, facilities (including innovation hubs [18] and open innovation testbeds) and partners from across EU supported activities (including those of the EIT, in particular through its KICs). The Commission will ensure close cooperation between the EIC, the EIT and InvestEU, to deliver complementarity and synergies in supporting start-ups and scale-ups.

[18] These are public or private facilities that offer access to latest knowledge and expertise on digital and related enabling technologies necessary for companies to become more competitive with regard to production, services and business processes.

Particular attention will be paid to ensuring proper and efficient complementarity with individual or networked Member States or interregional initiatives, including in the form of European Partnership.

1.1.1. The Pathfinder for Advanced Research

The *Pathfinder's* will provide grants to high-risk cutting-edge projects exploring new areas aiming to develop into potentially radical innovative technologies of the future and new market opportunities. It will build on the experience from the Future and Emerging Technology (FET) schemes supported under FP7 and Horizon 2020, including the Horizon 2020 FET-Innovation Launchpad, as well as the Horizon 2020 SME Instrument Phase 1.

The *Pathfinder* overall objective will be to nurture potential market creating innovation out of breakthrough ideas, and bring them to demonstration stage or development of business cases or strategies for further take-up by the *Accelerator* or any other market deployment solution. To that end, the *Pathfinder* will support the earliest stages of scientific and technological research and development, including proof of concept and prototypes for technology validation.

In order to be fully open to broad-sweeping explorations, opportunities of serendipity and unexpected ideas, concepts and discoveries, the *Pathfinder* will be mainly implemented through a continuous and competitive open call with cut-off dates for bottom-up proposals. The *Pathfinder* will also provide for competitive challenges to develop key strategic objectives[19] calling for deep-tech and radical thinking. The topics for those challenges will be determined in the work programmes. Regrouping of selected projects into thematic or objective driven portfolios will allow establishing critical mass of efforts and structuring new multidisciplinary research communities.

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[19] These could include topics such as Artificial Intelligence, Quantum technologies, Biocontrol or Second generation digital twins, or any other topics identified in the context of the Horizon Europe Strategic programming (including with Member States' networked programmes).

These portfolios of selected projects[20] will be further developed and enhanced, each along a vision developed with their innovators, but also shared with the research and innovation community at large. The *Pathfinder's Transition activities* will be implemented to help researchers and innovators develop the pathway to commercial development, such as demonstration activities and feasibility studies to assess potential business cases, and support the creation of spin offs and startups. These *Pathfinder's Transition activities* may also consist of complementary grants to top-up or enlarge the scope of previous and on-going actions, to bring in new partners, to enable collaboration within the portfolio and to develop its multidisciplinary community.

The *Pathfinder* will be open to all types of innovators, from individuals to universities, research organisations and companies, in particular startups and SMEs, and from single beneficiaries to multi-disciplinary consortia. In the case of single beneficiary projects, mid-caps and larger companies will not be permitted. The *Pathfinder* will be implemented mainly through collaborative research and in close coordination with other parts of Horizon Europe, in particular with the European Research Council (ERC), the Marie Skłodowska-Curie Actions (MSCA), the European Ecosystem part of Pillar III and the Knowledge and Innovation Communities (KICs) of the European Institute of Innovation and Technology (EIT) activities to identify radical innovations with breakthrough potential. It will also be implemented in close coordination with Member States programmes and activities.

[20] These may also include projects selected under Horizon 2020 programmes such as FET. These may also include other EU supported relevant activities and funded Seal of Excellence stemming from *Pathfinder* calls.

1.1.2. The Accelerator

Available private and corporate financing remains scarce between late stage of research and innovation activities and market take-up for high-risk breakthrough and market-creating innovations. In order to bridge the 'valley of death' for any type of high-risk innovations, including in particular for 'deep tech' innovations that are key to Europe's future growth, public support must develop a radically new approach. Where the market does not provide viable financial solutions, public support should provide for a specific risk-sharing mechanism, bearing more if not all of the initial risk of potential breakthrough market-creating innovations to attract alternate private investors in a second stage, as operations unfold and the risk is lowered.

Consequently the *Accelerator* will provide financial support to not yet 'bankable' or investors-attractive innovators and companies that have the ambition to develop and deploy in EU and international markets their breakthrough innovations and to scale up rapidly. For that purpose it will build on the experience from the Phases 2 and 3 of Horizon 2020 SME Instrument and from Horizon 2020 InnovFin, in particular through the addition of non-grant components and the ability to support larger and longer investments.

The *Accelerator* will mainly provide support in the form of EIC blended finance, a mix of:

– Grant or reimbursable advance[21], to cover innovation activities;

– Support for investment in equity[22] or other repayable forms, so as to bridge innovation activities with effective market deployment, including scale-up, in a manner that does not crowd out private investments or distorts competition in the internal market. When relevant it will channel the innovator to access to debt financing (e.g. loans or guarantees) provided by the InvestEU programme.

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[21] Reimbursable advance shall be paid back to the EU on an agreed schedule or be transformed into equity, if the beneficiary so choses.

[22] Usually no more than 25% of the voting rights. In exceptional cases, the EU may secure the acquisition of a blocking minority to protect European interests in essential areas, e.g. cyber security.

Support will be awarded through a single process and with a single decision, providing the supported innovator with a single global commitment to financial resources covering the various stages of innovation down to market deployment including pre-mass commercialisation. The full implementation of the awarded support will be subject to milestones and review. The combination and volume of financing will be adapted to the needs of the firm, its size and stage, the nature of the technology/innovation and the length of the innovation cycle. It will cover financing needs until replacement by alternative sources of investment.

For startups and SMEs with projects that are very high risk, the *Accelerator* may provide grant-only support. The support will be provided through the same continuously open and bottom-up call as the one used for the blended-finance support. A startup or an SME may benefit only once during Horizon Europe from grant-only support that will not exceed EUR 2.5 million. Projects shall include information on the capacities and willingness of the applicant to scale up.

For projects that have benefitted from a grant-only support, the *Accelerator* may subsequently provide them with an equity support only, through its SPV subject to the due diligence results of the latter.

When selected projects are receiving a grant component support for its innovation activities; these innovation activities may be implemented in collaboration with public or private research organisations, for example through subcontracting, to ensure that the beneficiary can have optimal access to technical and business expertise. This will allow the beneficiary to develop with a strong foundation in the existing knowledge, expertise and ecosystems across Europe.

Where the various risks are reduced (financial, technological, market, management, regulatory, etc.), the relative importance of the reimbursable advance component is expected to increase.

While the EU may bear alone the initial risk of selected innovation and market deployment actions, the aim will be to de-risk these and stimulate, from the out-set and during the development of the action, co-investments from alternative sources and even substitutive investors. Where relevant, milestones will establish co-investment objectives.

The *Accelerator* will mainly operate through a continuously open, and bottom-up call, with cut-off dates, targeting individual entrepreneurs (mainly start-ups and SMEs), with a particular attention paid to young and to female innovators. This open and bottom-up call will be complemented by targeted support for on emerging breakthrough, market-creating and/or deep-tech innovations of potential strategic significance. The topics for this targeted support will be described in the work programmes. Proposals may also be submitted by investors, including public innovation agencies, but the support will be awarded to the company.

The *Accelerator* will allow for take-up of innovations stemming from Pathfinder-supported projects and from other pillars of the EU Framework Programmes[23], in order to support them to reach the market. This identification of projects supported in other pillars of Horizon Europe and also previous Framework Programmes will be based on pertinent methodologies, such as the Innovation Radar.

In addition, in order to scale up and in compliance with Article 43.5(a) of Regulation [Framework programme], successful proposals from eligible national or regional programmes will also have access to the Accelerator evaluation phase under the following cumulative and sequential conditions:

(a) The Commission will first perform an in-depth mapping exercise of eligible national or regional programmes to identify the demand for such a scheme. The results of this mapping exercise will be published on the Participants portal and updated regularly.

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[23] Such as ERC Proof of Concept, from projects supported under the 'Global Challenges and Industrial Competitiveness" Pillar, startups emerging from the KICs of the European Institute of Innovation and Technology, … Including from Horizon 2020 activities, particularly project selected under Horizon 2020 SME Phase 2 and related Seal of Excellence financed by Member States, (existing and future) European Partnerships.

(b) A pilot, based on this mapping, will be launched in the first Horizon Europe work programme. Under this pilot, the following conditions must be met:

- the national or regional evaluation procedures shall be certified as complying with the standards under this Programme by the Commission according to criteria included in the Horizon Europe Work Programme;

- the Commission shall ensure equal treatment with other proposals in the evaluation of proposals submitted under the EIC Accelerator. In particular all eligible proposals shall be at equal footing at jury level (face-to-face interviews).

1.1.3. Additional EIC activities

Additionally, EIC will also implement:

– EIC business acceleration services in support of *Pathfinder* and *Accelerator* activities and actions. The aim will be to connect the EIC Community of funded innovators, including funded Seal of Excellence, to investors, partners and public buyers. It will provide a range of coaching and mentoring services to EIC actions. It will provide innovators with access to international networks of potential partners, including industrial ones, to complement a value chain or develop market opportunities, and find investors and other sources of private or corporate finance. Activities will include live events (e.g. brokerage events, pitching sessions) but also, the development of matching platforms or use of existing ones, in close relation with financial intermediaries supported by the InvestEU and with the EIB Group. These activities will also encourage peer exchanges as a source of learning in innovation ecosystem, making particular good use of Members of the High Level Advisory board of the EIC and EIC Fellows;

– EIC Fellowship to honour the EU's leading innovators. They will be awarded by the Commission on the advice of the High Level Advisory Board to recognise them as ambassadors for innovation;

– EIC Challenges, i.e. inducement prizes, to help develop novel solutions to global challenges, bring in new actors and develop new communities. EIC recognition prizes will include iCapital, the Climate innovation prize, the Social Innovation Inducement Prize, and the Women Innovators' Prize.[24] The design of its prizes will be linked to the EIC and to other parts of the EU Framework Programme, including missions and to other funding bodies. Opportunities for cooperation with organisations (such as enterprises, universities, research organisations, business accelerators, charities and foundations) will be explored.

– EIC Innovative Procurement, to procure prototypes, or develop first purchase programme to facilitate the testing and acquisition of pre-market innovative technologies by public entities.

1.2. Implementation

The implementation of the EIC calls for the deployment of specific management features, to reflect its innovator-centric approach and types of actions.

1.2.1. The EIC Board

The High Level Advisory Board of the EIC (*EIC Board*) shall assist the Commission in implementing the EIC. As well as advising on the EIC work programmes, the EIC Board shall take an active role in advising on the process of project selection and the management and following up actions. It will have a communication function, with members playing an ambassadorial role helping to stimulate innovation in the EU. Communication channels will include attendance at key innovation events, social media, constitution of an EIC community of innovators, engaging with key media with a focus on innovation, common events with incubators and acceleration hubs.

[24] The EIC prizes will take over the management of prizes launched under Horizon 2020 and provide for the design and implementation of new inducement prizes and recognition awards.

The EIC Board shall provide advice to the Commission regarding innovation trends or initiatives needed to enhance and foster the EU innovation ecosystem, including potential regulatory barriers. The Board's advice shall also identify emerging areas of innovation to be taken into account in the activities under the Global Challenges and Industrial Competitiveness pillar and missions. In this way, the Board is expected to contribute to the overall coherence of the Horizon Europe programme.

1.2.2. EIC programme managers

The Commission will take a pro-active approach to the management of high risk projects, through access to the necessary expertise.

The Commission will appoint on a temporary basis a number of EIC programme managers to assist it with business- and technology-based vision and operational guidance. The Programme Committee will be informed on the appointments.

Programme managers will come from multiple spheres, including companies, universities, national laboratories and research centers. They will bring deep expertise from personal experience and years in the field. They will be recognised leaders, either having managed multidisciplinary research teams or directing large institutional programs, and know the importance of communicating their visions tirelessly, creatively, and broadly. Lastly, they will have experience in overseeing important budgets, which require sense of responsibility.

Programme managers will be expected to boost the impact of EIC funding by fostering an « active management » culture, combining a sound technological knowledge with a hands-on approach involving development at portfolio and projects levels of vision-based budgets, timelines and milestones EIC projects must meet to receive continued funding.

In particular, programme managers oversee the implementation of *Pathfinder* and *Accelerator* calls, and propose rankings to the evaluation committee, based on clear criteria and in view of a consistent strategic portfolio of projects, expected to make essential contributions to the emergence of potential societal or economic market creating innovations.

Programme managers will have the task of nurturing *Pathfinder* portfolios by developing together with beneficiaries a common vision and a common strategic approach that leads to a critical mass of effort. This will involve the enhancement of new, recently developed fields of research, and the building up and structuring of new communities, with the objective of bringing transforming breakthrough ideas into genuine and mature market creating innovations. Programme managers will implement *transition activities*, further developing portfolio with additional activities and partners, and closely monitoring potential spin-offs and start-ups.

Programme managers will review *Pathfinder* and *Accelerator*'s projects, for each milestone or at relevant intervals, to assess whether they should be continued, reoriented or terminated according to defined methods and procedures for project management. Such assessments may involve external experts. The Commission will ensure that there is no conflict of interest of programme managers in the execution of all their tasks.

Given the high risk nature of the actions, it is expected that a significant number of projects will not reach completion. Budget decommitted from such terminations will be used to support other EIC actions and shall be communicated in a timely manner to the Programme Committee.

1.2.3. Implementation of the EIC blended finance

The Commission will manage all operational elements of Accelerator projects, including the grant or other non-repayable forms of support.

For the purpose of managing EIC blended finance, the Commission may make use of indirect management, or where this is not possible, may establish a special purpose vehicle (EIC SPV). The Commission shall seek to ensure the participation of other public and private investors. Where this is not possible at the initial set up, the special purpose vehicle will be structured in such a way that it can attract other public or private investors in order to increase the leverage effect of the Union contribution.

The investment strategy of the EIC SPV will be endorsed by the Commission. The EIC SPV also define and implement an exit strategy for its equity participations, which will include the possibility to propose the transfer of (a share) of an investment operation to the implementing partners supported under the InvestEU programme, where appropriate and for operations whose risks have been sufficiently lowered so that they meet criteria of Article 209(2) of the Financial Regulation. The Programme Committee will be informed accordingly.

The EIC SPV will perform due diligence, and negotiate technical terms of each investment in compliance with the principles of additionality and prevention of conflict of interests with other activities of the investees and of other counterparts. The EIC SPV will proactively leverage public and/or private investments into individual *Accelerator's* operations.

2. EUROPEAN INNOVATION ECOSYSTEMS

2.1. Rationale

To fully harness the potential of innovation involving researchers, entrepreneurs, industry and society at large, the EU must improve the environment within which innovation can flourish at all levels. This will mean contributing to the development of an effective innovation ecosystem at EU level, and encouraging cooperation, networking, and the exchange of ideas and knowledge, developing open innovation processes in organisations, funding and skills among national, regional and local innovation ecosystems.

The EU and Member States must also aim to develop ecosystems that support social innovation and public sector innovation, in addition to innovation in private enterprises. Indeed, the government sector must innovate and renew itself in order to be able to support the changes in regulation and governance required to support the large-scale deployment of innovations, including new technologies and a growing public demand for the more efficient and effective delivery of services. Social innovations are crucial to enhance the welfare of our societies.

2.2. Areas of intervention

As a first step the Commission will organise an EIC Forum of Member States and Associated countries' public authorities and bodies in charge of innovation policies and programmes, with the aim of promoting coordination and dialogue on the development of the EU's innovation ecosystem. Within this EIC Forum, the Commission will:

- Discuss the development of innovation-friendly regulation, through the continued application of the Innovation Principle and development of innovative approaches to public procurement including developing and enhancing the Public Procurement of Innovation (PPI) instrument to drive innovation. The Observatory of Public Sector Innovation will also continue to support internal government innovation efforts, alongside the revamped Policy Support Facility;

- Promote the alignment of research and innovation agendas with EU efforts to consolidate an open market for capital flows and investment, such as the development of key framework conditions in favour of innovation under the Capital Markets Union;

- Enhance coordination between national and regional innovation programmes and the EIC, so as to stimulate operational synergies and avoid overlaps, by sharing data on programmes and their implementation, resources and expertise, analysis and monitoring of technological and innovation trends, interconnecting respective innovators' communities;

- Establish a joint communication strategy on innovation in the EU. It will aim at stimulating the EU's most talented innovators, entrepreneurs, particularly young drivers, SMEs and start-ups, also from fresh corners of the EU. It will stress the EU added-value that technical, non-technical, and social innovators can bring to EU citizens by developing their idea/vision into a thriving enterprise (social value/impact, jobs and growth, societal progression).

Activities will be implemented to ensure effective complementarity between EIC's types of action and their specific focus on breakthrough innovation, with activities implemented by Member States and Associated Countries, but also by private initiatives, in order to support all types of innovation, reach out to all innovators across the EU, and provide them with enhanced and adequate support.

To that end, the EU will:

– Promote and co-fund joint innovation programmes managed by authorities in charge of public national, regional or local innovation policies and programmes, to which private entities supporting innovation and innovators may be associated. Such demand-driven joint programmes may target, among others, early stage and feasibility study support, academia-enterprise cooperation, support to high-tech SMEs' collaborative research, technology and knowledge transfer, internationalisation of SMEs, market analysis and development, digitalisation of low-tech SMEs, support the development and interconnection of open innovation infrastructures, such as pilots, demonstrators, maker spaces and testbeds, financial instruments for close to market innovations activities or market deployment, social innovation. They may also include joint public procurement initiatives, enabling innovations to be commercialised in the public sector, in particular in support of the development of new policy. This could be particularly effective to stimulate innovation in public service areas and to provide market opportunities to European innovators;

– Support joint programmes for inter-regional smart specialisation strategies in synergy with the EIT activities at national and regional level;

– Support also joint programmes for mentoring, coaching, technical assistance and other services that are delivered close to innovators, by networks such as National Contact Points, Enterprise Europe Network (EEN), clusters, pan-European platforms such as Startup Europe, regional or local innovation actors, public but also private, in particular incubators and innovation hubs that could moreover be interconnected to favour partnering between innovators. Support may also be given to promote soft skills for innovation, including to networks of vocational institutions and in close cooperation with the European Institute of Innovation and Technology and its KICs;

– Improve data and knowledge about innovation support, including mapping of support schemes, establishing data sharing platforms, benchmarking and evaluation of support schemes.

The EU will also launch actions necessary to further monitor and nurture the overall innovation landscape and innovation management capacity in Europe.

The ecosystem support activities will be implemented by the Commission, supported by an executive agency for the evaluation process.

PART - WIDENING PARTICIPATION AND STRENGTHENING THE EUROPEAN RESEARCH AREA

This part of the Programme shall implement concrete measures in support of widening participation and strengthending the European Research Area. It shall aim to strengthen collaborate links across Euroep and open up European R&I networks, as well as exploit the potential of the Union's talent pool by targeted actions.

The EU has a history of world-class scientific and technological achievements, but its research and innovation potential fails to be fully exploited. Despite much progress in developing the European Research Area (ERA), including the ERA roadmap and national ERA action plans, Europe has still a fragmented research and innovation landscape, and all Member States face bottlenecks in their research and innovation systems which require policy reforms. In some areas, progress is too slow to catch-up with an increasingly dynamic research and innovation ecosystem[25].

The level of research and innovation investment in Europe is still far below the policy objective of 3% of GDP[26] and continues to grow less than our main competitors such as US, Japan, China or South-Korea.

Meanwhile, there is a growing disparity in Europe between the innovation-leading and the innovation-lagging countries and regions. Change, for example through more and better links between research and innovation actors across Europe, is needed if Europe as a whole is to capitalise on excellence from across the continent, maximise the value of public and private investments, and their impacts on productivity, economic growth, job creation and well-being. In addition, there is a need for structural R&I policy reforms and better national and regional as well as institutional cooperation in the production and diffusion of high-quality knowledge.

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[25] The ERA progress report of 2018

[26] The Europe 2020 strategy

In addition, research and innovation are seen by some as distant and elitist without clear benefits for citizens, instilling attitudes that hamper the creation and uptake of innovative solutions, and scepticism about evidence-based public policies. This requires both better linkages between scientists, innovators, entrepreneurs, citizens and policy-makers, and more robust approaches to pooling scientific evidence itself.

The EU now needs to raise the bar on the quality and impact of its research and innovation system, requiring a revitalised European Research Area (ERA)[27], across the European Union and Associated Countries, better supported by the EU's research and innovation Framework Programme and national and regional programmes. Specifically, a well-integrated yet tailored set of EU measures[28] is needed, combined with reforms and performance enhancements at national level (to which the Smart Specialisation Strategies supported under the European Regional Development Fund as well as the Policy Support Facility can contribute) and, in turn, effective institutional changes within research funding and performing organisations, including universities, leading to outstanding knowledge production. By combining efforts at EU level, synergies can be exploited and the necessary scale can be found to make support to national policy reforms more efficient and impactful.

The activities supported under this part addresses ERA policy priorities, while generally underpinning all parts of Horizon Europe. Activities may also be established to foster brain circulation across ERA through mobility of researchers and innovators, taking into account current imbalances, and to help mature networks of scolars and researchers to put all their (intangible) assets to the service of the ERA and by supporting the development of domain-specific science roadmaps.

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[27] Council Conclusions on the ERA Roadmap, 19 May 2015 *[To be updated as necessary]*.
[28] TFEU Article 181.2

The goal is for an EU where knowledge and a highly skilled workforce circulate freely, research outputs are shared rapidly and efficiently, researchers benefit from attractive careers and gender equality is ensured, where Member States and Associated Countries develop common strategic research agendas, aligning national plans, defining and implementing joint programmes, and where the outcomes of research and innovation are understood and trusted by informed citizens and benefit society as a whole.

This part will contribute *de facto* to all Sustainable Development Goals (SDGs), but directly to the following: SDG 4 - Quality Education; SDG 5 - Gender Equality; SDG 9 - Industry, Innovation and Infrastructure; SDG 17 - Partnership for the Goals.

1. WIDENING PARTICIPATION AND SHARING EXCELLENCE[29]

Reducing disparities and the existing divide in research and innovation performance by sharing knowledge and expertise across the EU will help countries and regions that are lagging behind, including the EU outermost regions, to attain a competitive position in the global value chains.

Further action, for example through the promotion of openness and diversity of project consortia, is therefore needed to counter the trend for closed collaborations, which can exclude large number of promising institutions and individuals, in particular newcomers, and to exploit the potential of the EU's talent pool by maximising and sharing the benefits of research and innovation across the EU.

Within the broad areas of activities, the funding lines will facilitate specific research elements customised to the particular needs of the actions.

Broad Lines

- Teaming, to create new centres of excellence or upgrade existing ones in eligible countries, building on partnerships between leading scientific institutions and partner institutions;

- Twinning, to significantly strengthen universities or research organisations from eligible countries in a defined field, by linking it with internationally-leading research institutions from other Member States or Associated Countries ;

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[29] A criterion based on research and innovation excellence will be used to define those Member States and Associated Countries where legal entities need to be established in order to be eligible to submit proposals as coordinators under 'sharing excellence'. This criterion will address the dimensions of the overall economic performance (GDP), research performance and innovation performance in a combined manner normalised to the size of the related countries. The countries identified with this criterion are called 'eligible countries' in the context of 'sharing excellence'. On the basis of Article 349 TFEU, legal entities from Outermost Regions will be also fully eligible as coordinators under 'widening participation and sharing excellence'.

- ERA Chairs, to support universities or research organisations from eligible countries to attract and maintain high quality human resources under the direction of an outstanding researcher and research manager (the 'ERA Chair holder'), and to implement structural changes to achieve excellence on a sustainable basis;

- European Cooperation in Science and Technology (COST), involving ambitious conditions regarding the inclusion of eligible countries, and other measures to provide scientific networking, capacity building and career development support to young and advanced researchers from these target countries. 80% of the total budget of COST will be devoted to actions fully aligned with the objectives of this intervention area, including funding for new activities and services;

- MSCA grants, to enable researchers of any nationality to acquire and transfer new knowledge and to work on research and innovation in Widening countries in case their proposals fail to reach an adequate place in the ranking to be funded in the regular MSCA calls;

- Dedicated schemes for improving integration of research groups from Widening countries into collaboration consortia of leading scientific institutions;

- Activities may also be established to foster brain circulation of researchers of all ages and at all levels right across ERA and better exploitation of existing (and possibly jointly managed) research infrastructures in the targeted countries through mobility of researchers and innovators.

This intervention area will support the Horizon Europe specific objectives: Facilitate full engagement of Europe's talent pool in supported actions; Spread and connect excellence across the EU; Reinforce the creation of high quality knowledge; Increase cross-sectorial, cross-disciplinary cross-border cooperation.

2. REFORMING AND ENHANCING THE EU RESEARCH AND INNOVATION SYSTEM

Policy reforms at national level will be mutually reinforced and complemented through the development of EU-level policy initiatives, research, networking, partnering, coordination, data collection and monitoring and evaluation.

Broad Lines

- Strengthening the evidence base for research and innovation policy, for a better understanding of the different dimensions and components of national research and innovation systems, including drivers, impacts, associated polices;

- Foresight activities, to anticipate emerging needs and trends, in coordination and co-design with national agencies and future-oriented stakeholders and citizens, in a participative manner, building on advances in forecasting methodology, making outcomes more policy relevant, while exploiting synergies across and beyond the programme;

- Support for policy makers, funding bodies, research performing organisations (including universities) or advisory groups working on ERA and ERA related policies or implementing measures supporting the ERA (e.g. by establishing joint calls) to ensure that these are to be well-aligned towards developing and implementing a coherent and long-term sustaining ERA;

– Accelerating the transition towards open science, by monitoring, analysing and supporting the development and uptake of open science policies and practices[30], including the FAIR principles, at the level of Member States, regions, institutions and researchers, in a way that maximises synergies and coherence at EU level;

– Support to national research and innovation policy reform, including though a strengthened set of services of the Policy Support Facility (PSF)[31] (i.e. peer reviews, specific support activities, mutual learning exercises and the knowledge centre) to Member States and Associated Countries, operating in synergy with the European Regional Development Fund, the Structural Reform Support Service (SRSS) and the Reform Delivery Tool;

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30 The policies and practices to be addressed range from sharing research outputs as early and widely as possible through commonly agreed formats and a shared infrastructure (e.g. the European Open Science Cloud), citizen science, and developing and using new, broader approaches and indicators for evaluating research and rewarding researchers.

31 The Policy Support Facility (PSF), launched under Horizon 2020. The PSF works on a demand-driven basis and it offers, on a voluntary basis, high level expertise and tailor-made advice to national public authorities. Through its services, it has already been instrumental in provoking policy change in countries such as Poland, Bulgaria, Moldova or Ukraine and in bringing forward policy changes, driven by exchanges of good practice, in areas such as R&D tax incentives, open science, performance-based funding of public research organisations and the inter-operability of national research and innovation programmes.

– Providing researchers with attractive career environments, skills and competences needed in the modern knowledge economy[32]. Linking the ERA and the European Higher Education Area by supporting the modernisation of universities and other research and innovation organisations, through recognition and reward mechanisms to spur actions at national level, as well as incentives promoting the adoption of open science practices, entrepreneurship (and links to innovation ecosystems), trans-disciplinarity, citizen engagement, international and inter-sectoral mobility, diversity and inclusion plans, including gender equality, and comprehensive approaches to institutional changes.

– Citizen science, supporting all types of formal, non-formal and informal science education, ensuring a more effective and responsible engagement of citizens, regardless of age, background or abilities, in the co-design of research and innovation agenda settings and policy, in the co-creation of scientific content and innovation through transdisciplinary activities;

– Supporting gender equality, as well as other forms of diversity, in scientific careers, through structural changes in the organisation of research-performing institutions, and in decision making and advisory bodies, as well as the integration of the gender dimension in research and innovation content;

[32] Including notably the European Charter for researchers, the code of conduct for the recruitment of researchers, EURAXESS and RESAVER Pension Fund.

- Ethics and integrity, to further develop a coherent EU framework in adherence with the highest ethics standards and the European Code of Conduct for Research Integrity, the European Charter for Researchers and the Code of Conduct for the Recruitment of Researchers;

- Supporting international cooperation, through bilateral, multilateral and bi-regional policy dialogues with third countries, regions and international fora will facilitate mutual learning and priority setting, promote reciprocal access and monitor impact of cooperation;

- Scientific input to other policies, through the creation and maintenance of structures and processes to ensure that EU policy-making is based on the best available scientific evidence and high-level scientific advice;

- EU research and innovation programme implementation, including the collection and analysis of evidence for the monitoring, evaluation, design and impact assessment of the Framework Programmes;

- Strengthening dedicated support structures and facilitating trans-national cooperation among them (e.g. building on activities of National Contact Points in previous Framework Programmes); The Commission will ensure support to NCPs, inter alia through regular meetings (briefings) before important calls, networking of thematic NCPs and education on horizontal topics (e.g. the NCP Academy);

- Dissemination and exploitation of research and innovation results, data and knowledge, including through dedicated support to beneficiaries; fostering synergies with other EU programmes; targeted communication activities to raise the awareness of the broader impact and relevance of EU funded research and innovation.

ANNEX Ia

Possible ~~A~~areas for Missions and ~~Areas for~~ institutionalised European Partnerships to be established under Article 185 or 187 TFEU

In accordance with Article 7 and 8 of the Framework Programme, the **possible** areas for ~~possible~~ Missions and European Partnerships to be established under Articles 185 **or**~~and~~ 187 TFEU are set out in this Annex.

~~The list of Mission Areas and institutionalised European Partnerships may be reviewed in accordance with Article 12a.~~

I. ~~Indicative a~~**A**reas for Missions

Missions Area 1: Adapt**at**ion to Climate Change, including ~~and~~ Societal Transformation

Mission Area 2: **Paediatric** Cancer

Mission Area 3: Healthy **Seas,** Oceans and Natural Waters

Mission Area 4: ~~Carbon~~**Climate**-Neutral and Smart Cities

Mission Area 5: Soil Health ~~for sustainable food~~

Each mission will follow the principles set out in Article 7 paragraph 3 of the [Framework Programme]

II. ~~Indicative a~~**A**reas for institutionalised European Partnerships **on the basis of Article 185 TFEU or Article 187 TFEU**

Partnership Area 1: Faster development and safer use of health innovations for European patients, and global health.

Partnership Area 2:	Advancing key digital and enabling technologies and their use, including novel technologies such as Artifical Intelligence and quantum technologies.
Partnership Area 3:	European leadership in Metrology including an integrated Metrology system.
Partnership Area 4:	Accelerate competitiveness, safety and environmental performance of EU air traffic, aviation and rail.
Partnership Area 5:	Sustainable, inclusive and circular bio-based solutions.
Partnership Area 6:	Clean hydrogen and sustainable energy storage technologies with lower environmental footprint and less energy-intensive production.
Partnership Area 7:	Clean, connected, cooperative, autonomous and automated solutions for future mobility demands of people and goods.
Partnership Area 8:	Innovative and R&D intensive small and medium-sized enterprises.

~~It is understood that t~~**T**he process of assessing the need for an institutionalised European partnership in one of the above mentioned Partnership Areas ~~can~~ **may** result~~-~~ in **a proposal** ~~the decision not to put forward a proposal~~ on the basis of Article 185 TFEU or Article 187 TFEU, in accordance with the European Commission's right of initiative. ~~In that case t~~**Otherwise** the respective Partnership Area can **also** be subject to a partnership following Article 8(1)(a) or Article 8(1)(b) of the [Framework Programme] or be implemented by ~~regular~~ calls for proposals within Horizon Europe.

As the ~~indicative~~ **possible** areas for institutionalised European partnerships cover broad thematic fields, they can, based on the assessed needs, be implemented by more than one partnership.

ANNEX II

Programme Committee configurations

List of configurations of the Programme Committee in accordance with Article 12(2):

1. Strategic configuration: Strategic overview of the implementation of the whole programme, coherence across the individual work programmes of the different parts of the programme, including missions

2. European Research Council (ERC)

2a. Marie Skłodowska-Curie Actions (MSCA)

3. Research Infrastructures

4. Health

5. Culture and Inclusive Society

6. Civil Security for Society

6. Digital, Industry and Space

7. Climate and Energy

7a. Mobility

8. Bioeconomy, Food, Natural Resources and Environment

9. The European Innovation Council (EIC) and European Innovation ecosystems

9a. Widening participation and strengthening the European Research Area

Ad-hoc meetings could be organised within the clusters and/or with different Programme Committee configurations and/or with Committees established by other acts on horizontal and/or cross-cutting issues, such as space.

ANNEX III

Information to be provided by the Commission in accordance with Article 12(6)

1. Information on individual projects, enabling the monitoring of the entire lifetime of each proposal, covering in particular:

— submitted proposals,

— evaluation results for each proposal,

— grant agreements,

— terminated projects in accordance with Article 29(2) and (3) and Article 43(11) of the Regulation (Horizon Europe)

— completed projects.

2. Information on the outcome of each call and project implementation, covering in particular:

— results of each call,

— evaluation scores of proposals and deviations from these in their ranking list, based on their contribution to the achievement of specific policy objectives, including the constitution of a consistent portfolio of projects in accordance with Article 26(2) of the Regulation (Horizon Europe),

— requested adjustments to the proposals in accordance with Article 26(2) of the Regulation (Horizon Europe),

— outcome of negotiations on grant agreements,

— project implementation, including payment data and outcome of projects,

— proposals retained by independent experts evaluation, but rejected by the Commission in accordance with Article 43(7) of the Regulation (Horizon Europe).

3. Information on programme implementation, including relevant information at the level of the framework programme, the specific programme, each specific objective and related themes and the JRC, as part of the annual monitoring along the impact pathways defined in Annex V to the Regulation, as well as the synergies with other relevant Union programmes.

4. Information on the execution of the Horizon Europe budget, including information on commitments and payments for all European Partnerships, as well as financial balances between the EU and all associated countries.

5. Information on the implementation of the Knowledge and Innovation Communities (KIC) of the EIT, of activities under COST, and on externalised activities.