

Horizon 2020
Carvalho report - Specific Programme
Final Compromises - 28.11.2012

Includes:

Comments from EPP, S&D, ALDE, ECR, Greens, GUE

Opinions from AGRI, CULT, JURI, AFET, ENVI, FEMM

CA 1 - EPP - S&D - ALDE - ECR - Greens - GUE

6 - 170 - 171 - 172 - 173

Proposal for a decision
Recital 9

Text proposed by the Commission

(9) Space research and innovation, which is a shared competence of the Union, should be included as a coherent element in Part II 'Industrial leadership' in order to maximize the scientific, economic and societal impact and, to ensure an efficient and cost effective implementation.

Amendment

(9) Space research and innovation, which is a shared competence of the **European** Union, should be included as a coherent element in Part II 'Industrial leadership' in order to maximize the scientific, economic and societal impact and to ensure an efficient and cost effective implementation **carried out in coordination with Member States and ESA.**

Proposal for a decision
Recital 11

Text proposed by the Commission

(11) Part III ‘Societal challenges’ should increase the effectiveness of research and innovation in responding to key societal challenges by supporting excellent research and innovation activities. Those activities should be implemented using a challenge-based approach which brings together resources and knowledge across different fields, technologies and disciplines. Social sciences and humanities research is an important element for addressing all of the challenges. The activities should cover the full range of research and innovation **with an emphasis on innovation-related** activities such as piloting, demonstration, **test-beds**, and support for public procurement, pre-normative research and standard setting, and market uptake of innovations. The activities should support **directly** the corresponding sectoral policy competences at Union level. All challenges should contribute to the overarching objective of sustainable development.

Amendment

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Proposal for a decision
Recital 15 a (new)

Text proposed by the Commission

Amendment

(15 a) Horizon 2020, in which excellence is the main driver, should create, by means of the stairway to excellence, greater synergy, complementarity and interoperability with the structural funds, whose main driver is capacity building and smart specialisation. In this respect bridges should be built in both directions linking the two policies. This articulation should take into account of the specific characteristics of the regions referred to in Articles 174, 349 and 355(1) TFEU.

CA 2 - EPP - S&D - ALDE - Greens - GUE
10 - 11 - 188 - 189 - 190 - 191 - 192 - 193 - 194 - AGRI 5 - ENVI7 -

Proposal for a decision

Article 3 – paragraph 1 – subparagraph 1 – point c and d

Text proposed by the Commission

Amendment

(c) strengthening skills, training and career development, through the Marie Skłodowska-Curie actions (***‘Marie Curie actions’***);

(d) strengthening European research infrastructures, including e-infrastructures

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(d) strengthening European research infrastructures, including e-infrastructures;

(da) spreading excellence and widening participation;

CA 3 - EPP - S&D - ALDE - ECR - Greens
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AFET2 - AFET3 - ENVI8 - ENVI9 - ENVI10 - ENVI11 - ENVI12 - ENVI14 -
ENVI15 - FEM4

Article 3 – paragraph 3

Text proposed by the Commission

Part III ‘Societal challenges’ shall contribute to the priority ‘Societal challenges’ set out in Article 5(2)(c) of Regulation (EU) No XX/2012 [Horizon 2020] by pursuing research, technological development, demonstration and innovation actions which contribute to the following specific objectives:

- (a) improving the lifelong health and wellbeing;
- (b) securing sufficient supplies of safe and high quality food and other bio-based products, by developing productive and resource-efficient primary production systems, fostering related ecosystem services, along side competitive and low carbon supply chains;
- (c) making the transition to a **reliable**, sustainable and competitive energy system, in the face of increasing resource scarcity, increasing energy needs and climate change;
- (d) achieving a European transport system that **is** resource-efficient, environmentally-friendly, safe and seamless for the benefit of citizens, the economy and society;
- (e) achieving a resource-efficient and

Amendment

Part III ‘Societal challenges’ shall contribute to the priority ‘Societal challenges’ set out in Article 5(2)(c) of Regulation (EU) No XX/2012 [Horizon 2020] by pursuing **participatory and transdisciplinary** research, technological development, demonstration and innovation actions, **including socio-economic issues, social innovation and promoting research with and for society**. **These will** contribute to the following specific objectives:

- (a) improving the lifelong health and wellbeing **and improving solutions for keeping the autonomy of the ageing persons**;
- (b) securing sufficient supplies of safe and high quality food, **safeguarding quality agriculture** and **securing sufficient supplies of** other bio-based products, by developing **long-term** productive and resource-efficient primary production systems, fostering related ecosystem services, **reinforcing and nourishing the resource base**, along side competitive and **sustainable** supply chains;
- (c) making the transition to a **efficient**, sustainable, **safe** and competitive energy system, in the face of increasing resource scarcity, increasing energy needs and climate change;
- (d) achieving a European transport system that **is** resource-efficient, environmentally-friendly, safe, **reliable** and seamless for the benefit of **European** citizens, the economy and society;
- (e) achieving a resource-efficient,

climate change resilient economy and a sustainable supply of raw materials, in order to meet the needs of a growing global population within the sustainable limits of the planet's natural resources;

(f) fostering inclusive, innovative and **secure** European societies in a context of unprecedented transformations and growing global interdependencies.

resource-conserving and **accelerating** climate change **mitigation, considering its impacts in the shift of the ecosystem; structure, reduction of biodiversity and natural resource management** and a sustainable supply of raw materials, in order to meet the needs of a growing global population within the sustainable limits of the planet's natural resources;

(f) fostering inclusive, innovative and **reflective** European societies in a context of unprecedented transformations and growing global interdependencies;

(fa) protecting freedom and security of Europe and its citizens.

Article 4 – paragraphs 2 and 3

Text proposed by the Commission

2. The amount referred to in paragraph 1 shall be distributed among the four Parts set out in Article 2(2) of this Decision in accordance with **Article 6(2)** of Regulation (EU) No XX/2012 [Horizon 2020]. The indicative budgetary breakdown for the specific objectives set out in Article 3 of this Decision and the maximum overall amount of the contribution to the actions of the Joint Research Centre are set out in Annex II to Regulation (EU) No XX/2012 [Horizon 2020].

3. No more than 6 % of the amounts referred to in Article 6(2) of Regulation (EU) No XX/2012 [Horizon 2020] for the Parts I, II and III of the specific programme shall be for the Commission's administrative expenditure.

Amendment

2. The amount referred to in paragraph 1 shall be distributed among the four Parts set out in Article 2(2) of this Decision in accordance with **Articles 6(2) and 6(4)** of Regulation (EU) No XX/2012 [Horizon 2020]. The indicative budgetary breakdown for the specific objectives set out in Article 3 of this Decision and the maximum overall amount of the contribution to the actions of the Joint Research Centre are set out in Annex II to Regulation (EU) No XX/2012 [Horizon 2020].

3. *The amounts for the Commission's administrative expenditure shall come from the heading 5 of Multi-Annual Financial Framework.*

Article 5 – paragraphs 5 a (new)

Text proposed by the Commission

Amendment

5 a. Coordination will address fragmentation and improve the use of technological and infrastructural resources by the entire research community related to each thematic area. Strategic actions and scientific coordination will ensure expert input on policy from the outset, advance innovation and competitiveness by understanding the complexity of the innovation cycle, and encouraging participation from more researchers across borders. Strategic research and innovation coordination based on strategic scientific panels shall be established based on need and demand. .

When drafting the work programmes, the Commission shall be required to consult these strategic scientific panels as well as other stakeholders using existing instruments whenever relevant, such as, inter-alia, European Innovation Partnerships, European Technology Platforms and Joint Technology Initiatives.

Proposal for a decision
Article 7 – paragraph 1

Text proposed by the Commission

1. The Scientific Council shall be composed of scientists, engineers and scholars of the highest repute and appropriate expertise, 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 a consultation of the scientific community and a report to the European Parliament and Council.

Amendment

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CA 5 - EPP - S&D - ALDE - ECR - Greens - GUE
22 - 23 - 24 - 25 - 26 - 268 - 269 - 270 - 271 - 272 - 273 - 274 - 275 - 276 - 277 - 278 -
279 - 280 - 281 - 282 - 283 - 284 - 285 - 286 - 287 - 288 - 289 – 290 - 291 - CULT6 -
AGRI9 - AFET5 - ENVI20 - ENVI21 - ENVI22 - ENVI23 - FEMM9 -

Proposal for a decision

Annex 1 – point 1 – point 1.1

1.1 General

Regulation (EU) No XX/2012 (Horizon 2020) provides a set of principles in order to foster a programmatic approach whereby activities contribute in a strategic and integrated way to its objectives and in order to ensure strong complementarities with other related policies and programmes across the Union.

The indirect actions of Horizon 2020 will be implemented through the forms of funding provided for in the Financial Regulation, in particular grants, prizes, procurement and financial instruments. All forms of funding will be used in a flexible manner across all of Horizon 2020's general and specific objectives, with their use being determined on the basis of the needs and the specificities of the particular specific objective. *Particular attention will be paid, when financing SMEs, to simplification of procedures for accessing the funds and reporting obligations.*

Particular attention will be paid to ensuring a broad approach to innovation, which is not only limited to the development of new products and services on the basis of scientific and technological breakthroughs, but which also incorporates aspects such as the use of existing technologies in novel applications, continuous improvement, non-technological, social, *cultural and institutional* innovation *and maximising the dissemination, accessibility, and use of knowledge produced. Innovation in services will also be encouraged by investing in multi-disciplinary competences, creation of capabilities, knowledge and value based on service solutions and intangible contents.* Only a holistic approach to innovation can at the same time tackle societal challenges and give rise to new competitive businesses and industries. *The Horizon 2020 structure should be flexible in order to allow joint calls and activities organized by and funded from different challenges and parts of Horizon 2020.*

For the societal challenges and the enabling and industrial technologies in particular, there will be a particular emphasis on supporting activities which operate close to the end-users and the market, such as demonstration, piloting or proof-of-concept. This will also include *(deletion)* activities in support of social innovation, *innovation in services* and support to demand side approaches such as pre-standardisation or pre-commercial procurement, procurement of innovative solutions, standardisation and other user-centered measures to help accelerate the deployment and diffusion of innovative products and services into the market. In addition, there will be sufficient room for bottom-up approaches and open, light and fast schemes under each of the challenges and technologies to provide Europe's best researchers, entrepreneurs and enterprises, *in particular SMEs*, with the opportunity to put forward breakthrough solutions of their choice.

Within the societal challenges a challenge-based approach should be followed, in which basic science, applied research, knowledge transfer and innovation are

equally important and interlinked components. Furthermore, the right balance should be struck within the societal challenges and the enabling and industrial technologies between smaller and bigger projects, taking into account the specific sector structure, type of activity, technology and research landscape. The specific characteristics of the regions referred to in Articles 174, 349 and 355(1) TFEU will be taken into account in the research priorities.

Detailed priority setting during implementation of Horizon 2020 will entail a strategic approach to programming of research, using *transparent and participatory* modes of governance aligning closely with policy development yet cutting across the boundaries of traditional sectoral policies. *In order to improve the governance structure, it is necessary to demonstrate to what extent stakeholders and civil society representatives are involved in bottom-up processes, work programmes and decision-making.* This will be based on sound evidence, analysis and foresight, with progress measured against a robust set of performance indicators. This cross-cutting approach to programming and governance will allow effective coordination between all of Horizon 2020's specific objectives and will allow to address challenges which cut across them, such as for instance sustainability, climate change or marine sciences and technologies.

Horizon 2020 will be targeted towards activities where intervention at Union level brings added value above intervention at national or regional level by creating economies of scale and critical mass, reducing fragmentation and ensuring a Union-wide dissemination of results. These activities are mainly transnational, pre-competitive, collaborative projects and they shall comprise the majority of the total combined budget for the priority "Societal challenges" and the specific objective on "Leadership in enabling and industrial technologies".

Priority setting will equally be based on a wide range of inputs and advice. It will include, where appropriate, groups of independent experts set up specifically to advise on the implementation of Horizon 2020 or any of its specific objectives. These experts group shall show the appropriate level of expertise and knowledge in the covered areas and a variety of professional backgrounds, including industry and civil society involvement, *characterized and subject to geographical diversity and gender balance.*

The cross- and transdisciplinary nature of the societal challenges may require the setting up of dedicated strategic scientific panels. Their input, as well as other relevant stakeholders from academia, industry, end-users and civil society of the highest repute and appropriate expertise will be taken into account by the Commission. This will ensure a diversity of all sectors and research areas concerned, in order to monitor the appropriateness and sufficiency of present and planned actions and to be aware of neglected subjects and duplicated efforts. The Commission should seek to use existing instruments for this purpose wherever possible in implementing Horizon 2020, such as, inter-alia, European Innovative Partnerships, European Technology Platforms and Joint Programming Initiatives.

Priority setting may also take into account the strategic research agendas of European Technology Platforms or inputs from the European Innovation Partnerships *and FEST flagships provided these have been drafted in consultation with a wide range*

of experts and stakeholders. Where appropriate, public-public partnerships and public-private partnerships supported through Horizon 2020 will also contribute to the priority setting process and to the implementation, in line with the provisions laid down in Horizon 2020. Regular interactions with end-users, citizens and civil society organisations, *as well as national and regional authorities,* through appropriate methodologies such as consensus conferences, participatory technology assessments or direct engagement in research and innovation processes, will also be a cornerstone of the priority setting process.

As Horizon 2020 is a programme for seven years, the economic, societal and policy context in which it will operate may change significantly during its life-time. Horizon 2020 needs to be able to adapt to these changes. Under each of the specific objectives, there will therefore be the possibility to include support for activities beyond the descriptions set out below, where this is duly justified to address major developments, policy needs or unforeseen events.

CA 6 - EPP - S&D - ALDE - ECR - Greens - GUE
292 - 293 - 294 - 295 - 296 - 297 - 298 - 299 - 300 - 301 - 302 - 303 - CULT7 -
CULT8 - CULT9 - AGRI 10 - ENVI24 -

Proposal for a decision

Annex 1 – point 1 – point 1.2

1.2. Social sciences and humanities

Social sciences and humanities research will be fully integrated, *as a horizontal axis*, into each of the general objectives of Horizon 2020. *They shall be fully integrated through their representatives in programme committees and experts' groups in charge of drafting work-programmes and project evaluation, as well as through development of social sciences oriented calls.* This will include ample opportunities *and funding* for supporting such research through the European Research Council, the Marie Curie actions *and* the Research Infrastructures specific objective.

Social sciences and humanities are also mainstreamed as an essential element of the activities needed to tackle each of the societal challenges to enhance their impact *as well as to contribute to solutions through more participative research and to provide the expertise to systematically tackle the gender dimension.* This includes: understanding the determinants of health and optimising the effectiveness of healthcare systems, support to policies empowering rural, *mountainous, insular and remote* areas, *researching and preserving Europe's cultural heritage and richness*, promoting informed consumer choices, *creating an inclusive digital ecosystem based on knowledge and information*, robust decision making on energy policy and in ensuring a consumer friendly European electricity *and gas* grid, supporting evidence based transport policy and foresight, support to climate change mitigation and adaptation strategies, resource efficiency initiatives and measures towards a green, *fair* and sustainable economy.

In addition, the specific objective *'Understanding Europe in a changing world: inclusive, innovative and reflective societies'* will support social sciences and humanities research into issues of a horizontal nature such as the creation of smart and sustainable growth, social *and cultural* transformations in European societies, *political inclusion and democratic participation, the role of media and the formation of the public sphere*, social innovation, innovation in the public sector or the position of Europe as a global actor.

Proposal for a decision

Annex 1 – point 1 – point 1.3

1.3. *Industry* and *small and* medium-sized enterprises (SMEs)

With its potential to make Europe truly competitive, Horizon 2020 will foster a broader participation of private companies in all parts of the programme, particularly within part II ("Industrial Leadership") and part III ("Societal Challenges"). Collaboration between academia and industry a driving force for innovation will be strengthened in order to unlock full dynamic interaction between basic research, applied research and development and demonstration activities.

Horizon 2020 will encourage and support the participation of *all kind of* SMEs in an integrated way across all specific objectives.

In accordance with Article 18 of Horizon 2020, dedicated measures as set out in the specific objective 'Innovation in SMEs' (dedicated SME instrument) shall be applied in the specific objective 'Leadership in enabling and industrial technologies' and Part III 'Societal challenges'. *The dedicated SME instrument will target highly innovative SMEs showing a strong ambition to develop, grow and internationalise, regardless of whether they are high-tech and research-driven or non-research conducting companies, and shall be implemented in a consistent manner and through a single management body. At least 4 % of Horizon 2020 budget shall be used for the dedicated SME instrument. Furthermore, at least 20 % of the total combined budget for the specific objective 'Leadership in enabling and industrial technologies' and the priority "societal challenges" shall be going to SMEs.*

Particular attention shall also be paid to ensure the adequate participation and representation of SMEs in the governing structures of the European Research Areas and in particular of public-private partnerships.

Proposal for a decision

Annex 1 – point 1 – point 1.4

1.4 Access to risk finance

Horizon 2020 will help companies and other types of organisation gain access to loans, guarantees and equity finance via two facilities.

The debt facility will provide loans to single beneficiaries for investment in research and innovation; guarantees to financial beneficiaries making loans to beneficiaries; combinations of loans and guarantees, and guarantees or counter-guarantees for national, regional *and local* debt-financing schemes. It will include an SME window targeting R&I-driven SMEs with loan amounts that complement finance to SMEs by the Loan Guarantee Facility under the Programme for the Competitiveness of Enterprises and SMEs.

The equity facility will provide venture and/or mezzanine capital to individual enterprises in the early stage (start-up window) *as well as knowledge and technology transfer processes at the stages prior to the industry uptake phase (proof-of-concept window)*. The facility will also have the possibility to make expansion and growth-stage investments in conjunction with the Equity Facility for Growth under the Programme for the Competitiveness of Enterprises and SMEs, including in funds-of-funds.

These facilities will be central to the specific objective ‘Access to risk finance’ but may, where relevant, also be used across all other specific objectives of Horizon 2020.

Every effort will be undertaken to ensure the widest possible participation in the programme, of companies and/or organisations from all Member States and significantly facilitate access to funding. Special attention to less innovation performing regions will be paid in accordance with the principle of excellence.

Proposal for a decision

Annex 1 – point 1 – point 1.5

1.5 Communication and dissemination

A key added value of research and innovation funded at the Union level is the possibility to disseminate and communicate results on a continent wide scale to enhance their impact *and to spur social and economic growth*. Horizon 2020 will therefore include, under all of its specific objectives, dedicated support to dissemination (including through open access to research results), communication and dialogue actions, with a strong emphasis on communicating results to end-users, citizens, civil society organisations, industry and policy makers. To this extent, Horizon 2020 may make use of networks for information transfer *and digital repositories and libraries*.

Additional conditions will be laid down to facilitate the exploitation and dissemination of results concerning technologies with potential for tackling major societal challenges, for example the development into a novel medical technology (e.g. drug, diagnostic or vaccine) or technologies for fighting climate change.

Communication activities undertaken in the context of Horizon 2020 will also seek to raise public awareness on the importance of research and innovation by means of publications, events, knowledge repositories, databases, websites or a targeted use of social media. *When a decision to publish is taken, open access to scientific publications resulting from research receiving public funding from Horizon 2020 shall be mandatory and where appropriate fees associated with publishing in open access journals shall be eligible for reimbursement.*

Furthermore, open access to scientific data resulting from publicly funded research under Horizon 2020 shall be promoted, taking into account constraints pertaining to privacy, national security or intellectual property rights.

Communication will be in the European Union's name. In order to simplify the access to information and to develop an instrument with all the information demanded by the research community and, having regard the need for a transparency, Cordis, as a digital instrument should be revised and reformed in a clearer and flexible way.

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29 - 30 - 31 - 32 - 33 - 34 - 334 - 335 - 336 - 337 - 338 - 339 - 340 - 341 - 342 - 343 - 344 - 345 - 346 - 347 - 348 - 349 - 350 - 351 - 352 - ENVI28 - ENVI29

Proposal for a decision

Annex 1 – point 2

2. INTERNATIONAL COOPERATION

International cooperation with partners in third countries is necessary to address effectively many specific objectives defined in Horizon 2020, in particular those relating to Union external policies and international commitments. *(deletion)* International cooperation is also essential for frontier and basic research in order to capture the benefits from emerging science and technology opportunities. Promoting researchers and innovation staff mobility at an international scale is therefore crucial to enhance this global cooperation. Activities at the international level are equally important to enhance the competitiveness of European industry by promoting the take-up and trade of novel technologies, for instance through the development of worldwide standards and interoperability guidelines, and by promoting the acceptance and deployment of European solutions outside Europe.

The three priorities of Horizon 2020 shall include an international dimension as international scientific and technological cooperation is a crucial issue for the Union and its partners. The share for the international cooperation activities described shall be at least maintained at the level of the previous Framework Programmes.

The focus of international cooperation in Horizon 2020 will be on cooperation with three major country groupings: *industrialised and emerging economies, enlargement and neighbourhood countries and developing countries.*

(deletion) Horizon 2020 will promote cooperation at regional or multilateral level. International cooperation in research and innovation is a key aspect of the Union's global commitments and has an important role to play in the Union's partnership with developing countries, such as progressing towards the achievement of the Millennium Development Goals. *In accordance with EU development policy, targeted programmes should be implemented in conjunction with these countries in sectors which build the foundations for growth and help ensure that it is inclusive, notably social protection, health and education, as well as environmental protection, climate change prevention and adaptation measures.*

Article 21 of Horizon 2020 sets out the general principles for participation of organisations from third countries and international organisations. As research and innovation in general benefit largely from an openness towards third countries, Horizon 2020 will continue with the principle of general openness, while encouraging reciprocal access to third country programmes. *(deletion)*

(deletion) Targeted actions will be implemented taking a strategic approach *(deletion)* on the basis of common interest and mutual benefit *(deletion)*. *Coordination* and synergies with Member States' activities *will be sought*. This will include a

mechanism for supporting joint calls and the possibility of co-funding programmes together with third countries or international organisations.

Examples of areas where such strategic international cooperation may be developed are:

(a) The continuation *and geographical expansion to other developing regions* of the European and Developing Countries Clinical Trials Partnership (EDCTP2) on clinical trials *from Phase I-IV* for medical interventions against HIV, malaria and tuberculosis *and neglected diseases*;

(b) Support by way of an annual subscription to the *Human Science Frontier Programme* (HSFP) to allow non-G7 Member States of the Union to fully benefit from the funding provided by the HSFP;

(c) International consortium on *rare diseases*, with a number of Union Member States and third countries. The aim of this initiative is to develop by 2020, diagnostic tests for most rare diseases and 200 new therapies for rare diseases;

(d) Support to the activities of the International Knowledge-Based Bio-Economy Forum and the *EU-US Task Force* on Biotechnology Research as well as collaborative links with relevant international organisations and initiatives (such as global research alliances on agricultural greenhouse gases and on animal health) ;

(e) Contribution to *multilateral processes and initiatives*, such as the Intergovernmental Panel on Climate Change (IPCC), the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES), and the Group on Earth Observations (GEO);

(f) The *Space Dialogues* between the Union and the United States of America and Russia, the two major space faring nations, is an extremely valuable one and forms the basis for the establishment of strategic cooperation in space partnerships such as the International Space Station or launchers, and collaboration in cutting edge space RTD projects.

(fa) *The implementing arrangement for cooperative activities between the European Union and the United States of America in the field of Homeland Security/Civil Security/ Research, signed 18 November 2010;*

(fb) *Support research activities in the scope fair, sustainable and secure supply of raw materials ;*

(fc) *Cooperation with developing countries, namely from Sub-Saharan Africa, in the field of decentralised energy production for poverty alleviation;*

(fd) *Continuation of research collaboration with Brazil on new generation biofuels.*

Synergies between Horizon 2020 and the European Development Fund should be established in order to maximize the benefits from international cooperation with developing countries, especially in the areas of agriculture, health and energy.

European Development Fund could finance the implementation of Horizon 2020 activities and market uptake of research results.

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35 - 36 - 37 - 38 - 355 - 356 - 357 - 358 - 359 - 360 - 361 - 362 - 363 - 364 - 365 - 366
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Proposal for a decision

Annex 1 – point 3

3. COMPLEMENTARITIES AND CROSS-CUTTING ACTIONS

Horizon 2020 is structured around the objectives defined for its three major parts: generating excellent science, creating industrial leadership and tackling societal challenges. Particular attention will be paid to ensuring adequate coordination between these parts and fully exploiting the synergies generated between all specific objectives to maximise their combined impact on the higher level policy objectives of the Union. The objectives of Horizon 2020 will therefore be addressed through a strong emphasis on finding efficient solutions, going well beyond an approach based simply on traditional scientific and technological disciplines and economic sectors. *Special attention should be given to research efforts which one Member State alone cannot undertake or cannot undertake as efficiently as Member States working together and which will directly benefit citizens in the foreseeable future.*

Furthermore, in many cases, contributing effectively to the objectives of Europe 2020 and the Innovation Union will require solutions to be developed which are interdisciplinary in nature and therefore cut across multiple specific objectives of Horizon 2020. Particular attention will be given to responsible research and innovation. Gender will be addressed as a cross-cutting issue in order to rectify imbalances between women and men, and to integrate a gender dimension in the research and innovation programming and content. Horizon 2020 includes specific provisions to incentivise such cross-cutting actions, including by an efficient bundling of budgets. This includes also for instance the possibility for the societal challenges and enabling and industrial technologies to make use of the provisions for financial instruments and the dedicated SME instrument.

In order to reward the best Horizon 2020 grantees and best performing Horizon 2020 projects symbolic prizes will be given for each thematic area across all pillars.

Cross-cutting action will also be vital in stimulating the interactions between the societal challenges and the enabling and industrial technologies needed to generate major technological breakthroughs *and a fair economy*. Examples of where such interactions may be developed are: the domain of eHealth, *cyber security*, smart grids, *energy storage*, intelligent transport systems, mainstreaming of climate actions, *gender*, nanomedicine, *genetic technology*, *testing methods that are more predictive and more relevant to human beings*, *risk assessment*, *medical research*, advanced materials for lightweight vehicles or the development of bio-based industrial processes and products. Strong synergies will therefore be fostered between the societal challenges and the development of generic enabling and industrial technologies *and social innovation*. This will be explicitly taken into account in developing the multi-annual strategies and the priority setting for each of these specific objectives. It will require that stakeholders representing the different

perspectives are fully involved in the implementation and in many cases, it will also require actions which bring together funding from the enabling and industrial technologies and the societal challenges concerned. ***The success of the implementation of necessary changes really depends of the public engagement with Science and Innovation and its benefits.***

Smart specialisation platforms have a key role to play to this end, particularly in terms of creation and networking, the exchange of information, twinning schemes and support for research and innovation policies, whereby the specific circumstances of the outermost regions must be taken into account.

Particular attention will also be paid to the coordination of activities funded through Horizon 2020 with those supported under other Union funding programmes, such as the Common Agricultural Policy, the Common Fisheries Policy or the Erasmus For All: the Union's programme for Education, Training, Youth and Sport or the Health for Growth Programme, ***LIFE program and New Entrants' Reserve (NER300)***. This includes an appropriate articulation with the Cohesion policy funds, where support to capacity building for research and innovation at regional level may act as a 'stairway to excellence', the establishment of regional centres of excellence may help close the innovation divide in Europe or support to large-scale demonstration and pilot line projects may aid in achieving the objective of generating industrial leadership in Europe.

Structural Funds should be used to their full extent to support capacity building in the regions through dedicated activities aimed at enabling centres of excellence to develop, modernising universities, purchasing of scientific equipment, local technology transfer, supporting start-ups and spin-offs, local interaction between industry and academia, enabling clusters in the priority areas of Horizon 2020 and as a source of small grants given for the preparation of proposals to be submitted to Horizon 2020. This will allow a stairway of excellence to be developed, leading these regions to fully participate in the Horizon 2020, based on quality and excellence.

Downstream from Horizon 2020, the structural funds could be used to finance or co-finance the follow up to Horizon 2020 research projects and to valorise research results in such a way as to encourage easy access to knowledge or to facilitate the deployment of the resulting knowledge in terms of its direct economic or societal use. Building greater synergy, complementarity and interoperability between the instruments of Horizon 2020, in which excellence is the main driver, and the structural funds, by means of the stairway to excellence and whose main driver is capacity building and smart specialisation, providing that bridges are built in both directions linking the two programmes. Horizon 2020 projects should attract additional financing from the Structural Funds, the EIB and from the private sector, something that supposes adopting a multi-fund approach. An all-European common fund financed by the structural funds should be set up to promote collaborative European research.

CA 12 - EPP - S&D - ALDE - ECR - Greens
39 - 40 - 41 - 42 - 369 - 370 - 371 - 372 - 373 - 374 - 375 - 376 - ENVI4 - ENVI34 - ENVI35

Proposal for a decision
Annex 1 – point 4

4. PARTNERING

For achieving sustainable growth in Europe, the contribution of public and private players must be optimised. *In particular, to meet the Union 3% target of investments in R&D, private investments in research and innovation need to be substantially increased.* This is essential for consolidating the European Research Area and for delivering on the Innovation Union, *a Resource Efficient Europe*, the Digital Agenda and other Europe 2020 flagship initiatives. *To that end, Union funds should act as much as possible as leverage to further private and public investments.* Furthermore, responsible research and innovation requires that best solutions be derived from interactions between partners having various perspectives but common interests.

Horizon 2020 includes scope and a clear set of criteria for setting up public-public and public-private partnerships. Public-private partnerships can be based on a contractual arrangement between public and private actors and can in limited cases be institutionalised public-private partnerships (such as Joint Technology Initiatives and other Joint Undertakings).

Existing public-public and public-private partnerships may receive support from Horizon 2020, provided they address Horizon 2020 objectives, they meet the criteria laid down in Horizon 2020 and they have shown to make significant progress under the Seventh Framework Programme for Research, Technological Development and Demonstration (FP7), *according to the criteria laid down in Article 19(2) of Regulation (EU) No XX/XX [Horizon 2020] and in Article X of Rules of Participation of Horizon 2020. New innovative partnerships, including product development partnerships may also receive support provided they address Horizon 2020 objectives and meet the criteria.*

Cooperation with the Eureka initiative network, a natural partner for the design and implementation of innovation components of cohesion policy, notably when setting up regional innovation smart specialisation strategies will contribute to achieve the objectives of Horizon 2020 and thus further consolidate the Innovation Union.

Initiatives under Article 185 of the Treaty supported under FP6 and/or FP7 for which further support may be provided under the above conditions include: the European and Developing Countries Clinical Trials Partnership (EDCTP), Ambient Assisted Living (AAL), Baltic Sea Research and Development Programme (BONUS), Eurostars and the European Metrology Research Programme. *Stronger private sector involvement may be provided through European and National Technology Platforms.* Further support may also be provided to the European Energy Research Alliance (EERA) established under the Strategic Energy Technology Plan (SET Plan).

Joint Undertakings established in FP7 under Article 187 of the Treaty, for which further support may be provided under the above conditions are: the Innovative Medicines Initiative (IMI), Clean Sky, Single European Sky ATM Research (SESAR), Fuel Cells and Hydrogen (FCH), and Embedded computing systems (ARTEMIS) and Nanoelectronics (ENIAC). The latter two may be combined into a single initiative.

Other public-private partnerships supported under FP7 for which further support may be provided under the above conditions are: Factories of the Future, Energy-efficient Buildings, European Green Cars Initiative, Future Internet. Further support may also be provided to the European Industrial Initiatives (EIIs) established under the SET Plan.

Further public-public partnerships and public-private partnerships may be launched under Horizon 2020 where they meet the defined criteria *where the scope of the objectives required justifies such a set-up and where it can be demonstrated that no other forms of partnerships or funding instrument can fulfil the desired objective or generate the necessary leverage and involvement of players*. This may include partnerships on Information and Communication Technologies in the areas of Photonics and Robotics, on sustainable process industries, on bio-based industries, *on telemedicine, home treatment appliances* and on security technologies for maritime border surveillance *or critical infrastructure protection*.

Support to all the above-mentioned partnerships will be conditional to a cost-benefit analysis and a thorough assessment of their governance and functioning with regards to criteria of openness, transparency, effectiveness and efficiency. Moreover, the research priorities covered by these partnerships should also be funded through the work programmes in regular calls.

All the above-mentioned partnerships are strongly encouraged to collaborate and explore synergies with the European Institute of Innovation and Technology and its Knowledge Innovation Communities. Collaborations should be explored particularly in the field of education, in order to expand Europe's talent pool and guarantee the future availability of highly-skilled scientists and knowledge-workers.

CA 13 - EPP - S&D -ALDE - ECR - Greens - GUE
44 - 378 - 379 - 380- 381 - 382 - 383 - 384 - 385 - 386 - 387 - 388 - 389 - 390 - 391 -
392 - 393 - 394 - 395 - 396 - 397 - 398 - 399 - 400 - 401 - AFET6 - ENVI37 -
FEMM11 - FEMM12 - FEMM13

Annex 1

PART 1 - EXCELLENT SCIENCE

1. EUROPEAN RESEARCH COUNCIL

The European Research Council (ERC) will promote world class frontier research. Research at and beyond the frontiers of current understanding is both of critical importance to economic and social welfare, and an intrinsically risky venture, progressing on new and most challenging research areas and characterised by an absence of disciplinary boundaries.

In order to stimulate substantial advances at the frontiers of knowledge, the ERC will support individual teams to carry out research in any field of basic scientific and technological research which falls within the scope of Horizon 2020, including engineering, social sciences and the humanities. As appropriate, specific research topics or target groups (e.g. new generation researchers/emerging teams/*women*) may be taken into account, following the objectives of the ERC and needs for efficient implementation. Particular attention will be paid to emerging and fast-growing areas at the frontier of knowledge, and at the interface between disciplines.

Independent researchers of any age *and any gender*, including starting researchers making the transition to being independent research leaders in their own right *and researchers at the stage of consolidation of their own research career (consolidators)*, from any country in the world will be supported to carry out their research in Europe. *Return and reintegration of researchers after the end of an ERC funding period may also be supported, particularly in combination with the 'ERA chair' scheme.*

Research between excellent researchers from different Member-States may also be supported through the ERC Synergy Grant, which has proven to be very attractive for researchers in the previous framework programme.

An "investigator-driven" approach will be followed. This means that the ERC will support projects carried out by researchers on subjects of their choice within the scope of calls for proposals. Proposals will be evaluated on the sole criterion of excellence as judged by peer review, taking account of excellence in new groups, new generation researchers, as well as established teams, *gender equality* and paying particular attention to proposals which are highly pioneering and involve correspondingly high scientific risks.

The ERC will operate as a science-led funding body consisting of an independent Scientific Council, supported by a lean and cost-effective dedicated implementation structure.

The ERC Scientific Council will establish the overall scientific strategy and will have full authority over decisions on the type of research to be funded.

The Scientific Council will establish the work programme to meet the ERC's objectives based on its scientific strategy as below. It will establish the necessary international cooperation initiatives in line with its scientific strategy, including outreach activities to increase the visibility of the ERC for the best researchers from the rest of the world.

The Scientific Council will continuously monitor the operation of the ERC and consider how best to achieve its broader objectives. It will develop the ERC's mix of support measures as necessary to respond to emerging needs.

The ERC will aim for excellence in its own operations. The administrative and staffing costs for the ERC relating to the Scientific Council and dedicated implementation structure will be consistent with lean and cost-effective management. Administrative expenditure will be kept to a minimum, consistent with ensuring the resources necessary for world class implementation, in order to maximise funding for frontier research.

ERC awards will be made and grants operated according to simple procedures that maintain the focus on excellence, encourage initiative and combine flexibility with accountability. The ERC will continuously look for further ways to simplify and improve its procedures in order to ensure that these principles are met.

Given the unique structure and role of the ERC as a science-led funding body the implementation and management of the activities of the ERC will be reviewed and evaluated on an ongoing basis with the full involvement of the Scientific Council to assess its achievements and to adjust and improve procedures and structures on the basis of experience.

1.1. The Scientific Council

In order to carry out its tasks, as set out in Article 7, the Scientific Council will:

- (1) ***Develop*** scientific strategy:
 - establish the overall scientific strategy for the ERC, in the light of scientific opportunities and European scientific needs;
 - on a permanent basis, in accordance with the scientific strategy, ensure the establishment of the work programme and necessary modifications, including calls for proposals and criteria and, as may be required, the definition of specific topics or target groups (e.g. starting /emerging teams);
- (2) ***carry out*** scientific management, monitoring and quality control:
 - as appropriate, from a scientific perspective, establish positions on implementation and management of calls for proposals, ***develop*** 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 proposal to be funded will be determined under the supervision of the

Scientific Council; as well as any other matter affecting the achievements and impact of the ERC's activities, and the quality of the research carried out, including the principal provisions of the ERC Model Grant Agreement;

- monitor quality of operations and evaluate implementation and achievements and make recommendations for corrective or future actions.

(3) **organize** communication and dissemination:

- assure communication with the scientific community and key stakeholders, **including national, regional and local funding agencies** on the ERC's activities and achievements;
- regularly report to the Commission **and the European Parliament** on its own activities;
- **promote the active involvement by researchers from under-represented European regions.**

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

Where appropriate, the Scientific Council shall consult with the scientific, engineering and scholarly Community.

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 ERC President will reside in Brussels for the duration of the appointment and devote most of his/her time¹ to ERC business. He/she will be remunerated at a level commensurate with the Commission's top management.

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 European Research Council.

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

1.2. Dedicated implementation structure

(...)

1.3. Role of the Commission

In order to fulfil its responsibilities as set out in Articles 6, 7 and 8 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;

¹ In principle at least 80%

- 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;
- appoint ***and dismiss*** the Director and the Senior Staff 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 as provided by the ERC Rules of Submission and the ERC Model Grant Agreement, taking into account the positions of the Scientific Council;
- regularly inform the programme committee on the implementation of the ERC activities ***and results, ensuring they are continuously updated on the latest information.***

Annex 1

PART 1 - EXCELLENT SCIENCE

2. FUTURE AND EMERGING SCIENCES AND TECHNOLOGIES²

Future and Emerging *Sciences and Technologies* (FEST) activities will concretise different logics of intervention, from completely open to varying degrees of structuring of topics, communities and funding, structured around three pillars:

2.1. FET Open: fostering novel ideas

Supporting a large set of *early stage*, high risk visionary science and technology collaborative research projects is necessary for the successful exploration of new foundations for radically **new scientific knowledge and** future technologies. By being explicitly non-topical and non-prescriptive, this activity allows for new **and transformational** ideas, whenever they arise and wherever they come from, within the broadest spectrum of themes and disciplines. Nurturing such fragile ideas requires an agile, risk-friendly and highly interdisciplinary research approach, going well beyond the strictly technological realms. Attracting and stimulating the participation of new high-potential actors in research and innovation, such as young **and female** researchers and high-tech SMEs is also important for nurturing the scientific and industrial leaders of the future.

2.2. FET Proactive: nurturing emerging themes and communities

(...)

2.3. FET Flagships: tackling grand interdisciplinary science and technology challenges

Research initiatives within this challenge are science-driven, large-scale, multidisciplinary and built around a visionary unifying goal. They tackle grand science and technology challenges requiring cooperation among a range of disciplines, communities and programmes. The scientific advance should provide a strong and broad basis for future technological innovation and economic exploitation, as well as novel benefits for society. **Activities with a high social impact should be taken into consideration.** The overarching nature and magnitude implies that they can only be realised through a federated and sustained effort (in the order of 10 years duration).

Activities in the three FET pillars are complemented, by a wide range of *networking and community-based activities* for creating a fertile and vibrant European base for science-driven research towards future technologies. They will support the future developments of the FET activities, foster the debate on implications of new technologies, and accelerate impact. **FET activities should be open to collaboration with third countries, based on common interest and mutual benefit.**

² new terminology applying throughout all the Specific Program of Horizon 2020

2.4. Specific implementation aspects

The Commission will be required to consult relevant stakeholders on the FEST programme, including scientists, researchers and engineers of the highest repute and appropriate expertise, ensuring a diversity of research areas and acting in their personal capacity.

This consultation will provide for input, in particular, on:

- the overall scientific strategy for the FEST activities, in the light of scientific and application opportunities and needs at European level*
- the establishment of the work programme priorities and necessary modifications, including calls for proposals and criteria preventing overlaps.*
- the definition of specific topics for the top-down FEST activities (Proactive and Flagships), including in particular those emerging from the FEST bottom-up activities (Open) as well as from ERC grants funded in the relevant areas.*

To minimise duplication of effort, the Commission should seek to use existing instruments for consultation wherever possible in implementing Horizon 2020, such as, inter-alia, European Innovative Partnerships, European Technology Platforms and Joint Programming Initiatives.

Evaluation of all FEST projects will follow exclusively strict criteria of scientific and technological excellence.

The majority of FEST resources will be devoted to bottom-up collaborative frontier research in all fields.

FET will continue to be science-led supported by a light and efficient implementation structure. Simple administrative procedures will be adopted to maintain the focus on excellence in science-driven technological innovation, encourage initiative and combine flexibility with accountability. The most appropriate approaches will be used for probing the FET research landscape (e.g., for portfolio analysis) and for involving communities of stakeholders (e.g., for consultations). The aim will be for continuous improvement, and the search for further ways to simplify and improve procedures in order to ensure that these principles are met. Assessments of the effectiveness and impact of the FET activities will be carried out, complementing those at programme level.

Given its mission of fostering science-driven research towards future technologies, FET strives to bring together actors from science, technology and innovation. FET should therefore play an active and catalytic role in stimulating new thinking, new practices and new collaborations.

FET-Open groups activities for an entirely bottom up search for promising new ideas. The high-risk implied by each such idea is countered by exploring many of them. Efficiency in terms of time and resources, low opportunity cost for the proposers, and undisputable openness to non-conventional and interdisciplinary ideas are the key characteristics for these activities. Light-and-fast continuously open submission schemes will seek for high-risk promising new research ideas and will include tracks for new and high potential innovation actors such as young researchers and high tech

SMEs. It will be complemented with activities to actively stimulate creative out-of-the-box thinking.

FET proactive: this activity regularly opens calls on several high-risk, high-potential innovative themes, funded at such a level that several projects can be selected. These projects will be supported by community building actions that foster activities such as joint events, development of new curricula and research roadmaps. The selection of themes will take into account excellence in science-driven research towards future technologies, potential for creating a critical mass and impact on science and technology.

A number of large scale focused initiatives (FET Flagships) will be implemented. They will be based on partnerships that enable combining Union, national and private contributions, with a balanced governance that allows programme owners to have appropriate influence, as well as a large degree of autonomy and flexibility in the implementation, enabling the flagship to follow closely a broadly supported research roadmap. The selection will take into account the unifying goal, the impact, integration of stakeholders and resources under a cohesive research roadmap and support from stakeholders and national/regional research programmes.

CA 15 - EPP - S&D - ALDE - Greens - GUE
51 - 52 - 53 - 54 - 406 - 407 - 408 - 409 - 410 - 411 - 412 - 413 - 414 - 415 - 416 - 417
- 418 - 419 - 420 - 421 - 422 - 423 - 424 - 425 - 426 - 427 - 428 - 429 - 430 - 431 -
432 - 433 - 434 - 435 - 436 - CULT13 – AFET7 - AFET8 - FEM16 - FEM17 -
FEMM18 - FEMM19

Annex 1

PART 1 - EXCELLENT SCIENCE

3. MARIE CURIE ACTIONS

3.1. Fostering new skills by means of excellent initial training of researchers

Europe needs a strong and creative human resource base, mobile across countries and sectors, with the right combination of skills to innovate and to convert knowledge and ideas into products and services for economic and social benefit.

This will be achieved in particular by structuring and raising excellence in a substantial share of the high-quality initial training of early stage researchers and doctoral candidates throughout Member states and associated countries. By equipping early stage researchers with a diversity of skills that will allow them to face current and future challenges, the next generation of researchers will benefit from enhanced career perspectives in both public and private sectors, *including the non-for-profit civil society sector*, thereby enhancing also the attraction of young people to research careers. *It is for that reason as well that doctoral candidates must be clearly identified as one of the key target groups of the new programme for education, training, youth, and sport, whose resources must be used in a manner which complements Horizon 2020.*

The action will be implemented through support to Union-wide competitively selected research training programmes *allowing researchers to develop their research curriculum*, implemented by partnerships of universities, research institutions, businesses, SMEs and other socio-economic actors from different countries across Europe and beyond. Single institutions able to provide the same enriching environment will also be supported. Typically, successful partnerships will, *inter alia*, take the form of research training networks or industrial, *joint and multiple* doctorates, while single institutions will usually, *but not necessarily*, be involved in innovative doctoral programmes. In this frame, support is foreseen for the best early stage researchers from any country, *regardless of the gender* to join these excellent programmes.

These training programmes will address the development and broadening of core research competences, *allowing researchers to develop their research curriculum*, while equipping researchers with a creative mind, an entrepreneurial outlook and innovation skills that will match the future needs of the labour market. The programmes will also provide training in transferable competences such as teamwork, risk-taking, project management, standardisation, entrepreneurship, ethics, IPR, communication and societal outreach which are essential for the generation, development, commercialisation and diffusion of innovation.

3.2. Nurturing excellence by means of cross-border and cross-sector mobility

Europe has to be attractive for the best researchers, European and non-European. This will be achieved in particular by supporting attractive career opportunities for *early stage and* experienced researchers in both public and private sectors, *including the non-for-profit civil society sector*, and encouraging them to move between countries, sectors and disciplines to enhance their creative and innovative potential.

Funding will be given to the best or most promising experienced *and early stage* researchers, regardless of their nationality *or gender*, who want to develop their skills through a trans-national or international mobility experience. They can be supported along all the different stages of their career, including the most junior ones just after their doctoral degree or equivalent experience *and subsequently return to Europe, should they so wish*. These researchers will receive funding on the condition that they move from one country to another to broaden or deepen their competences in universities, research institutions, businesses, SMEs, *civil society organisations, research infrastructures, Knowledge and Innovation Communities of the EIT* or other socio-economic actors of their choice, working on research and innovation projects fitting their personal needs and interests. *Funding should also be available to promote researcher's mobility towards institutions in the less innovation performing regions*. They will also be encouraged to move from public to private sector or vice-versa through the support of temporary postings. Part-time opportunities allowing combined positions in both public and private sectors will also be supported to enhance the transfer of knowledge between sectors and also encourage the creation of start-ups *and spin-offs*. Such tailor-made research opportunities will help promising researchers to become fully independent and to facilitate career moves between public and private sectors.

In order to fully exploit the existing potential of researchers, possibilities to restart a research career after a break will *be supported. Re-integration of researchers into a longer term research position in Europe, including in the country of origin, after a trans-national/international mobility experiences, will also be supported. Mobility and opportunities for researcher's career development should be promoted.*

3.3. Stimulating innovation by means of cross-fertilisation of knowledge

Societal challenges are becoming more and more global and cross-border and cross-sector collaborations are crucial to successfully face them. Sharing of knowledge and ideas from research to *society and to* market is therefore vital and can only be achieved through the connection of people. This will be promoted through the support of flexible exchanges of highly skilled research and innovation staff between sectors, countries and disciplines.

European funding will support short term exchanges of research and innovation staff within partnerships of universities, research institutions, businesses, SMEs *research infrastructures, Knowledge and Innovation Communities of the EIT* and other socio-economic actors among Europe, as well as between Europe and third countries to reinforce international cooperation. *Specific measures will be taken with a view to strengthening the research capacities of developing countries*. It will be open to research and innovation staff at all career levels, from the most junior (post-graduate) to the most senior (management), including also administrative and technical staff. *In this sense, industrial doctoral programmes should be strengthened as an important*

element to foster an innovative spirit among researchers and create closer links between industry and academia.

3.4. Increasing structural impact by co-funding the activities

(...)

3.5. Specific support and policy actions

To efficiently meet the challenge it will be essential to monitor progress. The programme will support the development of indicators and the analysis of data related to researchers' mobility, skills and careers with a view to identifying gaps *and barriers* in the Marie Curie actions and to increasing the impact of these actions. These activities will be implemented seeking synergies and close coordination with the policy support actions on researchers, their employers and funders carried out under '*Science with and for Society*'. Specific actions will be funded to support initiatives to raise awareness on the importance of the research career and to disseminate research and innovation results emanating from work supported by Marie Curie actions.

(...)

3.6. Specific implementation aspects

The Marie Curie actions will be open to training and career development activities within all domains of research and innovation addressed under the Treaty, from basic research - *including in the social sciences and humanities* - up to market take-up and innovation services. Research and innovation fields as well as sectors will be chosen freely by the applicants.

To benefit from the worldwide knowledge base, the Marie Curie Actions will be open to researchers and innovation staff, as well as to universities, research institutions, businesses and other socio-economic actors from all countries, including third countries under the conditions defined in Regulation (EU) XX/2012 (Rules for Participation).

Throughout all the activities described above, attention will be paid to encourage a strong participation of enterprises, in particular SMEs, *civil society organisations* as well as other socio-economic actors for the successful implementation and impact of the Marie Curie actions. A long-term collaboration between higher education, research organisations and the private sector, taking into account the protection of intellectual property rights, is promoted throughout all the Marie Curie actions.

The possibility is retained, if specific needs arise, to target certain activities under the programme regarding specific societal challenges, 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.

In order to be open to all sources of talent, general measures to overcome any distortions in the access to the grants will be ensured, for example by encouraging equal opportunities in all Marie Curie actions and by benchmarking gender

participation, *the mobility of female researchers and by ensuring non-discrimination, in particular against gender or against researchers returning to work after a career break.* In addition, the Marie Curie actions will support researchers to get established on a more stable career path and to ensure that they can achieve an appropriate work/life balance, taking into account their family situation, and to contribute to facilitate resuming a research career after a break. The **general** principles of the European Charter for Researchers and Code of Conduct for the Recruitment of Researchers promoting open recruitment and attractive working conditions will *apply*.

A participant awarded funding under Marie Curie Actions should be allowed the option to phase their funding over an additional 12 month period if this is necessary in order to complete their research project.

CA 16 - EPP - S&D - ALDE - Greens - ECR - GUE
55 - 56 - 57 - 438 - 439 - 440 - 441 - 442 - 443 - 444 - 445 - 446 - 447 - 448 - 449 -
450 - 451 - 452 - 453 - 454 - FEMM20

Annex 1

PART 1 - EXCELLENT SCIENCE

4. RESEARCH INFRASTRUCTURES (...)

4.1. Developing the European research infrastructures for 2020 and beyond

4.1.1. *Developing (deletion) world-class research infrastructures*³

The aim is to ensure the implementation, long-term sustainability and efficient operation of the research infrastructures, **namely the infrastructures** identified by the European Strategy Forum on Research Infrastructures (ESFRI) and other **existing** world-class research infrastructures **based in Europe, including outstanding regional infrastructures of European value** which will help Europe to respond to grand challenges in science, industry and society. **A balanced distribution of new infrastructures will be taken into account.** This objective will address those infrastructures that are setting up or that have set up their governance, e.g. on the basis of the European Research Infrastructure Consortium (ERIC) or any equivalent structure at European or international level.

The Union funding will contribute to, as appropriate:

- (a) the *preparatory phase* of future infrastructures (e.g. detailed construction plans, legal arrangements, multiannual planning);
- (b) the *implementation phase* (e.g. R&D and engineering work jointly with industry and users, development of regional partner facilities aiming at a more balanced development of the European Research Area); and/or
- (c) the *operation phase* (e.g. **European-level coordination activities, transnational** access, data handling, outreach, training and international cooperation activities).
- (d) **the revamping phase (for example adaptation measures to ensure that existing infrastructures meet strategic needs more effectively).**

This activity will also support **design studies** for new research infrastructures through a bottom-up approach.

³ The ESFRI Roadmap includes around fifty infrastructures of key relevance for Europe (with estimated annual operating cost of two billion Euro) covering all scientific disciplines. Other European world-class facilities include infrastructures such as GÉANT or those identified in the CERN European Strategy for Particle Physics. All of them need partnership between Member States and long-term commitment for their implementation.

4.1.2. *Integrating and opening existing national research infrastructures of pan-European interest*

The aim is to open up key national research infrastructures to all European researchers, from both academia and industry, and to ensure their optimal use and joint development.

The Union will support networks that bring together and integrate, on European scale, key national ***fundamental and applied*** research infrastructures, ***with particular focus on promoting networking and integration of scientific communities of the less innovation performing regions, through, for instance, a more integrated Research Infrastructure landscape.***

Funding will be provided to support, in particular, the trans-national and virtual access of researchers and the harmonisation and improvement of the services the infrastructures provide. Around one hundred networks of infrastructures in all fields of science and technology would require such support, with up to twenty thousands researchers per year benefitting from access to these facilities.

4.1.3. *Development, deployment and operation of ICT-based e-infrastructures⁴*

The aim is to achieve by 2020 a single and open European space for online research where researchers enjoy leading-edge, ubiquitous and reliable services for networking and computing, and seamless and open access to e-Science environments and global data resources. ***It is therefore appropriate budget under this specific objective to go towards research and innovation in e-infrastructures.***

To achieve this goal, support will be given to: global research and education networks providing advanced, standardised and scalable inter-domain services on-demand; grid and cloud infrastructures providing virtually unlimited computational and data processing capacity; an ecosystem of supercomputing facilities, advancing towards exa-scale; a software and service infrastructure, e.g. for simulation and visualisation; real-time collaborative tools; and an interoperable, open and trusted scientific data infrastructure.

Universal online access by European universities and research institutions to the bulk of the world scientific publications will be supported by consolidating a EU e-infrastructure for an Online Open Science Library.

4.2. **Fostering the innovation potential of research infrastructures and their human capital**

4.2.1. *Exploiting the innovation potential of research infrastructures*

The goal is to stimulate innovation both in the infrastructures themselves and in their supplier and user industry.

⁴ As all research becomes computer- and data-intensive, access to state of the art e-infrastructures has become essential for all researchers. For example, GÉANT connects 40 million users in over 8,000 institutions across 40 countries, whereas the European grid infrastructure is the world's largest distributed computing infrastructure with over 290 sites in 50 countries. Relentless progress in ICT and the increasing needs of science for computing and processing massive amounts of data pose major financing and organisational challenges for ensuring seamless services to researchers.

To this end, support will be provided to

- (a) R&D partnerships with industry to develop Union capacities and industrial supply in high-tech areas such as scientific instrumentation or ICT;
- (b) pre-commercial procurement by research infrastructure actors to drive forward innovation and act as early adopters of technologies;
- (c) stimulate the use of research infrastructures by industry, e.g. as experimental test facilities or knowledge-based centres; and
- (d) encourage the integration of research infrastructures into local, regional and global innovation ecosystems

(e) foster access to private research infrastructures suitable for public research purposes.

(f) Support activities enhancing interoperability of research infrastructures including e-infrastructure

The Union actions will also leverage the use of research infrastructures, in particular e-infrastructures, for public services, social innovation, culture and education.

4.2.2. Strengthening the human capital of research infrastructures

The complexity of research infrastructures and the exploitation of their full potential require adequate skills for their managers, engineers and technicians, as well as users.

The Union funding will support the **education and** training of staff **using**, managing and operating research infrastructures of pan-European interest, the exchange of staff and best practices between facilities, **including a secondment scheme for senior staff and project managers, and** the adequate supply of human resources in key disciplines, including the emergence of specific education curricula. **Synergy and coherence with the Marie Skłodowska Curie actions and the Knowledge and Innovation Communities of the EIT shall be encouraged.**

4.3. Reinforcing European research infrastructure policy and international cooperation

4.3.1. Reinforcing European policy for research infrastructures

The aims are to exploit synergies between national and Union initiatives by setting up partnerships between relevant policy makers and funding bodies (e.g. ESFRI, e-Infrastructure Reflection Group (e-IRG), EIROforum organisations, national public authorities), to develop complementarities and cooperation between research infrastructures and activities implementing other Union policies (such as regional, cohesion, industrial, health, employment, **security** or development policy), and to ensure coordination between different Union funding sources. **Activities with a high social impact should be taken into consideration.** Union actions will also support survey, monitoring and assessment of research infrastructures at Union level, as well as relevant policy studies and communication tasks.

4.3.2. *Facilitate strategic international cooperation*

The aim is to facilitate the development of global research infrastructures i.e. research infrastructures that require funding and agreements on a global scale. The aim is also to facilitate the cooperation of European research infrastructures with their non-European counterparts, ensuring their global interoperability and reach, and to pursue international agreements on the reciprocal use, openness or co-financing of infrastructures. In this respect due account will be taken of the recommendations of the Carnegie Group of Senior Officials on Global Research Infrastructures. Attention will also be given to ensure adequate Union participation in coordination with international bodies such as the UN or the OECD. ***Research Infrastructure partnerships with developing countries shall also be addressed.***

4.4. **Specific implementation aspects**

(...)

CA 17- EPP - S&D - GUE

58 - 367 - 437 - 455 - 898 - 899 - 900 - 901 - 902 - 903 - 904 - 905 - 906 - 907 - 908 - 909 - 910 - 911 - 912 – 929 – AFET 12 - AFET13 - ENVI17 -

PART 1 - EXCELLENT SCIENCE

Annex 1 – section 1 – point 4 a (new)

4 a. Spreading Excellence and Widening Participation

There are significant disparities across Europe in research and innovation performance which need to be addressed *in accordance with the principle of excellence*.

In this context, measures will aim at fully exploiting the potential of Europe's talent pool and thereby optimising the economic and social impact of research and innovation and fostering the growth of the first sprouts of excellence such as small research groups and highly innovative start ups.

These measures include:

4a.1 - Twinning and networking measures:

(a) Linking in a competition emerging institutions *and* centres of excellence in less *innovation performing regions* to leading international counterparts elsewhere in Europe. This will involve twinning of staff exchanges, expert advice and assistance and the development of joint strategies for the development of centres of excellence. This may be supported by the Cohesion policy funds in less developed regions. Building links with innovative clusters and recognising excellence in less developed regions, including through peer reviews and awarding labels of excellence to those institutions that meet international standards, will be considered.

(b) Launching a competition for the foundation of internationally competitive research centres in cohesion regions: the candidates for the competition should be teams each comprising an innovative but still less developed region and an internationally recognised centre of excellence elsewhere in Europe. The scientific concepts underlying the newly founded research institutes should be assessed on the principle of excellence and based on the priorities identified in the regional Smart Specialization Strategy; the regions should be required to come up with a viable overall approach for an infrastructure and overall environment amenable to research and innovation, something to be built up with the help of their structural funds; this competition should provide a powerful complement to the efforts of the economically weaker regions to develop a long term Smart Specialisation Strategy.

(c) Establishing 'ERA Chairs' to attract outstanding academics to institutions with a clear potential for research excellence, in order to help these institutions fully unlock this potential and thereby create a level playing field for research and innovation in the European Research Area. This will include institutional and regional support for creating a competitive research environment and the framework conditions necessary for attracting, retaining and developing top research talent within these institutions.

(d) Attribution of "Return Grants" to excellent researchers currently working outside of Europe and who wish to work in Europe or to researchers already working in Europe who wish to move to a less innovation performing region.

(e) Support complementary agreements signed among organisations beneficiaries of the collaborative research projects with other entities and organisations established mainly in countries others than those directly involved in the project with the specific objective of facilitating training opportunities (namely doctoral and post-doctoral positions)

(f) Strengthening successful networks aiming at establishing high quality institutional networking in research and innovation. Particular attention will be paid to COST in order to promote activities to identify and connect "pockets of excellence" (high-quality scientific communities and early career investigators) throughout Europe.

(g) Developing specific training mechanisms on how to participate in Horizon 2020, taking full advantage of existing networks such as the National Contact Points.

(h) Setting up an online marketplace where intellectual property can be advertised in order to bring together the owners and users of IPR.

4a.2 - Building synergies with Structural Funds:

(i) Conferring a "seal of excellence" on positively evaluated ERC, Marie Skłodowska-Curie or collaborative project proposals that have not been able to achieve funding because of budgetary limitations; as well as to completed projects in order to facilitate funding of the follow up (e.g. pilot scale, demonstration projects or valorisation of research results) by national, regional or private sources. National, regional and private funds might thus be used to contribute to the funding of those projects that meet the criteria of excellence but cannot be funded due to lack of European funds.

(j) Supporting the development and monitoring of smart specialisation strategies. A policy support facility will be developed and policy learning at regional level will be facilitated through international evaluation by peers and best practice sharing.

CA 18 - EPP - S&D - ALDE - ECR - Greens
59 - 60 - 61 - 62 - 63 - 64 - 65 - 66 - 67 - 68 - 69 - 70 - 71 - 72 - 73 - 74 - 75 - 76 - 77 -
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Annex 1 - PART II - INDUSTRIAL LEADERSHIP

1. LEADERSHIP IN ENABLING AND INDUSTRIAL TECHNOLOGIES

General

The successful mastering and deployment of enabling technologies by European industry is a key factor in strengthening Europe's productivity and innovation capacity and ensuring Europe has an advanced, sustainable and competitive economy, global leadership in high-tech application sectors and the ability to develop unique solutions for societal challenges *and user needs*. ***Industrial sectors that have higher impact in value added, employment, importance for the rest of the economy and potential for reducing the cost of non-Europe should be targeted.*** Innovation activities will be combined with R&D, as an integral part of the funding. ***Substantial focus shall be given to small and medium scale projects.***

An integrated approach to Key Enabling Technologies

A major component of 'Leadership in Enabling and Industrial Technologies' are Key Enabling Technologies (KETs), defined as micro- and nanoelectronics, photonics, nanotechnology, biotechnology, advanced materials and advanced manufacturing systems⁵. Many innovative products incorporate several of these technologies simultaneously, as single or integrated parts ***as well as a huge amount of outcomes from basic scientific research, in particular from mathematics.*** While each technology offers technological innovation, the accumulated benefit from combining a number of enabling technologies ***and mathematical tools*** can also lead to technological leaps. Tapping into cross-cutting key enabling technologies will enhance product competitiveness and impact. The numerous interactions of these technologies ***and basic scientific results*** will therefore be exploited. ***(Deletion)***

This will include cross-cutting activities that bring together and integrate various individual technologies, resulting in technology validation in an industrial environment to a complete and qualified system, ready for the market. Strong private sector involvement in such activities will be a prerequisite and implementation will therefore notably be through public private partnerships. To this extent and through a dedicated governance structure, a joint work programme for cross-cutting KETs activities will be developed. Taking into account market needs and the requirements of the societal challenges, it will aim at providing generic KETs building blocks for different application areas, including societal challenges.

In particular support will focus on the pre-commercial and pre-competitive stages. Funding shall aim at tackling common technological barriers rather than picking

⁵ COM(2009)512

winners or the financing of particular production lines and single company activities. Activities shall be designed to support industrial competitiveness by stimulating industry, to increase its research and innovation investments and to improve in particular its resource and energy efficiency.

Specific implementation aspects

Innovation activities will *be fostered from the earliest stages of the passage from concept to market. They will also* include the integration of individual technologies; demonstrations of capacities to make and deliver innovative products and services; user and customer pilots to prove feasibility and added value; and large-scale demonstrators to facilitate market take-up of the research results *and implementation of small and medium scale projects to pave the way to large-scale projects. It is also important to promote at the European level bottom-up collaborative disruptive and incremental innovation approaches, both digital and physical, mobility of young innovators and incubators/accelerators.*

Various individual technologies will be integrated, resulting in technology validation in an industrial environment to a complete and qualified system, ready for the market. Strong private sector involvement in such activities will be a prerequisite, notably through public-private partnerships.

Demand-side actions will complement the technology push of the research and innovation initiatives. These include making the best use of public procurement of innovation; developing appropriate technical standards; private demand and engaging users to create more innovation-friendly markets.

For nanotechnology and biotechnology in particular, engagement with stakeholders and the general public will aim to raise the awareness of benefits and risks. Safety assessment and the management of overall risks in the deployment of these technologies will be systematically addressed. *Criteria and transparent procedures will be developed to assess, at an early stage of development, the social desirability and social acceptability of new technologies.*

Union RDI activities on the Technology Readiness Level scale will be in line with the OECD definition. The Commission will consider this definition in order to include technological research, product development and demonstration activities within its RDI portfolio.

These activities will complement support for research and innovation in enabling technologies, which may be provided by national or regional authorities under the Cohesion Policy funds, within the framework of smart specialisation strategies.

Strategic international cooperation initiatives will be pursued in areas of mutual interest and benefit with leading partner countries. Of particular, but not exclusive, interest for enabling and industrial technologies are

- the development of global standards;
- removing bottlenecks in industrial exploitation and conditions for trade;

- the safety of nanotechnology-based and biotechnology-based products;
- the development of materials and methods to reduce energy and resource consumption;
- industry-led, collaborative international initiatives within the manufacturing community;
- the interoperability of systems;
- ***the development and application of predictive and human relevant tools for safety testing, risk assessment and health research***

1.1. Information and Communication Technologies (ICT)

A number of activity lines will target *ICT industrial and technological leadership challenges* and cover ***ICT standards and protocols, as well as*** generic ICT research and innovation agendas, including notably:

1.1.1. *A new generation of components and systems: engineering of advanced, secure and smart embedded components and systems components*

The objective is to maintain and reinforce European leadership in technologies related ***to major information systems and to smart embedded components and systems and components***. It also includes micro-nano-bio systems, organic electronics, ***computational systems biology***, large area integration, underlying technologies for the Internet of Things (IoT)⁶ including platforms to support the delivery of advanced services, ***sensors***, smart integrated systems, ***distributed*** systems, ***systems*** of systems and complex systems engineering.

1.1.2. *Next generation computing: advanced and secure computing systems and technologies*

The objective is to leverage European assets in processor and system architecture, interconnect and data localisation technologies, cloud computing, ***large-scale and supercomputing, "big data"***, parallel computing, simulation software for all market segments of computing, ***uncertainty quantification, risk analysis and decision in engineering***.

1.1.3. *Future Internet: software, hardware, infrastructures, technologies and services*

The objective is to reinforce the competitiveness of European industry in developing, mastering and shaping the next generation Internet that will gradually replace the current Web, fixed, ***satellite*** and mobile networks and service infrastructures, and enable the interconnection of trillions of devices (IoT) across multiple operators and domains that will change the way we communicate, access and use knowledge. This includes R&I on networks, software and services, cyber security, privacy, trust ***and social implications***, wireless²² communication and all optical networks, immersive interactive multimedia and on the connected enterprise of the future. ***In particular***

⁶ Internet of Things will be coordinated as a cross-cutting issue

support will be provided for research and development of open-systems and distributive systems.

1.1.4. Content technologies and information management: ICT for digital content, cultural industries and creativity

The objective is to provide professionals and citizens with new tools to create, exploit and preserve all forms of digital content in any language and to model, analyse, and visualise vast amounts of data, including linked data. This includes new technologies for language, learning, interaction, digital preservation, ***arts, cultural resource access, content access and analytics; intelligent information management systems based on advanced data mining, machine learning and machine knowledge, statistical analysis and visual computing technologies.***

1.1.5. Advanced interfaces and robots: robotics and smart spaces

The objective is to reinforce European scientific and industrial leadership in industrial and service robotics, cognitive systems, ***artificial intelligence and neuroscience, advanced interfaces and smart spaces, and sentient machines, building on miniaturisation and increases in computing, and networking performance and progress in the ability to build systems that can learn, adapt and react.***

1.1.6. Micro- and nanoelectronics and photonics

The objective is to take advantage of the excellence of Europe in this key enabling technology and support the competitiveness and market leadership of its industry.

Activities will also include research and innovation on design, advanced processes, pilot lines for fabrication, related production technologies and demonstration actions to validate technology developments and innovative business models.

1.1.7. Quantum technologies: next generation of ICT devices through the combination of quantum physics and information science

The objective is to develop the next generation of ICT devices through the combination of quantum physics and information science, thereby securing the Union a key role in a future global market where the quantum limits will define the performance of industrial applications.

These ***seven*** major activity lines are expected to cover the full range of needs. These would include industrial leadership in generic ICT-based solutions, products and services needed to tackle major societal challenges as well as application-driven ICT research and innovation agendas which will be supported together with the relevant societal challenge.

Included under each of the ***seven*** big activity lines are also ***ICT-specific research infrastructures*** such as ***living labs for large-scale experimentation and infrastructures for underlying key enabling technologies*** and their integration in advanced products and innovative smart systems, including equipment, tools, support services, clean rooms and access to foundries for prototyping. ***Union funding will benefit to shared facilities and infrastructure open to multiple actors including in particular small and medium-sized firms.***

The fundamental rights and freedoms of natural persons and in particular their right to privacy are key in the EU. Horizon 2020 shall support research and development of systems that can give Europe's citizens full control of their communications.

1.2. Nanotechnologies

1.2.1. Developing next generation nanomaterials, nanodevices and nanosystems

Development and integration of knowledge at the cross-roads of different scientific disciplines, aiming at fundamentally new products enabling sustainable solutions in a wide range of sectors.

1.2.2. Ensuring the safe development, application of nanotechnologies

Advancing scientific knowledge of their potential impact on health or on the environment for pro-active, science-based governance of nanotechnologies and providing validated scientific tools and platforms for hazard, exposure and risk assessment and management along the entire life cycle of nanomaterials and nanosystems.

1.2.2a. Developing new tools for designing, simulation, characterization and manipulations of nanomaterials, components and systems

Studying, imaging and controlling the new nanomaterials and systems at the nanoscale.

1.2.3. Developing the societal dimension of nanotechnology

Addressing the human and physical infrastructure needs of nanotechnology deployment and focussing on governance of nanotechnology for societal benefit ***and on the attitudes of the public towards nanotechnology and related products taking into account the precautionary principle.***

1.2.4. Efficient synthesis and manufacturing of nanomaterials, components and systems

(...)

1.2.5. Developing capacity-enhancing techniques, measuring methods and equipment

(...)

1.3. Advanced materials

1.3.1 Cross-cutting and enabling materials technologies

Research on functional materials, ***technological materials, scarce materials and rare earth elements***, multifunctional materials such as self-repairing or biocompatible materials and structural materials, for innovation in all industrial sectors particularly for high value markets.

1.3.2. *Materials development and transformation*

Research and development to ensure **resource** efficient, sustainable **and safe and secure** scale up to enable industrial manufacturing of future products e.g. in the metal chemical **and renewable energy** industries.

1.3.3. *Management of materials components*

Research and development for new and innovative **production** techniques **for materials, components** and systems, joining, adhesion, separation, assembly, self-assembly and disassembling, decomposition and deconstruction.

1.3.4. *Materials for a sustainable and low carbon industry*

Developing new **materials, components**, products and applications and consumer behaviour that reduce energy demand and facilitate low-**emission** production, as well as process intensification, recycling, depollution and high added-value materials from waste and remanufacture.

1.3.5. *Materials for creative industries*

Applying design and the development of converging technologies to create new business opportunities, including the preservation of Europe's **heritage and** materials with historical or cultural value. **Protecting the cultural heritage: assessment, monitoring and choice of conservation materials and techniques, with reference to the environment and energy management, use and maintenance, and integration into contemporary and historical urban surroundings and archaeological and cultural contexts.**

1.3.5 a. *New raw materials for the chemical industry and carbon usage*

Development of an alternative feedstock basis for the chemical industry, ranging from coal, biomass, and waste materials, to environmentally friendly substitute petroleum as carbon source in the medium and long term.

CCU systems and technologies to convert CO₂ into products such as chemicals, fertilizers, fuels and bio-oils shall be explored, together with new storage technologies, including storage in chemical products, syngas-based production of fuels for storage as well as the development of low-cost and fuel-tolerant gasification technologies which are essential for these systems.

1.3.6. *Metrology, characterisation, standardisation and quality control*

(...)

1.3.7. *Optimisation of the use of materials*

Research and development to investigate alternatives to the use of materials, **including scarce and/or raw materials**, and innovative business model approaches.

1.4. Biotechnology

1.4.1. *Boosting **sustainable** cutting-edge biotechnologies as future innovation drivers*

The objective is to lay the foundations for the European industry to stay at the front line of innovation, also in the medium and long term. It encompasses the development of emerging tools such as synthetic biology, bioinformatics, systems biology and exploiting the convergence with other enabling technologies such as nanotechnology (e.g. bionanotechnology) and ICT (e.g. bioelectronics) **and plant and agricultural biotechnology**. These and other cutting-edge fields deserve appropriate measures in terms of research and development to facilitate effective transfer and implementation into new applications (drug delivery systems, biosensors, biochips, etc), **products and technologies, avoiding interference with natural environment and taking into account ethical principles**.

1.4.2. *Biotechnology-based industrial **products and processes***

The objective is twofold: on the one hand, enabling the European industry (e.g. chemical, health, mining, energy, pulp and paper, textile, starch, **crop production and food processing**) to develop new products, **materials** and **sustainable** processes meeting **agricultural and aquacultural**, industrial and societal demands; and competitive and enhanced biotechnology-based alternatives to replace established ones; on the other hand, harnessing the potential of biotechnology for detecting, monitoring, preventing and removing pollution. It includes R&I on enzymatic and metabolic pathways, bio-processes design, advanced fermentation, up- and downstream processing, gaining insight on the dynamics of microbial communities. It will also encompass the development of prototypes for assessing the techno-economic feasibility of the developed products and processes.

1.4.3. *Innovative and competitive platform technologies*

The objective is to develop platform technologies (e.g. **systems biology**, genomics, meta-genomics, proteomics, **phenomics**, molecular tools **and cell-based platforms**) triggering leadership and competitive advantage on a wide number of sectors **having economic impact. This approach can further advance the potential of novel SMEs**. It includes **development of activities for enhancing populations' health and well-being. It includes also** aspects, such as underpinning the development of bio-resources with optimised properties and applications beyond conventional alternatives; enabling exploration, understanding and exploitation in a sustainable manner of terrestrial and marine biodiversity for novel applications; and sustaining the development of biotechnology-based healthcare solutions (e.g. **pharmaceuticals**, diagnostics, biologicals, bio-medical devices, **healthier plants and animals for healthy nutrition**).

1.4.3 a. *Addressing environmental, societal and ethical concerns*

The objective is to take account of environmental, societal and ethical concerns with regard to certain types of technologies by developing assessment processes including broad consultation of stakeholders;

1.5. Advanced Manufacturing and Processing

1.5.1. *Technologies for Factories of the Future*

Promoting sustainable, industrial growth by facilitating a strategic shift in Europe from cost-based manufacturing to an approach based on the creation of high added value. This requires addressing the challenge of producing more **quality products**, while consuming less material, using less energy and creating less waste and pollution. The focus will be on the development and integration of the adaptive production systems of the future, with particular emphasis on the needs of European SMEs, in order to achieve advanced and sustainable manufacturing systems and processes.

1.5.2. *Technologies enabling Energy-efficient and low environmental impact buildings*

(...)

1.5.3. *Sustainable and low-carbon technologies in energy-intensive and resource intensive process industries*

Increasing the competitiveness of process industries, such as chemical, pulp and paper, glass, **construction** or non-ferrous metals and steel by drastically improving resource and energy efficiencies and reducing the environmental impact of such industrial activities, **such as clean combustion for lowering micro-particles and heavy metals emissions**. Focus will be on the development, and validation of enabling technologies for innovative substances, materials and technological solutions for low-carbon products and less energy-intensive processes and services along the value chain, as well as the adoption of ultra-low carbon production technologies and techniques to achieve specific GHG emission intensity reductions.

1.5.4. *New, sustainable business models*

Cross-sectoral cooperation in concepts and methodologies for 'knowledge-based', specialised production can boost creativity and innovation with a focus on business models in customised approaches that can adapt to the requirements of globalised value chains and networks, changing markets, and emerging and future industries. **Support in particular will be provided to development of novel eco-innovation business models and alternative resource-productive approaches.**

1.6. Space

1.6.1. *Enable European competitiveness, non-dependence and innovation in space activities*

Space includes, when it is referred to as a generic term, satellite observation, satellite navigation and satellite telecommunications industry, infrastructure (ground and space), services and applications.

The objective is to maintain a **(deletion)** leading role **on the global level** in space by safeguarding and developing a competitive space industry and research community and by fostering space-based innovation.

1.6.1.1. Safeguard a competitive space industry and research community

(...)

1.6.1.2. Boost innovation between space and non-space sectors

A number of challenges in space technologies have parallels to terrestrial challenges, for example in the fields of **mobility, agriculture**, energy, telecommunications, natural resource exploration, robotics, security, and health. These commonalities offer opportunities for early co-development, in particular by SMEs, of technologies across space and non-space communities, potentially resulting in breakthrough innovations more rapidly than achieved in spin-offs at a later stage. Exploitation of existing **and developing** European space infrastructure should be stimulated **and prepared** by promoting development of innovative products and services based on remote sensing and geo-positioning **and space based telecommunications**. Europe should furthermore reinforce the incipient development of an entrepreneurial space sector by well targeted **measures to encourage integrated use of several space-based services and in particular space promotion activities towards the broad public..**

1.6.2. Enabling advances in space technologies

The objective is to ensure the capability to access space and to operate space systems to the benefit of European society in the next decades.

The ability to access space and to maintain and operate European or international space systems in Earth orbit and beyond, are vital to the future of European society. The necessary capabilities require constant investments in a multitude of space technologies (e.g. launchers, satellites, robotics, instruments and sensors), and in operational concepts from idea to demonstration in space. Europe is currently one of the three leading space powers, but compared to the level of investment in space R&D in the United States of America (e.g. about 20 % of the total NASA budget), the European level of investment in future space technologies is insufficient (less than 10 % of total expenditure in space) and needs to be strengthened along the entire chain:

- (a) fundamental technological research, often relying heavily on key enabling technologies, with the potential of generating breakthrough technologies with terrestrial applications;
- (b) improvement of existing technologies, e.g. through miniaturisation, higher energy efficiency, and higher sensor sensitivity;
- (c) demonstration and validation of new technologies and concepts in the space and terrestrial analogue environments;
- (d) mission context, e.g. analysis of the space environment, **data transmission**, ground stations, protecting space systems from collision with debris and effects of solar flares (Space Situational Awareness, SSA), fostering innovative data **gathering** and **transmission and** sample archiving infrastructure;
- (e) Advanced navigation and remote sensing technologies, covering the research essential for future generations of Union space systems (e.g. Galileo).

1.6.3. Enabling exploitation of space data

The objective is to ensure more extensive utilisation of space data from existing and future European missions in the scientific, public and commercial domain.

Space systems produce information which often cannot be acquired in any other way. Despite world class European missions, publication figures show that data from European missions are not as likely to be used as data from US missions. A considerably increased exploitation of data could be achieved if a concerted effort were made to coordinate and organise the processing, validation and standardisation of space data from European missions. Innovations in data acquisition and processing, data fusion, and data dissemination, ***data analysis and data mining***, utilising also innovative ICT enabled forms of collaboration, can ensure a higher return on investment of space infrastructure. Calibration and validation of space data (for individual instruments, between instruments and missions, and with respect to in-situ objects) are key to efficient use of space data in all domains, but have been hampered by the lack of Union-level bodies or institutes mandated to ensure the standardisation of space-derived data and reference frames. Data access and exploitation of space missions is a matter that requires global coordination. For Earth observation data, harmonised approaches and best practices are partly achieved in coordination with the intergovernmental organization Group on Earth Observation, aiming to sustain a Global Earth Observation System of Systems, in which the Union participates.

Support will be provided for the development of a comprehensive and sustained global environmental observation and information system, including through fostering cooperation between climate modelling communities and environmental observation and data management communities. The inclusion of the Member States in such cooperation is essential since national authorities are often the owners of data records.

Support dedicated to research and development of space-related applications will in particular be devoted to supporting the meeting of the societal challenges such as climate change, environment, sustainable transport systems, agriculture. The objectives of knowledge sharing and interoperable development shall underpin support provided in these areas.

1.6.4. *Enabling European research in support of international space partnerships*

(...)

1.6.4 a. Developing applications in the area of GNSS to ensure positive return on investment in European satellite navigation systems

At the time when EGNOS is fully operational and Galileo successfully closed the In Orbit Validation, it is crucial for the European industries to adopt the new technology available and be prepared for full capability of Galileo in order to capture the socio-economic benefits, estimated at around EUR 90 billion. Research funding shall drive the development of EGNOS and Galileo in critical sectors like aviation and road transport and many professional applications, including precision agriculture, timing and geodesy, ensuring the use of new signals in current and future applications.

1.6.5. *Specific implementation aspects*

The implementation priorities of space research and innovation under Horizon 2020 are in line with the Union's space policy priorities as defined by the Space Council

and the Communication *Towards a space strategy for the European Union that benefits its citizens*⁷. The implementation will be developed in consultation with stakeholders from European space industry, SMEs, academia, and technology institutes, represented by the Space Advisory Group and important partners such as the European Space Agency and national space agencies. ***Activities shall be developed and implemented in a complementary way between the EU, ESA and the Member States.*** As regards the participation in international undertakings, the research and innovation agenda will be defined in collaboration with international partners (e.g. NASA, ROSCOSMOS, JAXA).

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COM(2011) 152

CA 19 - EPP - S&D - ALDE - ECR - Greens
78 - 79 - 80 - 81 - 537 - 538 - 539 - 540 - 541 - 542 - 543 - 544 - 545 - 546 - 547 - 548
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Annex 1 - PART II - INDUSTRIAL LEADERSHIP

2. ACCESS TO RISK FINANCE

Horizon 2020 will set up two facilities (the 'Equity facility' and the 'Debt facility'), composed of various windows. The Equity facility and the SME window of the Debt facility will be implemented as part of two EU Financial Instruments that provide equity and debt to support SMEs' R&I and growth.

The Equity facility and the Debt facility may, where appropriate, allow pooling of financial resources with Member States willing to contribute part of the Structural Funds allocated to them, in accordance with Article 31(1)(a) of the Structural Funds Council Regulation.

Instead of providing loans, guarantees or equity, etc, directly to final beneficiaries, the Commission will delegate financial *or other appropriate* institutions to provide support via, in particular, risk-sharing, guarantee schemes and equity and quasi-equity investments.

The risk sharing financing schemes shall also target unsolved needs within policies and sectors, notably regarding the societal challenges, which are pressing but chronically underfinanced by the private sector due to high risk thresholds.

2.1. Debt facility

The Debt facility will provide loans to single beneficiaries for investment in R&I; guarantees to financial intermediaries making loans to beneficiaries; combinations of loans and guarantees; and guarantees and/or counter-guarantees for national or regional debt-financing schemes. The Debt facility will undertake maturity enhancement activities, and it will support the dedicated SME Instrument (see Part II, section '3. Innovation in SMEs' of this Annex). Provisions from the debt facility may be combined, with the possible addition of grants (including lump sums), with provisions from the equity financial instrument in one or more integrated schemes. Soft loans and convertible loans may also be possible.

As well as providing loans and guarantees on a market-driven, first-come, first-served basis, the debt facility will target, under a series of compartments, particular policies and sectors. Ring-fenced budgetary contributions for this purpose may come from:

- (a) Other parts of Horizon 2020;
- (b) other frameworks, programmes and budget lines in the Union budget;
- (c) particular regions and Member States that wish to contribute with resources available from the Cohesion Policy funds;

- (d) specific entities (such as Eureka or Joint Technology Initiatives) or initiatives.

Such budgetary contributions may be made or topped up at any time during the course of Horizon 2020.

Risk-sharing and other parameters may vary within policy or sector compartments, provided their values or states comply with the common rules for debt instruments. Furthermore, compartments may have specific communications strategies within the overall promotional campaign for the Debt facility. In addition, specialist intermediaries at national level may be used if specific expertise is needed to assess prospective loans in the domain of a particular compartment.

The European Investment Fund, managing the Debt facility on behalf of the Commission, may have a limited mandate to lend to projects carrying a high technological risk and not merely to offer below-market-rate loans to projects with a low technological risk. This mandate, however, will be subject to strict portfolio and project risk management criteria and appropriate risk return criteria and oversight.

The SME window under the Debt facility shall target R&I-driven SMEs with loan amounts exceeding EUR 20%⁸, thus complementing finance to SMEs by the Loan Guarantee Facility under the Programme for the Competitiveness of Enterprises and SMEs.

The leverage of the Debt facility — defined as the total funding (i.e. Union funding plus contribution from other financial institutions) divided by the Union financial contribution — is expected to range from an average 1.5 to 6.5, depending on the type of operations involved (level of risk, target beneficiaries, and the particular debt financial instrument facility concerned). The multiplier effect — defined as the total of investments made by supported beneficiaries divided by the Union financial contribution — is expected to be 5 to 20, again depending on the type of operations involved.

2.2. Equity facility

The Equity facility will focus on early-stage venture capital funds providing venture capital and/or mezzanine capital to ***early-stage*** individual portfolio enterprises. These enterprises may, in addition, seek debt financing from financial intermediaries implementing the Debt facility.

The equity facility will also support knowledge and technology transfer processes at the stages prior to the industry uptake phase with the aim of verifying and, where appropriate, increasing the innovatory market impact of the transfer.

The facility will also have the possibility to make expansion and growth-stage investments in conjunction with the Equity Facility for Growth (EFG) under the

⁸ *The final amount will be in line with the one agreed in the COSME programme.*

Programme for the Competitiveness of Enterprises and SMEs (this includes investments in *public and private* funds-of-funds with a broad investor base and includes private institutional and strategic investors as well as national public and semi-public financial institutions). In the latter case, the investment from the Equity Facility of Horizon 2020 shall not exceed 20 % of the total EU investment except in cases of multi-stage funds, where funding from EFG and the equity facility for RDI will be provided on a pro rata basis, based on the funds' investment policy. Like the EFG, the Equity Facility shall avoid buy-out or replacement capital intended for the dismantling of an acquired enterprise. The Commission may decide to amend the 20% threshold in light of changing market conditions.

Investment parameters will be set in such a way that specific policy objectives, including the targeting of particular groups of potential beneficiaries, can be achieved while still preserving the market-oriented, demand-driven approach of this instrument. The Equity facility may be supported by budgetary contributions from other parts of Horizon 2020; other frameworks, programmes and budget lines in the Union budget; particular regions and Member States; and specific entities or initiatives.

The leverage of the Equity facility — defined as the total funding (i.e., Union funding plus contribution from other financial institutions) divided by the Union financial contribution — is expected to be around 6, depending on market specificities, with an expected multiplier effect — defined as the total of investments made by supported beneficiaries divided by the Union financial contribution — of, on average, 18.

2.3. Specific implementation aspects

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Annex 1 - PART II - INDUSTRIAL LEADERSHIP

3. INNOVATION IN SMEs

3.1. Support to SMEs through a dedicated SME instrument

SMEs will be supported across Horizon 2020. For this purpose a dedicated SME instrument is targeted at all types of *innovation in* SMEs showing a strong ambition to develop, grow and internationalise. It will be provided for all types of innovation, including non-technological and service innovations. The objective is to help filling the gap in funding for early stage high risk research and innovation, stimulate breakthrough innovations and increase private-sector commercialisation of research results.

Successful participation in the SME instrument should constitute a quality label for the SME participants facilitating access to public procurement.

The dedicated SME instrument will be used in all the societal challenges and the enabling and industrial technologies.

Only SMEs will be allowed to apply for funding and support. They can form collaborations according to their needs, including for subcontracting research and development work. Projects must be of clear interest and potential benefit to SMEs and have a distinct European dimension.

The SME instrument will cover all fields of science, technology and innovation in a bottom-up approach ***with open calls*** within a given societal challenge or enabling technology so as to leave sufficient room for all kinds of promising ideas, notably cross-sector and inter-disciplinary projects, to be funded.

The SME instrument will provide simplified and staged support. Its three phases will cover the whole innovation cycle. Transition from one phase to the next will be seamless provided the SME project has proven to be worth further funding during a previous phase. ***SMEs can apply directly to Phase 2, independently from Phase 1.*** At the same time each phase will be open to all SMEs:

- Phase 1: Concept and feasibility assessment:

SMEs will receive funding to explore the scientific or technical feasibility and the commercial potential of a new idea (proof of concept) in order to develop an innovation project. A positive outcome of this assessment will allow for funding under the following phase(s).

- Phase 2: R&D, demonstration, market replication:

The full range of research and development ***and innovation activities*** will be supported ***through an Innovation Voucher which SMEs can use to work***

individually or with one or more research performers (universities, research centres or other companies in another Member State or Associated Country). Although a particular focus will be given to demonstration activities (testing, prototype, scale-up studies, design, piloting innovative processes, products and services, performance verification etc.) and market replication, R&D activities are also possible.

- Phase 3: Commercialisation:

This phase will not provide direct funding other than support activities, but aims to facilitate access to private capital and innovation enabling environments. Links to the financial instruments (see Part II, section 2 'Access to Risk Finance of this Annex) are foreseen, for example by giving SMEs that have successfully completed phases 1 and/or 2 priority within a ring-fenced volume of financial resources. SMEs will also benefit from support measures like networking, training, coaching and advice. In addition this part may connect to measures promoting pre-commercial procurement and procurement of innovative solutions.

The SME instrument may also serve as an instrument for pre-commercial procurement or procurement of innovative solutions for specific top-down identified common need of EU public procurers in Europe.

Uniform promotion, implementation and monitoring of the SME instrument across Horizon 2020 will ensure easy access for SMEs. *To provide a single entry point for SMEs, the SME instrument shall be implemented by a single body such as a specialised executive agency.* Relying on existing SME support networks *and other innovation service providers and* a mentoring scheme for the beneficiary SMEs shall be established to accelerate impact from the support provided.

A dedicated body of stakeholders and experts in SME research and innovation will be set up with view to promoting and accompanying the specific SME measures of Horizon 2020.

3.2. Specific support

3.2.1. Support for research intensive SMEs

A specific action will promote market-oriented innovation of R&D performing SMEs. It targets research intensive SMEs in high-technology sectors that also need to demonstrate their capability to commercially exploit the project results.

The action will cover the entire field of science and technology with a bottom-up approach to fit the needs of R&D performing SMEs.

The action will be implemented by an Article 185 TFEU initiative building on the *Eurostars* Joint Programme and reorienting it along the lines stated in its interim evaluation.

3.2.2. *Mainstreaming SME support and enhancing the innovation capacity of SMEs*

Activities assisting the implementation and complementing the SME specific measures across Horizon 2020 will be supported, notably to enhance the innovation capacity of SMEs. Activities may include awareness raising, information and dissemination, training and mobility activities, networking and exchange of best practices, developing high quality innovation support mechanisms and services with strong Union added value for SMEs (e.g. intellectual property and innovation management, knowledge transfer, innovative use of ICT and e-skills in SMEs), as well as assisting SMEs to connect to research and innovation partners across the Union, allowing them to spin in technology and develop their innovation capacity **and their capacity to incorporate innovations and transform research results into innovative products, processes and services.**

Intermediary organisations representing groups of innovative SMEs shall be invited to conduct cross-sectoral and cross-regional innovation activities with SMEs having mutually reinforcing competences, in order to develop new industrial value chains.

In addition, enhanced participation of SMEs in the governance of the programme in particular the participation in the setting of research agendas and implementation of the public-private partnerships shall be promoted throughout Horizon 2020.

Synergies with Union cohesion policy will be sought in the context of national and regional innovation strategies for smart specialisation. ***These synergies may also build on the bottom-up national and regional experience of Eureka and Eurostars in supporting SME innovation and research activities.***

A reinforced link with the Enterprise Europe Network (under the Programme for the Competitiveness of Enterprises and SMEs) is envisaged. The support could range from improved information and advisory services through mentoring, coaching and partner search activities for SMEs wishing to develop cross-border innovation projects, to providing innovation support services. This will consolidate the 'one stop shop' approach of the Enterprise Europe Network to supporting SMEs, together with a strong regional and local presence of the network.

3.2.3. *Supporting market-driven innovation*

This will support market-driven innovation in view of enhancing the innovation capacity of firms by improving the framework conditions for innovation as well as tackling the specific barriers preventing the growth of innovative firms, in particular SMEs and enterprises of intermediate size with potential for fast growth. Specialised innovation support (on e.g. ***support in registering IP and IP*** exploitation, networks of procurers, support to technology transfer offices, strategic design, ***cluster development***) and reviews of public policies in relation to innovation will be supported.

3.2.3a – Supporting the transfer of knowledge and technology between public research and the market

The objective is to support the transfer processes between the sphere of public research and innovative SME, as an effective mechanism for the market transfer of research results and inventions generated by universities and research centres.

PART III - SOCIETAL CHALLENGES

Science with and for Society: a cross-cutting challenge

In order to build an effective dialogue between science and society, to recruit new talent for science and to pair scientific excellence with social awareness and responsibility the following activities will be supported. These actions should complement existing actions at Members States level and are horizontal to the whole Horizon 2020.

- *Attractive scientific and technological careers for young students: Promoting scientific careers in the **fields of science, technology and engineering in schools; opening up universities for young students; fostering sustainable interaction between schools and research institutions, and between students and their families, science teachers and researchers.***

- *Gender equality in its both dimensions: ensuring gender equality in research careers and decision-making and including gender considerations in the research development. Promotion of gender equality in particular by supporting changes in the organisation of research institutions and in the content and design of research activities.*

- *Integration of society in science and innovation issues: Enable all societal actors to engage in the research and innovation cycle and promote trans-disciplinary research and innovation in order to increase the quality, relevance, acceptability and sustainability of innovation outcomes by integrating society's interests and values; in particular support the participation of citizens and civil society organisations in research and innovation activities; promoting the interest of society in science and innovation issues; monitoring the perception of science by the citizens and supporting their participation in issues related to the development of science and technology.*

- *Encourage citizens to engage in science: A scientifically literate, responsible and creative society will be nurtured through the promotion of and research on appropriate science education methods, **contributing to better formal and informal science and technology education, to project-based science activities and to the networking of scientists and non-scientists at national, European and international level.***

- *Open access to scientific results and data in order to augment scientific excellence and economic competitiveness: Promotion of a single data base with all European funded research projects. National and regional funding authorities will be encouraged to share the same information on national/regional projects. The inclusion of scientific data in this database will be promoted.*

- *Governance for the development of responsible research and innovation: Shaping governance for the development of responsible research and innovation by engaging all stakeholders (researchers, public authorities, industry), fostering the*

role of scientific expertise in decision-making processes, namely the participation of scientists and independent research organisations in societal controversies and in risk-governance related issues. An Ethics Framework for research and innovation, based on the fundamental ethical principles - including those *enshrined* in the Charter of Fundamental Rights and all the relevant Union laws and Conventions - will be promoted in coordination with relevant international organisations. *The opinion of the European Group of Ethics in Science and New Technologies should be considered.*

- Knowledge on science communication: In order to improve knowledge circulation within the scientific community and the wider public, the accessibility and use of the results of publicly funded research will be further developed. This will increase knowledge on science communication in order to improve the quality and effectiveness of interactions between scientists, the media and the public and promote wider participation of citizens as active stakeholders and, whenever possible and appropriate, as participants of research.

CA 21 - EPP - S&D - ALDE - ECR - Greens - GUE

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PART III - SOCIETAL CHALLENGES

1. HEALTH, DEMOGRAPHIC CHANGE AND WELLBEING

Effective health promotion, supported by a robust evidence base, prevents disease, improves wellbeing, *reduces disability, dependency and social exclusion and* is cost effective. Health promotion and disease prevention also depend on an understanding of the determinants of health, on effective preventive tools, such as vaccines, on effective health and disease surveillance and preparedness, and on effective screening programmes, *and on better and integrated patient-centred health care delivery. The cultural, social, behavioural and psychological dimensions of health shall also be taken into account. Social sciences and humanities thus have an important role to play in understanding health and wellbeing.*

Successful efforts to prevent, manage, treat and cure disease, disability and reduced functionality *as well as the study of living standard of elderly citizens* are underpinned by the fundamental understanding of their causes, processes and impacts, as well as factors underlying good health and wellbeing. Effective sharing of data and the linkage of these data with real-world large scale cohort studies is also essential, as is the translation of research findings into the clinic, in particular through the conduct of clinical trials.

An increasing disease, *particularly chronic disease*, and disability burden in the context of an aging population places further demands on health and care sectors, *but also in social innovation research and development.* If effective health and care is to be maintained for all ages, efforts are required to *improve and speed-up* decision making *and awareness-raising* in *disease* prevention and treatment provision, *rehabilitation and retraining* to identify and support the dissemination of best practice in the healthcare sector, and to support integrated care, *including interventions of complementary and alternative medicine and* the uptake of technological, organisational and social innovations empowering older persons in particular to remain active and independent, *in full respect for their health care choices.* Doing so will contribute to increasing, and lengthening the duration of their physical, social, *economic* and mental well-being. *Special attention should be devoted to chronic diseases, such as cancer, cardiovascular, rheumatic and musculoskeletal, diabetes, respiratory and mental diseases.*

All of these activities will be undertaken in such a way as to provide support throughout the research and innovation cycle, ***including support for excellent basic research in health***, strengthening the competitiveness of the European based industries ***and SMEs*** and development of new market opportunities, ***based on an integrated and patient-centred approach***.

Programmes and projects under this topic should coordinate their research programmes with and take advantage of ESFRI research infrastructures. In order to foster strategic coordination of health research and innovation across Horizon 2020 and promote transnational medical research, the corresponding Strategic Scientific Panel for Health will be established. This co-ordinated, European effort will increase the scientific and human capabilities in health research.

1.1. Understanding the determinants of health, improving health promotion and disease prevention

A better understanding of the determinants of health is required in order to provide evidence for effective health promotion, ***wellbeing*** and disease prevention, and will also allow the development of comprehensive health and wellbeing indicators in the Union ***and worldwide***. Environmental, ***occupational***, behavioural (including life-style), ***biological, genetic***, socio-economic, ***pathogen*** and genetic factors, in their broadest senses will be studied. Approaches will include the long term study of cohorts and their linkage with data derived from ‘-omics’ research, and other methods.

In particular, a better understanding of the environment as a determinant of health will require integrated ***and human-relevant*** molecular biological, epidemiological and toxicological approaches to investigate health-environment relationships ***and to elucidate the underlying mechanisms of illness and human toxicity***, including studies of modes of action of chemicals, combined exposures to pollution and other environmental and climate related stressors, integrated toxicological testing as well as alternatives to animal testing. Innovative approaches to exposure assessment are needed using new-generation ***and human-relevant*** biomarkers based on ‘omics’ and epigenetics, human biomonitoring, personal exposure assessments and modelling to understand combined, cumulative and emerging exposures, integrating socio-economic and behavioural factors. Improved links with environmental data using advanced information systems will be supported.

In this way, existing and planned policies and programmes can be assessed and policy support provided. Similarly, improved behavioural interventions, prevention and education programmes can be developed including those pertaining to health literacy in nutrition, vaccination and other primary care interventions. ***‘Health-in-all’ approaches (such as those addressing the environment and the work place) can likewise be developed in order to minimise risk factors.***

1.2. Developing effective screening programmes and improving the assessment of disease susceptibility

The development of screening programmes depends on the identification of early biomarkers of risk and of disease onset, and their deployment depends on the testing and validation of screening methods and programmes. Identifying individuals and

populations at high-risk of disease will allow personalised, stratified and collective strategies for efficacious and cost effective disease prevention to be developed.

1.3. Improving surveillance and preparedness

Human populations are under threat from new and emerging infections (including those resulting from climate change), from drug resistance to existing pathogens and from other direct and indirect consequences of climate change. ***Predictive mathematical theories and improved methods for surveillance, early warning networks, health service organisation and preparedness campaigns are needed for the modelling of epidemics, for effective pandemic response, for responses to non infectious disease consequences of climate change, as are efforts to maintain and enhance capabilities to combat drug resistant infectious disease. In order to face up to these global challenges, the EU will, in partnership with the countries concerned, implement measures aimed at achieving concrete results in health policy, improving health care services and supporting their own research capacity.***

1.4. Understanding disease

There is a need for an improved understanding of health and disease, in people of all ages, so that new and better prevention measures, diagnosis and treatments can be developed. ***Fundamental excellent research and interdisciplinary***, translational research on the patho-physiology of disease is essential to improve the understanding of all aspects of disease processes, including a re-classification of normal variation and disease based on molecular data, and to validate and use research results in clinical applications.

Underpinning research will encompass and encourage development and use of new tools and approaches for the generation of biomedical data and include "-omics", high throughput and systems medicine approaches. These activities will demand close linkage between fundamental and clinical research and with long term cohort studies (and the corresponding research domains) as described above. Close links with research and medical infrastructures (databases, bio-banks etc.) will also be required, for standardisation, storage, sharing and access to data, which are all essential for maximising data utility and for stimulating more innovative and effective ways of analysing and combining datasets.

1.5. Developing new and better preventive vaccines and drugs

There is a need for more effective ***drugs and*** preventive vaccines (or alternative preventive interventions) and evidence-based vaccination schemes for an expanded range of diseases, ***including poverty-related diseases such as HIV/AIDS, tuberculosis, malaria and neglected diseases.*** This relies on a better understanding of disease and disease processes and their consequent epidemics and that clinical trials and associated studies are undertaken.

1.6. Improving diagnosis

An improved understanding of health, disease and disease processes at all ages is needed to develop new and more effective diagnostics, ***including in vitro and image***

diagnostics. Innovative and existing technologies will be developed *so that they can be adapted to different environmental and socio-economic conditions*, with the goal of *ensuring (detection)* earlier, more accurate diagnosis and by allowing for *better and more accessible* patient-adapted treatment *in the pre-hospital as well as in hospital phase*. *Mutations causing genetic diseases will be identified and the availability of diagnostic tests will be significantly increased.*

1.7. Using in-silico medicine for improving disease management and prediction

(...)

1.8. Developing adapted treatments and treating disease

There is a need to support the improvement of cross-cutting support technologies for drugs, *biotherapies*, vaccines and other therapeutic approaches, including transplantation, gene and cell therapy ; to increase success in the drug and vaccine development process (including alternative methods to replace classical safety and effectiveness testing e.g. the development of new methods); to develop regenerative medicine approaches, including approaches based on stem cells; to develop improved medical and assistive devices and systems; *to improve palliative therapies*; to maintain and enhance our ability to combat communicable, *poverty-related, neglected*, rare, major and chronic diseases and undertake medical interventions that depend on the availability of effective antimicrobial drugs; and to develop comprehensive approaches to treat co-morbidities at all ages and avoid poly-pharmacy. These improvements will facilitate the development of new, more efficient *and adapted*, effective and sustainable treatments for disease and for the management of disability, *both outside and inside hospital*. *Research shall make it possible to improve advanced therapies and cellular therapies. This shall be focused on the treatment of chronic diseases.*

1.9. Transferring knowledge to clinical practice and scalable innovation actions

Clinical trials are the means to transfer biomedical knowledge to application in patients and support for these will be provided, as well as for the improvement of their practice. Examples include the development of better methodologies to allow trials to focus on relevant population groups, including those suffering from *rare diseases* other concomitant diseases and/or already undergoing treatment, the determination of comparative effectiveness of interventions and solutions, as well as enhancing the use of databases and electronic health records as data sources for trials and knowledge transfer. *Specific support should be ensured for the preclinical and/or clinical development of substances with a clear potential to address largely unmet medical needs, such as designated orphan drugs*. Similarly, support for the transfer of other types of interventions such as those related to independent living into real world environments will be provided. *Ethical principles, and in particular the Helsinki Declaration, require that data from all research activity carried out on humans be made public.*

1.10. Better collection and use of health *data and standardised data analysis techniques*

The integration of infrastructures and information structures and sources (including those derived from cohort studies, protocols, data collections, indicators, etc.) as well as the standardisation, interoperability, storage, sharing of and access to data, will be supported to enable such data to be properly exploited. Attention should be given to data processing, knowledge management, modelling and visualisation *as well as to mechanisms ensuring the long-term sustainability of such infrastructures in order to make the best use of resources.*

1.11. Improving scientific tools and methods to support policy making and regulatory needs

There is a need to support the development, *the integration and use* of scientific tools, methods and statistics for rapid, accurate and predictive assessment of the safety, efficacy and quality of health technologies including new drugs, biologics, advanced therapies and medical devices. This is particularly relevant for new developments in domains including those concerning vaccines, cell/tissue and gene therapies, organs and transplantation, specialist manufacturing, bio banks, new medical devices, diagnostic/treatment procedures, genetic testing, interoperability, *telemedecine* and e-health, including privacy aspects. Similarly, support for improved risk assessment methodologies, testing approaches and strategies relating to environment and health are required, *including more predictive and efficient pre-clinical safety assessments (e.g. consistency approach together with other non-animal or reduction approaches)*. There is also a need to support the development of relevant methods for assisting the assessment of ethical aspects of the above domains.

1.12. Healthy and active ageing, independent and assisted living

(...)

1.13. Individual empowerment for self-management of health

Empowering individuals to improve and manage their health throughout life will result in cost savings to healthcare systems by enabling the management of chronic disease outside institutions and improve health outcomes. This requires research into behavioural and social models, social attitudes and aspirations in relation to personalised health technologies, mobile and/or portable tools, new diagnostics and personalised services which promote a healthy lifestyle, wellbeing, self-care, improved citizen/healthcare professional interaction, personalised programmes for disease and disability management, *to enhance patients' personal and social autonomy*, as well as support for knowledge infrastructures.

1.14. Promoting integrated care including psychosocial aspects

Supporting the management of chronic disease *and conditions* outside institutions also depends on improved cooperation between the *patients and the* providers of health, social or informal care, Research and innovative applications will be supported for decision making based on distributed information, and for providing evidence for large scale deployments and market exploitation of novel solutions, including interoperable tele-health and tele-care services. Research and innovation to improve the organisation of long-term care delivery *and public health system* will also be supported. *Interdisciplinary research in social sciences is also needed to provide the most suitable solutions for addressing the needs of the patients in their everyday life*

and to contribute to their empowerment, especially for patients living with chronic conditions, such as rare disease patients.

1.15. Optimising the efficiency and effectiveness of healthcare systems and reducing inequalities through evidence based decision making and dissemination of best practice, and innovative technologies and approaches.

(...)

1.15b. Developing simulation-based medical devices

The drop in costs of sequencing and other –omics technologies as well as the availability of high power computing allows in the near future for the first time the development of mechanistic, computer-based simulation models and its implementing medical devices, which will support treatment decision of physician based on evidence and prior simulation before use as well as new and cheaper drug development technologies. Precision medicines become possible with the ultimate goal of curing diseases not only treating and reducing the growth rate of health care spending.

1.15c (new) Promoting personalised medicine for severe disease

Personalised medicine must be developed in order to generate new preventive and therapeutic strategies which can be adjusted to patient requirements, so as to increase the prevention and early detection of diseases. The factors which influence therapeutic decision-making must be identified, further elucidated and developed through research.

1.16. Specific implementation aspects

Support provided will cover the full spectrum of activities from *capacity building*, knowledge and technology transfer (*including health policy*), *implementation, monitoring and assessment of* large scale demonstration actions, leading to scalable solutions for Europe and beyond.

It is widely recognized that coordinated and strategic planning of health research is urgently needed in order to tackle the major health challenges facing Europe. Coordination can address fragmentation and improve the use of technological and infrastructural resources by the entire biomedical research community. Success and innovation in health research moreover requires a long-term commitment to sustain excellent research.

Strategic action and high-level scientific assistance can ensure expert input on policy from the outset, advance innovation and competitiveness by understanding the complexity of the innovation cycle, encourage participation from more researchers across borders and science-based savings for national health systems.

As a first step, the Strategic Scientific Panel for Health research will be established in order to respond to the urgent need of fostering strategic scientific coordination of health research across Horizon 2020 and of promoting translational medical research. Such strategic coordination will aim at contributing to defining biomedical research and translation programmes based upon the best scientific

leadership and that should ensure expert scientific input on policy from the outset and warrant cost-effectiveness for national health systems. Strategic scientific coordination will also aim at attracting other areas of scientific and technological research to the opportunities provided by modern biomedical research.

By establishing Horizon 2020 internal strategic coordination across health research issues, based upon top-level scientific advisory, the Strategic Scientific Panel will also provide the impetus and instruments needed to promote interaction and synergies at a larger scale. Voluntary convergence among national funding agencies, and with the Commission, on specific objectives, whenever appropriate, as well as strategic specific partnership, at Union level, between industry, national agencies and the Commission and strategic convergence at programme level involving regulatory bodies and national health authorities will be pursued.

CA 22 - EPP - S&D - ALDE - ECR - Greens - GUE
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ENVI77 - ENVI78 - ENVI79 - ENVI80 - ENVI81 - ENVI82

PART III - SOCIETAL CHALLENGES

2. **FOOD QUALITY, SECURITY AND SAFETY, SUSTAINABLE AGRICULTURE AND FORESTRY, MARINE AND MARITIME RESEARCH AND BIO-BASED INDUSTRIES**

2.1. **Sustainable and competitive agriculture, livestock farming and forestry**

Appropriate knowledge, *knowledge transfers*, tools, services and innovations are necessary to support more productive, resource-efficient, *resource-protecting* and resilient agriculture and forestry systems that supply sufficient food, feed, biomass and other raw-materials, deliver *and maintain* ecosystems services while at the same time *preserving* the *natural resource base, biodiversity and support (deletion)* of thriving rural livelihoods, *safeguarding consumer health and reducing the environmental impact. The aim is that of establishing food production systems that strengthen, reinforce and nourish the resource base, which would allow sustainable wealth generation.* Research and innovation will provide options for integrating agronomic and environmental goals into *more* sustainable production, *such as*: increasing productivity and resource efficiency of agriculture; reducing agricultural greenhouse gases (GHGs) emissions; reducing leaching of nutrients from cultivated lands into terrestrial and aquatic environments; decreasing dependence from international plant derived protein imports to Europe; *understanding the complex relationship of agriculture and forestry with the hydrologic cycle; improving (deletion) agricultural systems and landscapes, recycling of nutrients and organic matter and preserving water and soil resources, thereby improving adaptive capacities of farmers with regard to climate change and uncertainties.*

2.1.1. *Increasing production efficiency and coping with climate change, while ensuring sustainability and resilience*

Activities will enhance productivity as well as the adaptive capacity of plants, animals and production systems to cope with rapidly changing environmental/climatic conditions and increasingly scarce natural resources, *especially water*. The resulting innovations *and their transfer to all economic actors involved* will help to move towards a low energy, low emission, *low external input* and low waste economy, along the entire food and feed supply chain. In addition to contributing to food security *and consumer health*, new opportunities will be created for the use of biomass and by-products from agriculture and forestry for a wide range of non-food applications.

Multi *and trans*-disciplinary approaches *along the whole supply chain* will be sought to improve the performance of plants, animals, micro-organisms, while ensuring

efficient resource use (water, *soil*, nutrients, energy), *the quality of production* and the ecological integrity *and vitality* of rural areas. Emphasis will be placed on integrated and diverse production systems and agronomic practices, including the use of precision technologies and ecological intensification approaches to benefit *all types of agriculture*. *The appropriate use of treated wastewater as a means of increasing production efficiency must be considered. Reducing leaching of nutrients from cultivated lands into terrestrial and aquatic environments, avoiding diffuse pollution through groundwater returning to surface water bodies, is particularly important.*

Genetic improvement of plants and animals for adaptation and productivity traits will call for all appropriated conventional and modern breeding approaches and for a better use *and conservation* of genetic resources, *opening avenues for the production of new and diversified products (food, feed, materials, energy), which meet the increasing demand for low-carbon short-chain delivery systems*. Due attention will be given to on-farm soil management for increasing soil fertility as a basis for crop productivity. Animal and plant health will be promoted and integrated disease/pest control measures will be further developed.

Strategies for the eradication of animal diseases including zoonoses will be tackled along with research on antimicrobial resistance. Studying the effects of practices on animal welfare will help meet societal concerns. The above listed areas will be underpinned by more fundamental research to address relevant biological questions as well as to support the development and implementation of Union policies *and Europe's leading role in global initiatives*.

2.1.2. Strengthening multi-functionality of agriculture, including (deletion) ecosystem services and public goods

Agriculture and forestry are unique systems delivering commercial products but also wider societal public goods (including cultural and recreational value) and important ecological services such as functional and in-situ biodiversity, pollination, water *storage and* regulation, landscape, *soil functionality*, erosion reduction, *resilience to floods and drought* and carbon sequestration / GHG mitigation. Research activities will support the provisions of these public goods and services, through the delivery of management solutions, decision-support tools and the assessment of their non-market value. Specific issues to be dealt with include the identification of farming/forest systems and landscape patterns likely to achieve these goals. *Socio-economic and comparative assessment of farming/forestry systems and their sustainability performance will be addressed*. Shifts in the active management of agricultural systems - including the use of technologies and change of practices - will increase GHG mitigation and the adaptive capacity of the agriculture sector to the adverse effects of climate change. *This also calls for integrated water management and alternative sources (e.g. treated wastewater) for irrigation (agriculture, landscape and forestry), environmental restoration/enhancement, forest-fire fighting and public water supply.*

2.1.3. Empowerment of rural areas, support to policies and rural innovation

Development opportunities for rural communities will be mobilised by strengthening their capacity for primary production and delivery of eco-systems services as well as

by opening avenues for the production of new and diversified products (food, feed, materials, energy), which meet the increasing demand for low-carbon short-chain delivery systems. Socio-economic research along with the development of new concepts and institutional innovations is needed to ensure cohesion of rural areas and prevent economic and social marginalisation, foster diversification of economic activities (including service sector), ensure appropriate relations between rural and urban areas, as well as facilitate knowledge exchange, demonstration, innovation and dissemination and foster participatory resource management. Also, there is a need to look at ways in which public goods in rural areas can be converted into local/regional socio-economic benefits. Innovation needs defined at regional and local levels will be complemented by cross-sectoral research actions at inter-regional and European levels. By providing the necessary analytical tools, indicators, models and forward looking activities, research projects will support policy makers and other actors in the implementation, monitoring and assessment of relevant strategies, policies and legislation, not only for rural areas but for the whole bio-economy. Tools and data are also required to allow for proper assessment of potential trade-offs between various types of resource use (land, water and other inputs) and bio-economy products. Socio-economic and comparative assessment of farming/forestry systems and their sustainability performance will be *assessed using social, economic and ecologic criteria*.

2.2. Sustainable and competitive agri-food sector for a safe, affordable and healthy diet

Consumer needs for safe, healthy and affordable food have to be addressed, while considering the impacts of food consumption behaviour and food and feed production on human health and the total ecosystem. Food and feed security and safety, the competitiveness of the European agri-food industry and the sustainability of food production and supply will be addressed, covering the whole food chain and related services, whether conventional or organic, *for all types of farming and products*, from primary production to consumption. *Competitiveness can be defined on various levels, and the aim is to achieve systems which also enable farmers to be competitive on a local and regional level. There should be coherence in the Union's approach so that striving for competitiveness on a global market should not run contrary to Union efforts and funding to create vibrant local economies and short food production and supply chains.*

This approach will contribute to (a) achieving food safety and security for all Europeans and eradication of hunger in the world (b) decreasing the burden of food- and diet-related diseases *and obesity* by promoting the shift towards healthy and sustainable diets, via consumer education and innovations in the *agriculture and* food industry (c) reducing water and energy consumption in food processing, transport and distribution and (d) reducing food waste by 50 % by 2030 *and (e) achieving a broad diversity of healthy, authentic, high quality and safe food for all.*

2.2.1. *Informed consumer choices (...)*

2.2.2. *Healthy and safe foods and diets for all (...)*

2.2.3. *A sustainable and competitive agri-food industry*

The needs for the food and feed industry to cope with social, environmental, climate and economic change from local to global will be addressed at all stages of the food

and feed production chain, including **agricultural production**, food design, processing, packaging, process control, **water reuse**, waste reduction, by-product valorisation and the safe use or disposal of animal by-products. Innovative and sustainable resource-efficient processes and diversified, safe, **healthy**, affordable and high quality products will be generated. This will strengthen the innovation potential of the European food supply chain, enhance its competitiveness, create economic growth and employment and allow the European food industry to adapt to changes. Other aspects to address are traceability, logistics and services, socio-economic factors, the resilience of the food chain against environmental and climate risks, and the limitation of negative impacts of food chain activities and of changing diets and production systems on the environment.

2.3. Unlocking the potential of fisheries, aquaculture and marine biotechnologies

One of the main features of living aquatic resources is that they are renewable and their sustainable exploitation relies on in depth understanding and a high degree of quality and productivity of the aquatic ecosystems. The overall objective is to sustainably exploit aquatic living resources to **fulfil social needs, deliver** economic benefits/returns from Europe's oceans, **seas, rivers and other water bodies, while protecting biodiversity, ecosystem services and preserving the resource base**. This includes the need to optimise the sustainable contribution of fisheries and aquaculture to food security in the context of the global economy, **especially reducing** the heavy Union's dependence on seafood imports (approximately 60 % of total European sea food consumption depends on import and the Union is the world's largest importer of fisheries products), and to boost marine biotechnologies to fuel 'blue' growth. **Cross-cutting marine and maritime scientific and technological knowledge will be addressed with a view to unlock the potential of the seas and inland waters across the range of marine and maritime industries, while protecting the environment and adapting to climate change**. In line with current policy frameworks, research activities will underpin the ecosystem approach to the management and exploitation of natural resources, and the 'greening' of the sectors involved.

2.3.1. Developing sustainable and environmentally-friendly fisheries

The new Common Fisheries Policy, the Marine Strategy Framework Directive and the Union's Biodiversity Strategy call for European fisheries to be more sustainable, competitive, and environmentally-friendly. The move towards an ecosystem approach to fisheries management will require an in depth understanding of marine ecosystems **and rebuilding fish stocks by keeping them above the levels which can produce the maximum sustainable yield**. New insights, tools and models will be developed to improve understanding of what makes marine ecosystems healthy and productive and to assess, evaluate and mitigate the impact of fisheries on marine ecosystems (including deep sea). (...)

2.3.2. Developing sustainable and competitive European aquaculture

Sustainable aquaculture has a large potential for the development of healthy safe and competitive products tailored to consumer needs and preferences as well as for environmental services (bioremediation, land and water management, etc) and energy production but it needs to be fully realised in Europe. Knowledge and technologies will be strengthened in all aspects of domestication of established species and

diversification for new species while taking into account the interactions between aquaculture and the aquatic ecosystems, and the effects of climate change and how the sector can adapt to them. Innovation will also be promoted for sustainable production systems in inland, on the coastal zone and offshore. Emphasis will also be given to understanding the social, economic *and environmental* dimensions of the sector to underpin cost and energy efficient production matching with the market and consumer demands, while ensuring competitiveness and attractive prospects for investors and producers.

2.3.3. *Boosting marine innovation through biotechnology and protecting biodiversity (...)*

More than 90 % of the marine biodiversity remains unexplored, offering a huge potential for discovery of new species and applications in the field of marine biotechnologies, which is foreseen to generate a 10 % annual growth for this sector. Support will be given to further explore the large potential offered by marine biodiversity and aquatic biomass to bring innovative *and sustainable* processes, products and services on the markets with potential applications in sectors including chemical and material industries, pharmaceutical, fisheries and aquaculture, energy supply and cosmetic. ***Environmental concerns regarding the use of biotechnology in open marine ecosystems have to be carefully taken into account.***

2.4. Sustainable and competitive bio-based

(...)

2.4.1. *Fostering the bio-economy for bio-based industries*

Major progress towards low carbon, resource efficient and sustainable industries will be supported through discovery and exploitation of terrestrial and aquatic biological resources, while minimising adverse environmental impacts. Potential trade-offs between the various uses of biomass should be ***carefully assessed, in particular ensuring that new uses of biomass does not jeopardise food production and security, does not lead to unsustainable land-use conversion or land-grabbing practices.*** The development of bio-based products and biologically active compounds for industries and consumers with novel qualities, functionalities and improved sustainability will be targeted. The economic value of renewable resources, bio-waste and by-products will be maximised through new and resource efficient processes.

2.4.2. *Developing integrated biorefineries*

Activities will be supported to boost sustainable bioproducts, intermediates and bioenergy/biofuels, predominantly focussing on a cascade approach, prioritising the generation of high added-value products. Technologies and strategies will be developed to assure the raw material supply. Enhancing the ***availability, range and characteristics*** of types of biomass for use in second and third generation biorefineries, including ***agriculture, horticulture***, forestry, biowaste and industrial by-products, will help avoid food/fuel conflicts and support economic development of rural and coastal areas in the Union.

2.4.3. *Supporting market development for bio-based products and processes*

Demand-side measures will open new markets for biotechnology innovation. Standardisation at Union and international levels is needed for, amongst others,

determination of bio-based content, *resource use efficiency (land, water, nutrients)*, product functionalities and biodegradability. Methodologies and approaches to *lifecycle* analysis need to be further developed and continuously adapted to scientific and industrial advances. Research activities supporting product and process standardisation, *public procurement* and regulatory activities in the field of biotechnology are considered essential for supporting the creation of new markets and for realising trade opportunities.

2.4a. Cross-cutting marine and maritime research

2.4a.1. Climate change impact on marine ecosystems and maritime economy

Activities will be supported to increase the current understanding of the functioning of marine ecosystems, the interactions between oceans-atmosphere. This will increase the ability to assess the role of the oceans on climate and the impact of climate change and ocean acidification on marine ecosystems and coastal areas.

2.4a.2. Develop the potential of marine resources through an integrated approach

Boosting long-term, sustainable maritime growth and create synergies across all the maritime sectors requires an integrated approach. Research activities will focus on preserving the marine environment as well as the impact of maritime activities and products on non-maritime sectors. This will allow advances in the field of eco-innovation such as new products, processes and the application of management concepts, tools and measures to assess and mitigate the impact of human pressures on the marine environment in order to advance towards a sustainable management of maritime activities

2.4a.3. Cross-cutting concepts and technologies enabling maritime growth

Advances in cross-cutting enabling technologies (e.g. ICT, electronics, nanomaterials, alloys, biotechnologies, etc) and new developments and concepts in engineering will continue to enable growth. Activities will allow major breakthroughs in the field of marine and maritime research and ocean observation (e.g. deep-sea research, observing systems, sensors, automated systems for monitoring of activities and surveillance, screening marine biodiversity, marine geohazards, Remotely Operated Vehicles, etc). The aim is to reduce the impact on the marine environment (e.g. underwater noise, introduction of invasive species and pollutants from sea and land, etc) and minimize the carbon foot-print of human activities. Cross-cutting enabling technologies will underpin the implementation of marine and maritime Union policies.

2.5. Specific implementation actions

Beyond the general sources of external advice, specific consultations will be sought from the Standing Committee on Agricultural Research (SCAR) on a range of issues, including on strategic aspects through its foresight activity and on the coordination of agricultural research between national and Union levels. Appropriate links will be

established with the actions of the European Innovation Partnership 'Agricultural Productivity and Sustainability'. *The roadmap of the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD), developed in open partnership with multi-stakeholder organisations, including FAO, GEF, UNDP, UNEP, UNESCO, the World Bank, and the WHO, will be also guiding the development of specific work programmes under this challenge.*

The impact and dissemination of research results will be actively supported through specific actions on communication, knowledge *and technology* exchange and the involvement of various actors all along the projects. Implementation will combine a wide range of activities, including substantial demonstration and pilot activities. Easy open access to research results and best practices will be fostered, where appropriate via databases.

The specific support to SMEs will allow for an increased participation of farms, fishermen and other types of micro-enterprises in research and demonstration activities. The specific needs of the primary production sector for innovation support services and outreach structures will be taken into account. Implementation will combine a wide range of activities, including knowledge exchange actions where the involvement of farmers and intermediaries will be actively ensured in view of summarising the research needs of end-users. Easy open access to research results and best practices will be fostered.

Support to standard setting will be used to help accelerate market deployment for novel bio-based goods and services *ranging from terrestrial and aquatic production systems through to the end-consumer.*

Consideration may be given to support to the Joint Programming Initiatives (JPIs) including 'Agriculture, Food Security and Climate Change'; 'A Healthy Diet for a Healthy Life'; and 'Healthy and Productive Seas and Oceans' and to implementing possible public-private partnerships in the field of bio-based industries.

Synergies with and further deployment by other Union funds related to this societal challenge, such as the Rural Development Funds and Fisheries Funds will be sought.

Forward looking activities will be undertaken across the sectors of the bio-economy, including the development of data bases, indicators and models addressing global, European, national and regional dimensions. A European bio-economy observatory, *bringing together all stakeholders from science, industry and civil society* shall be developed for mapping and monitoring Union and global research and innovation activities, developing key performance indicators, and monitoring innovation policies in the bio-economy.

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104 - 105 - 106 - 107 - 108 - 109 - 110 - 111 - 112 - 113 - 114 - 115 - 116 - 117 - 118 - 119 - 734 - 735 - 736 - 737 - 738 - 739 - 740 - 741 - 742 - 743 - 744 - 745 - 746 - 747 - 748 - 749 - 750 - 751 - 752 - 753 - 754 - 755 - 756 - 757 - 758 - 759 - 760 - 761 - 762 - 763 - 764 - 765 - 766 - 767 - 768 - 769 - 770 - 771 - 772 - 773 - 774 - 775 - 776 - 777 - 778 - 779 - 780 - 781 - 782 - 783 - 784 - 785 - 786 - 787 - 789 - 790 - 791 - 792 - 793 - 794 - 795 - 796 - 797 - 798 - 799 - 800 - 801 - 802 - 803 - 804 - 805 - 806 - 807 - 808 - 809 - 810 - 811 - 812 - 813 - 814 - 815 - 816 - 817 - 818 - AGRI31 - ENVI13 - ENVI25 - ENVI83 - ENVI84 - ENVI85 - ENVI86 - ENVI87 - ENVI88

PART III - SOCIETAL CHALLENGES

3. SECURE, CLEAN AND EFFICIENT ENERGY

3.1. Increasing energy efficiency and reducing energy consumption and carbon footprint through smart and sustainable *and secure* use

The energy sources and consumption patterns of Europe's industries, transport, buildings, towns and cities are *often inefficient and* largely unsustainable, leading to significant environmental and climate change impacts. The development of *new and existing near-zero-energy and positive energy buildings, renewable energy technologies*, highly efficient industries and mass take-up of energy-efficient approaches by companies, individuals, communities and cities will require not only technological advances, but also non-technological solutions such as new advisory, financing and demand management services. In this way energy efficiency *and savings will* provide one of the most cost effective ways to reduce energy demand, thereby enhancing security of energy supply, reducing environmental and climate impacts and boosting competitiveness *and Union leadership in this field*.

3.1.1. *Bring to mass market technologies and services for a smart and efficient energy use*

Reducing energy consumption and eliminating energy waste, while providing the services that society and economy need, requires not only that more, efficient, cost-competitive, *safe*, environmentally-friendly, and smarter products and services are brought to mass market but also the integration of components and devices in such a way that they cooperate to optimise the overall energy use of buildings, services and industry.

To ensure full adoption and full benefits for consumers (including the possibility for them to monitor their own consumption), energy performance of these technologies and services needs to be *improved*, customised and optimised for and in their application environments. This requires not only researching, developing and testing innovative Information and Communication Technologies (ICT) and monitoring and control techniques but also large-scale demonstration projects and pre-commercial deployment activities to ensure interoperability and scalability. Such projects should aim to develop common procedures to collect, collate and analyse energy consumption and emissions data to improve the measurability, transparency, *accuracy*, social acceptability, planning and visibility of energy use and its environmental impacts.

3.1.2. *Unlock the potential of efficient and renewable heating-cooling systems*

A substantial share of energy is consumed for heating or cooling purposes across the Union and the development of cost-effective, **sustainable** and efficient technologies, system integration techniques e.g. network connectivity with standardised languages and services in this area would have a major impact in reducing energy demand. (...)

3.1.3. *Foster European Smart cities and Communities*

Urban areas are one of the largest consumers of energy in the Union and emit a correspondingly large share of greenhouse gases, while generating a substantial amount of air pollutants. ***In that context, there is a need of promoting integrated systemic urban development strategies that take into account: energy efficiency, accessibility, green spaces, adaptation of habitats and social integration.*** At the same time, urban areas are affected by decreasing air quality and climate change and have to develop their own mitigation and adaptation strategies. Finding innovative energy solutions (energy efficiency, ***integration of renewables within the built environment***, electricity and heating and cooling supply systems), integrated with transport, waste and water treatment as well as ICT solutions for the urban environment are therefore crucial in the transformation towards a low carbon society. Targeted initiatives in support to the convergence of industrial value chains of the energy, transport and ICT sector for smart urban applications need to be envisaged. At the same time, new technological, organisational, planning and business models need to be developed and tested at full scale according to the needs and means of cities and communities. Research is also needed to understand the social, economic, ***environmental*** and cultural issues that are involved in this transformation.

3.2. **Sustainable, low-carbon, low-cost electricity supply**

Electricity will play a central role in the establishment of an environmentally sustainable low-carbon economy. The uptake of low-carbon electricity generation is too slow due to the high costs involved. There is a pressing need to find solutions that reduce ***entry barriers (deletion)***, with enhanced performance and sustainability, to accelerate the market deployment of low carbon electricity generation. ***Activities should cover research and innovation in renewable energy technologies in order to improve their efficiency and reduce the costs of those technologies, making them more competitive on the market. It is necessary in particular to:***

3.2.1. *Develop the full potential of wind energy*

The objective for wind energy is to reduce the cost of electricity production of onshore and offshore wind by up to about 20 % by 2020 compared to 2010, to increasingly move offshore, and to enable proper integration in the electricity grid. The focus will be on the ***design***, development, testing and demonstration of next generation wind energy conversion systems of larger scale, higher conversion efficiencies and higher availabilities for both on- and off-shore (including remote locations and hostile weather environments) as well as new serial manufacturing processes. ***To this end, collaboration with other parts of the Horizon 2020 programme regarding research on the availability, production and substitution of novel and technological materials, including rare-earth products, and other critical resources which are necessary for wind turbines, should be promoted. The feasibility of remote and hostile weather locations should be investigated using appropriate atmosphere and ocean modelling tools.***

3.2.2. *Develop efficient, reliable and cost-competitive solar energy systems*

The cost of solar energy, covering photovoltaics (PV) and concentrating solar power (CSP), should be halved by 2020 compared to 2010, if it is to gain share of the electricity market.

For PV, this will need *(deletion)* research on ***higher performance manufacturing processes and products***, demonstration and testing of mass production with a view to large-scale deployment ***of both centralised and small scale decentralized PV-systems and an increased focus on European strength positions such as industrial design and building integration***.

For CSP, the focus will be on developing ways to increase efficiency ***and dispatchability***, while reducing costs and environmental impact. ***In addition to research topics, the objective is to foster*** industrial up-scaling of demonstrated technologies by building first-of-a-kind power plants. Solutions to efficiently combine the production of solar electricity with ***other renewables as biomass in hybrid plants which will allow for firm electricity generation or other purposes as*** water desalination will be ***tested as well as solutions to store solar power efficiently***.

3.2.3. *deletion (moved to 3.2.4 new)*

3.2.4. *Develop geothermal, hydro, marine and other renewable energy options*

Geothermal, hydro, and marine energy as well as other renewable energies can contribute to the decarbonisation of the European energy supply while enhancing its flexibility to variable production and use of energy. The objective is to bring to commercial maturity cost-effective and sustainable technologies, enabling large-scale deployment at an industrial scale including grid integration. Ocean energies such as tidal, current or wave energy offer truly zero-emission, predictable energy. Research activities should include laboratory scale innovative research into low-cost reliable components and materials in a high corrosion, biofouling environment as well as demonstrations under the varied conditions found in European waters. ***Besides pilot installations, demonstration projects should include adequate management systems based on information provided by monitoring and forecasting tools, aiming at the protection of assets.***

3.2.4b. *Decentralised energy production*

Distributed energy production, such as electricity micro-generation, plays an important role in inland isolated regions and islands. Adequate solutions for energy production and energy systems management will be further investigated. International cooperation activities with developing countries with regard to poverty alleviation will be promoted.

3.2.4d. *Develop competitive and environmentally safe technologies for CO₂ capture, transport and storage*

Carbon capture and storage (CCS) *(deletion)* is a key option that ***has*** to be widely deployed on a commercial scale at global level to meet the challenge of a decarbonised power generation and low carbon industry by 2050. The objective is to minimise the extra-cost of CCS in the power sector for coal-fired and gas-fired power

plants compared to equivalent plants without CCS and energy intensive industrial installations.

Support will be given, in particular, to demonstrate the full CCS chain for a representative portfolio of different capture, transport and storage technology options ***as well as to raise public awareness***. This will be accompanied by research to deliver more efficient power and capture technologies, improved components, integrated systems and processes, ***(deletion)*** for fossil fuelled power plants and other carbon-intensive industries going into operation after 2020. ***Furthermore, research on safe geological storage and rational solutions for the utilisation of captured CO2 will be conducted to enable the commercial deployment of CCS.***

3.3. Alternative fuels and mobile energy sources

(...)

3.3.1. Make bio-energy competitive and sustainable

The objective for bio-energy is to bring to commercial maturity the most promising technologies, to permit large-scale, sustainable production of advanced second ***and third*** generation biofuels of different value chains for transport, and highly ***energy*** efficient combined heat and power from biomass ***(deletion)***. The aim is to develop and demonstrate the technology for different bio-energy pathways at different scales, taking account of differing geographical and climate conditions and logistical constraints. Longer term research will support the development of a sustainable bio-energy industry beyond 2020. These activities will complement upstream (feedstock, bio-resources) and downstream (integration into vehicle fleets) research activities carried out in other relevant Societal Challenges.

3.3.2. Reducing time to market for hydrogen and fuel cells technologies

(...)

3.3.3. New alternative fuels

There is a range of new options with long term potential, such as powdered metal fuel, fuel from photosynthetic microorganisms (in water and land environments) and from artificial photosynthesis mimics ***or from low temperature pyroelectrical water decomposition***. These new paths may offer potential for more efficient energy conversion, more cost-competitive and sustainable technologies, and almost neutral ‘greenhouse gases’ emitting processes that do not compete for agricultural lands. Support will be given notably to bring these new and other potential technologies from laboratory to demonstration scale size in view of pre-commercial demonstration by 2020.

3.4. A single, smart flexible European energy grid

Energy networks have to respond to three interrelated challenges to enable a consumer friendly and increasingly decarbonised electricity system: creating a pan-European market; integrating a massive increase of renewable energy sources; and managing interactions between millions of suppliers and customers (where increasingly households will be both), including owners of electrical vehicles. Future electricity networks will play a key role for the transition to a fully decarbonised

electricity system, while providing additional flexibility and cost benefits to the consumers. The overriding goal by 2020 is to transmit and distribute about 35 % of electricity from dispersed and concentrated renewable energy sources.

A strongly integrated research and demonstration effort will support the development of new components and technologies which will respond to the particularities of both the transmission and distribution side of the grid, as well as storage.

All options to successfully balance energy supply and demand must be considered to minimise emissions and costs. New power systems technologies, **demand management** and a bi-directional digital communication infrastructure must be researched and integrated into the electricity grid. This will contribute to better plan, monitor, control and securely operate networks in normal and emergency conditions as well as to manage the interactions between suppliers and customers and to transport, manage and trade energy flow. For the deployment of future infrastructure, indicators and cost benefit analysis should take into account energy system-wide considerations. In addition, synergies between smart grids and telecommunication networks will be maximised in order to avoid duplication of investments and to accelerate the take up of smart energy services.

Novel energy storage means (including both large scale and batteries) and vehicle systems will provide the required flexibility between production and demand. Improved ICT technologies will further increase the flexibility of electricity demand by providing customers (industrial, commercial and residential) with the necessary automation **and control** tools.

New planning, market and regulatory designs need to drive the overall efficiency and cost-effectiveness of the electricity supply chain and interoperability of infrastructures as well as the emergence of an open and competitive market for smart grid technologies, products and services. Large-scale demonstration projects are needed to test and validate solutions and assess the benefits for the system and for individual stakeholders, before deploying them across Europe. This should be accompanied by research to understand how consumers and businesses react to economic incentives, behavioural changes, information services and other innovative opportunities provided by smart grids.

3.4.1. Energy storage

With increasing implementation of renewable energies the demand for storage of variable renewables becomes more and more important. A development of storage technologies will become mandatory, for short-term storage (minute reserve in tertiary grid control) as well as for long-term applications from hours up to seasonal storage. The large temporal range requires a broad range of technologies. The objective is to develop different routes using electrical, mechanical, chemical and thermal storage

3.4.2. Back-up and balancing technologies

Flexible and efficient fossil fuel power plants are still essential for ensuring grid stability and security of electricity supply. In a transition period, moving on towards

a low-carbon economy, we are facing the challenge to balance electricity from variable renewables with electricity from flexible conventional power plants. Conventional power plants are currently designed to operate at base-load, whereas, when backing up renewable energy, they will frequently run at part-load. In this mode, they are less efficient with an impact on emissions.

Research is needed to optimise the flexibility and efficiency of conventional power plants when operated part-load, thus ensuring that flexible and efficient backup will be available to accompany and support the growth of renewable energy and gradually enabling a higher integration of electricity from variable renewables into the grid.

According to Commission analysis in Energy Roadmap 2050, the Unions' power sector will have to decarbonise by 93-99% by 2030. In view of this, further research is urgently needed to accelerate the development and deployment of non-fossil fuel back-up and balancing technologies that are flexible and fully sustainable, in order to successfully integrate the rapidly growing supply of variable renewable energy sources.

3.5. New knowledge and technologies

Novel, more efficient and cost-competitive technologies will be required for the long term. Progress should be accelerated through multi-disciplinary research to achieve scientific breakthroughs in energy related concepts and enabling technologies (e.g. nano-science, material science, solid state physics, ICT, bio-science, computation, space, *critical metals from waste, residuals and by-products*); as well as the development of innovations in future and emerging technologies.

Advanced research will also be needed to provide solutions to adapt energy systems to changing climatic conditions. *The challenges created by the variable character of solar and wind energy must be addressed.* Priorities may be adjusted to new scientific and technological needs and opportunities or newly-observed phenomena which could indicate promising developments or risks to society and that may emerge during the course of implementation of Horizon 2020.

3.6. Robust decision making and public engagement

(...)

3.7. Market uptake of energy innovation, empowering markets and consumers through *Intelligent Energy Europe III*

(...)

Such innovations will focus on creating favourable market conditions at the regulatory, administrative and financing level for renewable and *end-user energy efficient* technologies and solutions. Support will be given to measures facilitating the energy policy implementation, preparing the ground for rollout of the investments, supporting the capacity building and acting on public acceptance *and participation*.

(...)

3.8. Specific implementation aspects

The priority setting for the implementation of the activities in this challenge is led by the need to strengthen the European dimension of energy research and innovation. A main aim will be to support the implementation of the research and innovation agenda of the Strategic Energy Technology Plan (SET Plan)⁹ to achieve the **2020 and 2050's** objectives of the Union's energy and climate change policy. The SET-Plan roadmaps and implementation plans will therefore provide a valuable input for the formulation of the work programmes. The SET Plan governance structure will be used as a principle basis for strategic priority setting and the coordination of Energy Research and innovation across the Union. ***The input of the industry within the governance of the European Industry Initiatives will be taken formally and transparently into account with respect to tools financing priorities identified in the EIIs Implementation Plans. The Initiatives will be financed through dedicated budget lines per technologies created under the SET-Plan budget line.***

The non-technological agenda will be guided by the Union's energy policy and legislation. The enabling environment for mass deployment of demonstrated technological and service solutions, processes and policy initiatives for low-carbon technologies and energy efficiency across the Union shall be supported. This may involve support to technical assistance for development and roll-out of energy efficiency and renewable energy investments.

Partnering with European stakeholders will be important to share resources and implement jointly. It may be envisaged, on a case by case basis, that existing European Industrial Initiatives of the SET Plan are turned into formalised public-private partnerships, if considered appropriate, to increase the level and coherence of national funding and to stimulate joint research and innovation actions among Member States. Consideration will be given to provide support, including with Member States, to alliances of public research performers, in particular, the European Energy Research Alliance established under the SET Plan to pool public research resources and infrastructures to address critical research areas of European interest. International coordination actions shall support the SET Plan priorities according to the variable geometry principle, taking account of countries capabilities and specificities.

In the field of energy, full use should be made of the SET Plan Steering Group to coordinate the use of the Common Provisions Regulation with the use of auctioning revenues from phase 3 of the Emissions Trading scheme, NER300, projects funded with Horizon 2020 and national funds, with a view to using them to fund large-scale demonstration projects.

Despite the fact that Horizon 2020 funding is not provided through mechanisms that require the pooling of national co-funding, positive measures are needed to allow the full participation of project partners from Member States currently unable to provide co-funding.

The European Commission's Information System of the SET-Plan will be mobilised to develop, together with stakeholders, key performance indicators (KPIs) to monitor

⁹ COM(2007) 723

the progress of implementation and which will be revised on a regular basis to account of the latest developments. More broadly, implementation under this Challenge will seek to improve the coordination of relevant Union Programmes, initiatives and policies, such as Cohesion policy, in particular through the national and regional strategies for smart specialisation, and the Emission Trading Scheme mechanisms, for example concerning support to demonstration projects.

The priorities on decision making and market uptake should be built on the success of the Intelligent Energy Europe (IEE) Programme, which since its creation in 2003 has provided funding for more than 500 European projects involving 3,500 European organisations. IEE Programme should continue with similar objectives and managed along the same lines as done so far.

It is appropriate for three quarters of the budget under this challenge to go towards research and innovation in renewable energy, end-use energy efficiency, smart grids and energy storage. An additional 15% of the budget of the current societal challenge should be allocated to the IEE Programme.

PART III - SOCIETAL CHALLENGES

4. SMART, GREEN, SECURE AND INTEGRATED TRANSPORT AND MOBILITY

4.1. Resource efficient transport that respects the environment and public health

Europe has set a policy target of achieving a 60 % reduction of CO₂ by 2050 *compared to 1990 levels*. It aims at halving the use of ‘conventionally-fuelled’ cars in cities and achieving virtually CO₂-free city logistics in major urban centres by 2030. Low-carbon fuels in aviation should reach 40 % by 2050, and CO₂ emissions from maritime bunker fuels should be reduced by 40 % by 2050 *compared to 2005 levels*.

Research and innovation will substantially contribute to the development and take up of the necessary solutions for all transport modes, which will drastically reduce transport's emissions that are harmful to the environment (such as CO₂, NO_x, and SO_x), lower its dependence on fossil fuels, and hence reduce transport impact on biodiversity and preserve natural resources.

This will be done through work on the following specific activities:

4.1.1. *Making aircraft, vehicles and vessels cleaner and quieter will improve environmental performance and reduce perceived noise and vibration*

The activities in this domain will focus on the end products, but will also address lean and ecological design and manufacturing processes, *considering the entire life-cycle process* with recyclability integrated in the design phase.

- (a) Developing and accelerating the take-up of cleaner propulsion technologies is important for reducing or eliminating CO₂ and pollution *from all kind* of transport (*e.g. particulate matter*). New and innovative solutions are necessary, based on electric engines and batteries, fuel cells, or hybrid propulsion. Technological breakthroughs will also help improve the environmental performance of traditional propulsion systems.
- (b) Exploring options for the use of low emission alternative energies will help reduce the consumption of fossil fuels. This includes using sustainable fuels and electricity from renewable energy sources in all modes of transport including aviation, reducing fuel consumption through energy harvesting or diversified energy supply and other innovative solutions. New holistic approaches will be pursued encompassing vehicles, energy storage and energy supply infrastructure, including vehicle-to-grid interfaces and innovative solutions for the use of alternative fuels.
- (c) Reducing the weight of aircraft, vessels and vehicles and lowering their aerodynamic, hydrodynamic or rolling resistance by using lighter materials, leaner structures and innovative design, will contribute to lower fuel consumption.

4.1.2. *Developing smart equipment, infrastructures and services*

This will help optimise transport operations and reduce resource consumption. The focus will be on the efficient use and management of airports, **heliports**, ports, logistic platforms and surface transport infrastructures, as well as on autonomous and efficient maintenance and inspection systems. Particular attention will be given to the climate resilience of infrastructures, cost-efficient solutions based on a life-cycle approach, and the wider take-up of new materials allowing for more efficient and lower cost maintenance. Attention will also be paid to accessibility, **in particular to islands and remote areas** and social inclusiveness.

4.1.3. *Improving transport and mobility in urban areas*

(...)

4.2. **Better mobility and accessibility, less congestion, more safety and security**

(...)

4.2.1. *A substantial reduction of traffic congestion*

This can be achieved by implementing a fully intermodal ‘door-to-door’ transport **and mobility** system and by avoiding unnecessary use of transport. This means promoting greater integration between transport modes, the optimisation of transportation chains and better integrated transport **and logistics** services **leveraging new and more performing navigation systems, such as EGNOS and Galileo**. Such innovative solutions will also facilitate accessibility, including for the ageing population, **persons with reduced mobility (PRMs)** and **disabled and vulnerable** users.

4.2.2. *Substantial improvements in the mobility of people and freight*

This can be achieved through the development and widespread use of intelligent transport applications and management systems. This entails: planning, demand management, information, **ticketing** and payment systems that are interoperable Europe-wide; and the full integration of information flows, management systems, infrastructure networks and mobility services into a new common multi-modal framework based on open platforms. This will also ensure flexibility and rapid responses to crisis events and extreme weather conditions by reconfiguring travel across modes. New positioning, navigation and timing applications, made possible through the Galileo and EGNOS satellite navigation systems, **are key enablers** in achieving this objective.

(a) Innovative air traffic management technologies will contribute to a step-change in safety and efficiency with rapidly increasing demand, to achieve improved punctuality, to reduce time spent in travel-related procedures at airports and to achieve resilience in the air transport system. **Innovative navigation systems, leveraging the European GNSS, such as EGNOS, will optimise landing approaches, increase flight safety and reduce fuel consumption, with better use of major airports and allowing full exploitation of minor ones.** The implementation and further development of the ‘Single European Sky’ will be supported with solutions for increased automation and autonomy in air traffic management and aircraft control, better integration of air and ground components, and novel solutions for the efficient and seamless handling of passengers and freight throughout the transport system.

(b) For waterborne transport, improved and integrated planning and management technologies will contribute to the emergence of a ‘Blue Belt’ in the seas around Europe, improving port operations, and to a suitable framework for inland waterways.

(c) For rail and road, the optimisation of network management will improve efficient use of infrastructure and make cross-border operations easier. Comprehensive cooperative road traffic management and information systems will be developed, relying on vehicle to vehicle and vehicle to infrastructure communication **and on European satellite navigation systems.**

4.2.3. *Developing and applying new concepts of freight transport and logistics*

(...)

4.2.4. *Reducing accident rates and fatal casualties and improving security*

(...)

4.3. Global leadership for the European transport industry

By staying ahead in new technologies and reducing the costs, **improving resource and energy efficiency** of existing manufacturing processes, research and innovation will contribute to growth and highly skilled jobs in the European transport industry, in the face of growing competition. At stake is the preservation of the competitiveness of a major economic sector that directly represents 6.3 % of the Union GDP and employs nearly 13 million people in Europe. Specific objectives include the development of the next generation of innovative transport means and to prepare the ground for the following one, by working on novel concepts and designs, smart control systems and efficient production processes. Europe aims at becoming the world-leader in efficiency and safety in all modes of transport.

Research and innovation will focus on the following specific activities:

4.3.1. *Developing the next generation of transport means as the way to secure market share in the future*

It will help enhance European leadership in aircraft, **rotorcraft, regional and small aircrafts**, high speed trains, (sub) urban rail transport, road vehicles, electromobility, passenger cruise ships, ferries and specialised high technology ships and marine platforms. It will also spur the competitiveness of European industries in upcoming technologies and systems and support their diversification towards new markets, including in sectors other than transport. This includes the development of innovative safe aircraft, vehicles and vessels that incorporate efficient propulsion units, high performance and intelligent control systems.

4.3.2. *On board, smart control systems (...)*

4.3.3. *Advanced production processes (...)*

4.3.4. *Exploring entirely new transport concepts (...)*

4.3 a. Smart logistics

This will help to design and develop more efficient and greener logistics transport systems through facilitation and cost/time optimisation.

This includes a better understanding of consumer patterns and the impact on urban freight logistics, traffic and congestion is needed in order to develop smart logistics; to develop new IT and management tools for logistics, by improving real time information systems to manage, track and trace freight flows, integration and communication on vehicle and with infrastructure; to develop unconventional systems for goods distribution; to develop competitive intermodal solutions for the supply chain and logistics platforms that improve freight flows.

4.4. Socio-economic and behavioural research and forward looking activities for policy making

Actions to support policy analysis and development including on socio-economic, *psychological/behavioural and geographic* aspects of transport *and mobility* are necessary to promote innovation and meet the challenges raised by transport *and mobility*. Activities will target the development and implementation of European research and innovation policies for transport *and mobility*, prospective studies and technology foresight, and strengthening of the European Research Area.

Understanding user behaviour, social acceptance *of behavioural change towards more sustainable transport modes*, impact of policy measures, mobility patterns, *awareness-raising by carbon-footprint tools* and business models and their implications are of paramount importance for the evolution of the European transport *and mobility* system. Scenario development taking into account societal trends, *demographic change*, policy objectives and technology foresight in a 2050 perspective will be carried out. In view of better understanding the links between territorial development and the European transport system, *between green logistics, mobility management and transport avoidance*, robust models are needed on which sound policy decisions can be taken.

Research will focus on how to prevent social inequalities in access to mobility, and how to improve the position of vulnerable road users. Economic issues must also be addressed, focusing on ways to internalise the externalities from transport *and mobility* across modes, as well as taxation and pricing models. Prospective research is needed to assess future requirements for skills and jobs.

4.5. Specific implementation aspects

(...)

CA 25 - EPP - S&D - ALDE - ECR – Greens - GUE
152 - 126 - 167 - 128 - 129 - 130 - 131 - 132 - 133 - 134 - 135 - 136 - 1367 - 138 -
139 - 140 - 141 - 142 - 143 - 144 - 845 - 846 - 847 - 848 - 849 - 850 - 851 - 852 - 853
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ENVI47 - ENVI89 - ENVI90 - ENVI91 - ENVI92 - ENVI93 - ENVI94 - ENVI95 -
ENVI96- ENVI97 -ENVI98 - ENVI99 - ENVI100 - ENVI101 - ENVI102 - ENVI103
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PART III - SOCIETAL CHALLENGES

5. CLIMATE ACTION, *ENVIRONMENT*, RESOURCE EFFICIENCY AND SUSTAINABLE USE OF RAW MATERIALS

5.1. Fighting and adapting to climate change

Current CO₂ concentrations in the atmosphere are close to 40 % higher than those at the start of the industrial revolution and at the highest levels experienced in the last 2 million years. Non-CO₂ greenhouse gases *and particles* also contribute to climate change and are playing an increasingly significant role. Without decisive action, climate change could cost the world at least 5 % of GDP each year; and up to 20 % under some scenarios.

In contrast, with early and effective action the net costs could be limited to around 1% of GDP per year. Meeting the 2°C target and avoiding the worst impacts of climate change will require developed countries to cut greenhouse gas emissions by 80-95% by 2050 compared to 1990 levels.

The aim of this activity is therefore to develop and assess innovative, cost-effective and sustainable adaptation and mitigation measures, targeting both CO₂ and non-CO₂ greenhouse gases *and aerosols*, and underlining both technological and non-technological green solutions, through the generation of evidence for informed, early and effective action and the networking of the required competences.

To achieve this, research and innovation will focus on the following:

5.1.1. *Improve the understanding of climate change and the provision of reliable climate projections*

Better understanding of the causes and evolution of climate change and more accurate climate projections are crucial for society to protect lives, *economic activities*, goods and infrastructures and ensure effective decision making. It is essential to further improve the scientific knowledge-base of climate drivers, processes, mechanisms and feedbacks associated with the functioning of oceans, terrestrial ecosystems and the atmosphere *as well as polar regions*. Improved climate predictions at pertinent temporal and spatial scales will be supported via the development of more accurate scenarios and models, including fully coupled Earth-system models.

5.1.2. *Assess impacts, vulnerabilities and develop innovative cost-effective adaptation and risk prevention measures:*

There is incomplete knowledge on the ability of society and the economy to adapt to climate change. Effective, equitable and socially acceptable measures towards a

climate resilient environment and society require the integrated analysis of current and future impacts, vulnerabilities, population exposure, risks, costs and opportunities associated with climate change and variability, taking into account extreme events and related climate-induced hazards and their recurrence. This analysis will also be developed on the adverse impacts of climate change on biodiversity, ecosystems and ecosystem services, infrastructures and economic and natural assets. ***For instance, climate changes are likely to enhance the occurrence of extreme hydrological phenomena (floods and droughts) with major impacts in water resources, ecosystems and the sustainability of economic activities as known today. Impact on water availability is especially relevant. In many regions of the Union scarcity will be intensified and a more uneven distribution in space and time will occur, requiring new forms of management.*** Emphasis will be placed on the most valuable natural ecosystems and built environments, as well as key societal, cultural and economic sectors across Europe. Actions will investigate the impacts and growing risks for human health stemming from climate change and increased greenhouse gases concentrations in the atmosphere. Research will evaluate innovative, equitably distributed and cost-effective adaptation responses to climate change, including the ***specificities of islands and outermost regions and the*** protection and adaptation of natural resources and ecosystems, and related effects, to inform and support their development and implementation at all levels and scales. This will also include the potential impacts, costs and risks, of geo-engineering options. The complex inter-linkages, conflicts and synergies of adaptation and risk-prevention policy choices with other climate and sectoral policies will be investigated, including impacts on employment and the living standards of vulnerable groups.

5.1.3. *Support mitigation policies*

(...)

5.1.3b (new) *Cultural heritage*

Research strategies, methodologies and tools needed to enable a dynamic and sustainable cultural heritage in Europe in response to climate change. Cultural heritage in its diverse physical forms provides the living context for resilient communities responding to multivariate changes. Research in cultural heritage requires a multidisciplinary approach to improve the understanding of historical material. Activities shall focus on identifying resilience levels via observations, monitoring and modelling as well as provide for a better understanding on how communities perceive and respond to climate change and seismic and volcanic hazards.

5.2. ***Protecting the environment, sustainably management of natural resources, water, biodiversity and ecosystems***

Societies face a major challenge to establish a sustainable balance between human needs and the environment. Environmental resources, including water, air, biomass, fertile soils, ***forestry***, biodiversity, ecosystems and the services they provide, underpin the functioning of the European and global economy and quality of life. Global business opportunities related to natural resources are expected to amount to over EUR 2 trillion by 2050. Despite this, ecosystems in Europe and globally are being degraded beyond nature's ability to regenerate them and environmental resources are

being over-exploited **and even destroyed**. For example, 1000 km² of some of the most fertile soils and valuable ecosystems are lost every year in the Union, while a quarter of fresh water is wasted.

Continuing these patterns is not an option. Research must contribute to reversing the trends that damage the environment and to ensuring that ecosystems continue to provide the resources, goods and services that are essential for well-being and economic prosperity.

The aim of this activity is therefore to provide knowledge for the management **and protection** of natural resources that achieves a sustainable balance between limited resources and the needs of society and the economy.

To achieve this, research and innovation will focus on the following:

5.2.1. Further our understanding of the functioning of ecosystems, their interactions with social systems and their role in sustaining the economy and human well-being.

Society's actions risk triggering changes in the environment that are irreversible and which alter the character of ecosystems. It is vital to anticipate these risks by assessing, monitoring and forecasting the impact of human activities on the environment, and environmental changes on human well-being. ***A better understanding of the environmental determinants of health and wellbeing and the mediating mechanisms is required in order to provide evidence for effective health protection strategies and inform the Union programmes and policies.***

Research on marine, (from coastal zones to the deep sea), **polar**, fresh-water, terrestrial and urban ecosystems, including groundwater dependent ecosystems **and their biological diversity**, will improve our understanding of the complex interactions between natural resources and social, economic, and ecological systems, including natural tipping points, and the resilience, or fragility, of human and biological systems. It will examine how ecosystems function and react to anthropogenic impacts, how **these impacts** can be **minimised, how ecosystems can be** restored, and how this will affect economies and human well-being. It will also investigate solutions for addressing resource challenges. It will contribute to policies and practices that ensure that social and economic activities operate within the limits of the sustainability and adaptability of ecosystems and biodiversity.

A better understanding of the physical and social phenomena that lead forest fires is of paramount need. Simulation, data collection and analysis is fundamental to feed research based decision support systems as a primordial way to prevent forest fires and increase efficiency in their combat and decrease damages in human, environmental, social and economic assets.

5.2.1a Ensuring action to safeguard the sustainable transition, management and use of water resources and water services.

In the future the great challenges for water research will primarily result from the necessity of viewing the topic increasingly in connection with questions of global change, climate change, the growing geopolitical significance as well as energy and health aspects. Water resources should be viewed and managed holistically. This includes natural regions and ecological questions, an understanding of ecosystem services as a process, protection of drinking water quality and different political systems and institutional structures. The knowledge base should integrate the

concept of 'environmental flows' and take into account the ecosystem services supported by water; stresses the need to take into account that water cycle changes depend on habitat and this has influence on the percentage of water that is recycled.

With respect to water, management strategies integrating natural bodies and alternative sources (e.g. treated wastewater) for the often-conflicting uses (agriculture, landscape maintenance, environmental restoration/enhancement, forest fire fighting, recreational activities and public supply) are envisaged. Attention shall be given to the water quantity and quality of natural bodies, particularly those used for drinking water abstraction.

The aim is to improve an innovative knowledge base on (transitions in) water supply, water purification, closing the water cycle, energy /raw material recovery and improving end-user engagement/behaviour to meet future needs.

5.2.1b Reaching the Good Environmental Status of Europe's seas and Oceans

Climate change and resources exploitation are main threats to ecosystems. The protection and sustainable management of natural resources and biodiversity assessment and conservation in coastal and marine (including deep sea) ecosystems through innovative observation and monitoring tools is of paramount importance. Also, the mitigation of coastal and marine biodiversity threats (including habitat change and fragmentation, invasive species, overexploitation and pollution) must be guaranteed.

The aim is to Enhancing the knowledge and impacts of marine contaminants to reach and maintain the good environmental status of European seas and oceans as required in the marine strategy directive (MSFD) and to promote and improved the marine spatial planning tools including coastal protection and marine protected areas.

5.2.2. Provide knowledge and tools for effective decision making and public engagement

Social, economic and governance systems still need to address both resource depletion and the damage to ecosystems. Research and innovation will underpin policy decisions needed to manage natural resources and ecosystems so as to avoid, or adapt to, disruptive climate and environmental change and **its impacts and** to promote institutional, economic, behavioural and technological change that ensure sustainability. Emphasis will be put on critical policy relevant ecosystems and ecosystem services, such as fresh water, seas and oceans, **polar regions**, air quality, biodiversity, land use, **forest fires** and soil. The resilience of societies and ecosystems to catastrophic events, including natural hazards, will be supported through improving capacities for forecasting, early warning, and assessing vulnerabilities and impacts, including the multi-risk dimension. Research and innovation will thus provide support for environmental and resource efficiency policies, and options for effective evidence-based governance within safe operating limits. Innovative ways will be developed to increase policy coherence, resolve trade-offs and manage conflicting interests. **Special attention will also be given to** improve public awareness of research results, the participation of citizens in decision-making **and the public acceptance of innovations**

and innovative technologies. Availability and productivity of all the substantial resources must be analysed at the various relevant territorial scales: global, regional and local and the related socioeconomic consequences should be analysed in order to elaborate options for political actions.

5.2.2a Addressing resource consumption patterns and lifestyles changes.

Research into sustainability lifestyle changes and fostering emergence of sustainable lifestyles. Support implementation of demand-side innovations and solutions to reduce resource use and unsustainable use of resources

5.3. Ensuring the sustainable use, management and supply of non-energy and non-agricultural raw materials

Sectors such as construction, chemicals, automotive, aerospace, machinery and equipment, which have a combined added value in excess of EUR 1,000 billion and provide employment for some 30 million people, all depend on access to raw materials. ~~(deletion)~~Nonetheless, whilst the Union is one of the world's largest producers of certain industrial minerals, it remains a net importer of most of them. Furthermore, the Union is highly dependent on imports of metallic minerals and is totally import dependent for some critical raw materials.

Recent trends indicate that demand for raw materials will be driven by *continued demand from developed economies* the development of emerging economies and by the rapid diffusion of key enabling technologies. Europe has to ensure a sustainable management and secure a sustainable supply of raw materials from inside and outside its borders for all sectors that depend on access to raw materials. Policy targets for critical raw materials are outlined in the Commission's Raw Materials Initiative¹⁰.

The aim of this activity is therefore to improve the knowledge base on raw materials, *both on land and sea-bed* and develop innovative solutions for the cost-effective and environmentally friendly exploration, extraction, processing, *resource efficiency, re-use*, recycling and recovery of raw materials and for their substitution by economically attractive alternatives with a lower environmental impact. *International co-operation including co-operation on developing better international resource governance and co-operation between national geological surveys will be relevant in this context and will be pursued.*

To achieve this, research and innovation will focus on the following:

5.3.1. *Improve the knowledge base on the availability of raw materials*

(...)

5.3.2. *Promote the sustainable and efficient supply and use of raw materials, covering exploration, extraction, processing, recycling and recovery*

Research and innovation is needed over the entire life cycle of materials, in order to secure an affordable, reliable, and sustainable supply and management of raw materials essential for European industries. Developing and deploying economically

¹⁰ COM (2008) 699

viable, socially acceptable and environmentally friendly exploration, extraction, processing **and recycling** technologies will boost the efficient use of resources. This will also exploit the potential of urban mines. New and economically viable recycling and materials recovery technologies, business models and processes will also contribute to reducing the Union's dependence on the supply of primary raw materials. This will include the need for longer use, high-quality recycling and recovery, and the need to drastically reduce **both the normal consumption as well as the wastage of these resources**. A full life-cycle approach will be taken, from the supply of available raw materials to end of life, with minimum energy and resources requirements.

5.3.3. *Find alternatives for critical raw materials (...)*

5.3.4. *Improve societal awareness and skills on raw materials (...)*

5.4. Enabling the transition towards a sustainable society and economy through eco-innovation

(...)

5.4.1. *Strengthen eco-innovative technologies, processes, services and products (deletion)*

All forms of innovation, both incremental and radical, combining technological, organisational, societal, behavioural, business and policy innovation, and strengthening the participation of civil society, will be supported. This will underpin a more circular economy, while reducing environmental impacts and taking account of rebound effects on the environment. This will include business models, industrial symbiosis, product service systems, product design, full life cycle and cradle-to-cradle approaches. The aim will be to improve resource efficiency by reducing, in absolute terms, inputs, waste and the release of harmful substances along the value chain and foster re-use, recycling and resource substitution. ***With current economic context, priority needs to be given to support private companies with an emphasis on SMEs in introducing environmental innovative ideas into the market, as successfully done by the previous Eco-innovation market replication.*** Emphasis will be given to facilitate the transition from research to market, involving industry and notably SMEs, from the development of prototypes to ***pre-commercial demonstration***. Networking among eco-innovators will also seek to enhance the dissemination of knowledge and better link supply with demand.

Networking among eco-innovators will also seek to enhance the dissemination of knowledge and better link supply with demand.

5.4.1a (new) Promote the first application and market replication of near commercial eco-innovative solutions

It is not uncommon that highly promising and technically advanced eco-innovative technologies, processes, services and products do not reach the market due to pre-commercialisation challenges and the residual risk linked to scaling-up. Eco-innovative solutions that have been technically demonstrated do not realise their full environmental and economic potential as their market introduction is perceived as too risky by private investors. This is in particular true for solutions originating

from start-ups and innovative SMEs. The aim will be to support projects concerned with the first application and market replication of eco-innovative techniques, products, services or practices of Union relevance, that have already been technically demonstrated but that, owing to residual risk, have not yet penetrated the market. Actions should contribute to removing barriers to the development and wide application of eco-innovation, create or enlarge markets for the solutions concerned and improve the competitiveness of Union enterprises, especially SMEs, on world markets.

5.4.2. *Support innovative policies and societal changes (...)*

5.4.3. *Measure and assess progress towards a green economy (...)*

5.4.4. *Foster resource efficiency through digital systems (...)*

5.5. Developing comprehensive and sustained global environmental observation and information systems

Comprehensive environmental observation and information systems are essential to ensure the delivery of the long-term data and information required to address this challenge. These systems will be used to assess and predict the condition, status and trends of the climate, natural resources including raw materials, ecosystems and ecosystem services, as well as to evaluate low-carbon and climate mitigation and adaptation policies and options across all sectors of the economy. Information and knowledge from these systems will be used to stimulate the smart use of strategic resources; to support the development of evidence-based policies; to foster new environmental and climate services; *to support digital technologies for the monitoring, follow-up and management of water resources via satellite*; and to develop new opportunities in global markets.

Capabilities, technologies and data infrastructures for earth observation and monitoring must build on advances in ICT, space technologies and enabled networks, remotely sensed observations, novel in situ sensors, mobile services, communication networks, participatory web-service tools and improved computing and modelling infrastructure, with the aim of continuously providing timely and accurate information, forecasts and projections. Free, open and unrestricted access to interoperable data and information will be encouraged, as well as the effective storage, management and dissemination of research results.

5.6. Specific implementation aspects

(...)

CA 26 - EPP– S&D – ALDE - Greens - GUE
145 - 146 - 147 - 148 - 149 - 150 - 151 - 154 - 878 - 879 - 880 - 881 - 882 - 883 - 884
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914 - 915 - 916 - 917 - 918 - 921 - 927 - 928 - 930 - 931 - CULT17 - CULT22 -
CULT23 - CULT24 - CULT25 - CULT26 - CULT27- AFET10 - AFET11 - AFET14
- ENVI106 - FEMM21 - FEMM22

PART III - SOCIETAL CHALLENGES

6. ***UNDERSTANDING EUROPE IN A CHANGING WORLD – INCLUSIVE, INNOVATIVE AND REFLECTIVE SOCIETIES***

6.1. **Inclusive societies**

Current trends at play in European societies bring with them opportunities for a more united Europe but also risks. These opportunities and risks need to be understood and anticipated in order for Europe to evolve with adequate solidarity and cooperation at social, economic, political and cultural levels, taking into account an increasingly interconnected world.

In this context, the objective is to enhance social, economic and political inclusion, combat poverty, enhance human rights, digital *and educational* inclusiveness, equality, solidarity, *cultural diversity* and inter-cultural *dialogue* by supporting interdisciplinary research, indicators *development*, technological advances, organisational solutions and new forms of collaboration and co-creation. Research and other activities shall support the implementation of the Europe 2020 strategy as well as other relevant Union foreign policies. *Social sciences and humanities* research *will* have an important role to play in this context. Specifying, monitoring and assessing the objectives of European strategies and policies will require focused research on high-quality statistical information systems, and the development of adapted instruments that allow policy makers to assess the impact and effectiveness of envisaged measures, in particular in favour of social inclusion.

The following specific objectives will be pursued:

6.1.1. *Promoting smart, sustainable and inclusive growth*

The constant quest for economic growth carries a number of important human, social, environmental and economic costs. A smart, sustainable and inclusive growth in Europe implies substantial changes in the way growth and wellbeing are defined, measured (including through the measurement of progress beyond the commonly used GDP indicator), generated and sustained over time. Research will analyse the development of sustainable lifestyles and socio-economic behaviours and values and how they relate to paradigms, policies and to the functioning of institutions, markets, firms, governance and belief systems in Europe. It will develop, *taking into account the economic and social diversity*, tools for a better assessment of the contextual and mutual impacts of such evolutions and policy options in areas such as employment, taxation, inequalities, poverty, social inclusion, education and skills, community development, competitiveness and the Internal Market. It will also analyse how national economies evolve and which forms of governance at European and international level could help prevent macro-economic imbalances, monetary difficulties, fiscal competition, unemployment and employment problems and other

forms of economic and financial disorders. It will take into account the growing interdependencies between Union and global economies, markets and financial systems. ***The European cities have to be at the heart policies aiming to create growth, jobs and a sustainable future. The scrutiny of their performance – how well they function, their liveability, their attractiveness to investment and skills – is therefore critical to Europe's success. A European research agenda knowledgeable of inclusive urban development is more able to mitigate the social and the economic cost of inter-regional contrasts.***

6.1.2. Building resilient and inclusive societies in Europe

Understanding social, ***political and cultural*** transformations in Europe requires the analysis of changing democratic practices and expectations as well as of the historical evolution of identities, diversity, territories, ***languages***, religions, cultures and values. This includes a good understanding of the history of European integration. Besides, understanding the strains and opportunities arising from the uptake of ICT, both at individual and collective levels, is important in order to open new paths of inclusive innovation. It is essential to identify ways to adapt and improve the European welfare systems, public services and the broader social security dimension of policies in order to achieve cohesion, ***gender equality*** and promote more social and economic equality, and ***intra- and*** intergenerational solidarity. Research will analyse how societies and politics become more European in a broad sense through evolutions of identities, cultures and values, the circulation of ideas and beliefs and combinations of principles and practices of reciprocity, commonality and equality. It will analyse how vulnerable populations can participate fully in society and democracy, notably through the acquisition of various skills and the protection of human rights. The analysis of how political systems respond or not to such social evolutions and themselves evolve will thus be central. Research will also address the evolution of key systems that provide underlying forms of social bonds, such as family, work, education and employment and help combat poverty. It will take into account the importance of migration, and demography in the future development of European policies.

Given the increasing socio-economic importance of digital inclusion, research and large-scale innovation actions will promote inclusive ICT solutions and the effective acquisition of digital skills leading to the empowerment of citizens and a competitive workforce. Emphasis will be given to new technological advances that will enable a radical improvement in personalisation, user-friendliness and accessibility through a better understanding of citizen, consumer and user behaviours and values, including persons with disabilities. This will require an "inclusion by design" research and innovation approach.

6.1.2a. Addressing European models for social cohesion and well-being

Europe and the Union have developed a specific and rather unique combination of economic progress, social policies aimed at a high level of social cohesion, humanistic shared cultural values embracing democracy and the rule of common law, human rights, the respect and preservation of the diversity of cultural heritage, as well as the promotion of education and science, arts and humanities as fundamental drivers of social and economic progress and wellbeing. This

"European Social Model" has somehow contributed to shaping the unity of Europe and its international role.

Globalisation and demography, as well as European integration itself, and the shifting international economical and financial environment, can now be perceived both as major challenges and as factors shaping the diversity and the future of European social models of economic development.

Research able to contribute new knowledge to our understanding of those factors and challenges across Europe, and how public policies may interact and contribute to the sustainability of our major social and economic objectives, is therefore a priority to be addressed.

Benchmarking the dynamics of European societies and economies in view of strengthening Europe's unity and inclusiveness as fundamental drivers of economic and social progress, assessing and comparing public policies against the variety of challenges across Europe, understanding the new conditions and opportunities for greater European integration, assessing the role of the European model and of its social, cultural, scientific and economic components and synergies as sources of comparative Union advantages at world level, shall be considered.

6.1.3. Strengthening Europe's role as a global actor. (...)

6.1.4. *(delete)*

6.2. Innovative and reflective societies

(...)

6.2.1. *Strengthening the evidence base and support for the Innovation Union and European Research Area*

In order to assess and prioritise investments and strengthen the Innovation Union and the European Research Area, the analysis of research and innovation policies, systems and actors in Europe and third countries as well as the development of indicators, data and information infrastructures will be supported. ***Coordination with other European policies, such as education, innovation and cohesion policies will also be envisaged, as stated in The Ljubljana Process.*** Forward-looking activities and pilot initiatives, economic analysis, policy monitoring, mutual learning, coordination tools and activities and the development of methodologies for impact assessment and evaluations will also be needed, exploiting direct feedback from research stakeholders, enterprises, public authorities, ***civil society organizations*** and citizens.

To ensure a single market for research and innovation, measures to incentivise ERA compatible behaviour will be implemented. Activities underpinning policies related to the quality of research training, mobility and career development of researchers will be supported, including initiatives to provide for mobility services, open recruitment, researchers' rights and links with global researcher communities. These activities will be implemented seeking synergies and close coordination with the Marie Curie Actions under 'Excellent science'. Institutions presenting innovative concepts for the rapid implementation of ERA principles, including the European Charter for Researchers and the Code of Conduct for the Recruitment of Researchers, will be supported.

As regard coordination of policies, a facility for policy advice will be set up to make expert policy advice available to national authorities when defining their National Reform Programmes and research and innovation strategies.

To implement the Innovation Union initiative, there is also a need to support (private and public) market-driven **and non-market driven** innovation in view of enhancing the innovation capacity of firms and fostering European competitiveness **as well as social, economic and ecological resilience**. This will require improving the overall framework conditions for innovation as well as tackling the specific barriers preventing the growth of innovative firms. Powerful innovation support mechanisms (for e.g. improved cluster management, public-private partnerships and network cooperation), highly specialised innovation support services (on e.g. IPR management/exploitation, innovation management, networks of procurers) and reviews of public policies in relation to innovation will be supported. Issues specific to SMEs will be supported under the specific objective 'Innovation in SMEs'.

6.2.2. *Exploring and understanding new forms of innovation, including social innovation and creativity*

Social innovation generates new goods, services, processes and models that meet societal needs and create new social relationships. It is important to understand how social innovation and creativity may lead to change in existing structures and policies and how they can be encouraged and scaled-up. Grassroots on-line and distributed platforms networking citizens and allowing them to collaborate and co-create solutions based on an extended awareness of the social, **cultural**, political and environmental context can be a powerful tool to support the objectives of Europe 2020. Support will also be given to networking and experimentation of the use of ICT for improving learning processes, as well as to networks of social innovators and social entrepreneurs.

It will be essential to promote innovation in order to foster efficient, open and citizen-centric public services (eGovernment). This will require multidisciplinary research on new technologies and large-scale innovation related in particular to digital privacy, interoperability, personalised electronic identification, open data, dynamic user interfaces, citizen-centric public service configuration and integration and innovation driven by users, including in social sciences and the humanities. Such actions will also address social-network dynamics and crowd-sourcing and smart-sourcing for co-production of solutions addressing social problems, based on open data sets. They will help to manage complex decision-making, in particular the handling and analysis of huge quantities of data for collaborative policy modelling, simulation of decision-making, visualisation techniques, process modelling and participatory systems as well as to analyse changing relationships between citizens and the public sector. **Increased levels of complexity, the implications of questions posed by technology, advanced computation, life sciences and bio-engineering impinge upon areas of knowledge traditionally related with human studies, such as philosophy, theology, and legal, political and economic thought should be addressed. It is important to combine art, science and entrepreneurship; new forms of urban expression; knowledge, art and entrepreneurship related to the integration of multiculturalism and integration of migratory flows; multilingualism.**

6.2.1a. – Exploring processes which provide a favourable background to creativity and innovation

Providing a better understanding of the social, cultural, economic and political context for innovation shall be a priority. New knowledge on how "innovative societies" emerge and prosper is needed. In the current international economic context, this requires a fresh view of the conditions for sustainability of innovative socio-economic environments based on detailed and systematic field work and comparative analysis.

Social cohesion and predictable justice, education, democracy, tolerance and diversity are factors that need to be carefully considered with a view to identifying and better exploiting European comparative advantages at world level and of providing improved evidence-based support to innovation policies.

In particular, the role of youth perception of the opportunities for innovation in the current economic environment of high unemployment in many EU regions shall be carefully understood in relation to education and to the risk of brain-drain.

The role of risk governance policies need to be better understood in its relations with innovation policies and the shaping factors and actors of innovation. Clarifying, in the context of innovation, some of the current controversies, namely the debate risk versus precaution, or the role of distinct regulatory environments, is of major importance and requires new unbiased scientific approaches.

6.2.3. Understanding coherent and effective cooperation with third countries.

International cooperation is an horizontal priority through the whole Horizon 2020. Horizontal activities will ensure the strategic development of international cooperation across Horizon 2020 and address cross-cutting policy objectives. Exploring how activities to support bilateral, multilateral and bi-regional policy dialogues in research and innovation with third countries, regions, international fora and organisations can facilitate policy exchange, mutual learning and priority setting, promote reciprocal access to programmes and monitor the impact of cooperation **is extremely important in order to enhance the potential benefits of international cooperation.** Exploring innovative ways of networking and twinning activities will facilitate optimal partnering between research and innovation actors on both sides and improve competencies and cooperation capacity in less advanced third countries. Activities will also **examine how** coordination of Union and national cooperation policies and programmes as well as joint actions of Member States and Associated Countries with third countries **can be improved in order to** enhance their overall impact. Finally, **the effectiveness and appropriateness** of European research and innovation 'presence' in third countries **will be explored with the aim to** consolidate and strengthen, notably by promoting the creation of European 'science and innovation houses', services to European organisations extending their activities into third countries and the opening of research centres established jointly with third countries to organisations or researchers from other Member States and Associated Countries.

6.2.4. Regulatory and economical challenges for the future

The objective is to research how and where there may be need for new regulatory frameworks to accommodate for the new relationships between citizens and their

societies, as well as markets and their consumers. This includes cross-scientific research combining legal analysis with the economic, cultural and social impacts of the technological changes.

6.2.5. Cultural heritage and European identity

The aim is to contribute to an understanding of Europe's intellectual basis: its history and the many European and non-European influences European diversity and its opportunities should be recognized and considered.

European collections, including digital ones, in libraries, archives, museums, galleries and other public institutions have a wealth of rich, untapped documentation and objects for study. These cultural heritage resources represent the history of individual Member States but also the collective heritage of a European Union that has emerged through time. Such materials should be made accessible through new and innovative technologies and integrated information services to researchers and citizens to enable a look to the future through the archive of the past and to contribute to the European participative intelligence. Accessibility and preservation of cultural heritage in these forms is needed for the vitality of the living engagements within and across European cultures by also considering the importance of cultural heritage as strong economic driver in a post-industrial economy and its contribution to sustainable economic growth.

CA 27 - EPP– S&D – ALDE - ECR

187 - 155 - 932 - 933 - 934 - 935 - 936 - 937 - 938 - 939 - 940 - 941 - 942 - 943 - 944
- 945 - 946 - 951 - 952 - 953 - 954 - 955 - 956 - 957 - 958 - 959 - 960 - 961 - 962 -
963 - 964 - 965 - 966 - 967 - 968 - 969 - 970 - 971 - 972 - 973 - 974 - 975 - 976 - 977
- CULT29 - CULT30 – AFET15 - ENVI107

PART III - SOCIETAL CHALLENGES

6.a (new). **Secure societies** - *Protecting freedom and security of Europe and its citizens*

The European Union, its citizens and its international partners are confronted with a range of security threats **and challenges such as** crime, terrorism and mass emergencies due to man-made or natural disasters. These threats can span across borders and **affect** physical targets or the cyberspace. Attacks against Internet sites of public authorities and private entities, for instance, not only undermine the citizen's trust but may seriously affect such essential sectors as energy, transport, health, finance or telecommunications.

In order to anticipate, prevent and manage these threats, it is necessary to develop and apply innovative technologies, solutions, foresight tools and knowledge, stimulate cooperation between providers and users, find civil security solutions, improve the competitiveness of the European security, **(deletion)** and services industries and prevent and combat the abuse of privacy and breaches of human **and fundamental** rights..

The coordination and improvement of the security research area will thus be an essential element and will help to map present research efforts, including foresight, and improve relevant legal conditions and procedures for coordination, including **standardisation** activities.

Activities will follow a mission-oriented approach and integrate the relevant societal dimensions. They will support the Union's policies for security, defence policies, and the relevant new provision of the Lisbon Treaty, and ensure cyber security, trust and privacy **by design and fundamental rights compliance (deletion)**. The following specific objectives will be pursued:

6.a.1. Fighting crime and terrorism.

The ambition is both to avoid an incident and to mitigate its potential consequences. This requires **an understanding of underlying causes and impacts, as well as the development of** new technologies and capabilities (including against cyber crime and cyber terrorism) for the support to health, food, water and environmental security which are essential for the good functioning of society and economy. **(deletion)**. This will include analysing and securing public and private critical networked infrastructures and services against any type of threats. **Attention shall also be paid to the social and behavioural dimensions of crime and terrorism, in order to fully understand their causes and impacts, and to identify effective social policy measures to address these. Additional topics aimed at improving the protection of citizens will foster the development of secure civil societies.**

6.a.2. Protecting and improving the resilience of critical infrastructures

New technologies and dedicated capabilities will help to protect critical infrastructures, systems and services (including communications, transport, health, food, water, energy, logistic and supply chain, and environment). This will include analysing and securing public and private critical networked infrastructures and services against any type of threat.

6.a.3. Strengthening security through border management and maritime security

Technologies and capabilities are also required to enhance systems, equipments, tools, processes, and methods for rapid identification to improve border security ***and management***, including both control and surveillance issues, while exploiting the full potential of EUROSUR, ***the European external border Surveillance System***. These will be developed and tested considering their effectiveness, compliance with legal and ethical principles, proportionality, social acceptability and the respect of fundamental rights. Research will also support the improvement of the integrated European border management, including through increased cooperation with candidate, potential candidate and European Neighbourhood Policy countries. ***The full range of maritime security aspects will be addressed. This includes blue border management aspects as well as protection and control of water transport.***

6.a.4. Providing cyber security

Cyber security is a prerequisite for people, business and public services in order to benefit from the opportunities offered by the Internet. It requires providing security for systems, networks, access devices, and software and services, including cloud computing, while taking into account the interoperability of multiple technologies.

Research will prevent, detect and manage in real-time cyber-attacks across multiple domains and jurisdictions, and to protect critical ICT infrastructures. ***The digital society is in full development with constantly changing uses and abuses of the Internet, new ways of social interaction, new mobile and location-based services and the emergence of the Internet of Things. This requires a new type of research which should be triggered by the emerging applications, usage and societal trends.***

6.a.5. Increasing Europe's resilience to crises and disasters and supporting the Union's internal and external security policies

Europe's preparedness and resilience to crisis and disasters needs to be increased. This requires the development of dedicated technologies and capabilities to support different types of emergency management operations (such as civil protection, fire fighting and marine pollution, humanitarian aid, ***(deletion)***, development of medical information infrastructures rescue tasks ***(deletion)*** as well as law enforcement. Research will cover the whole crisis management chain and societal resilience, and support the establishment of a European emergency response capacity.

The dividing line between external and internal security is increasingly blurred, conflicts outside of Europe and their consequences can rapidly have a direct impact on Europe's security. Furthermore the interface between civil and defence oriented activities and policies requires particular attention as there is a large opportunity to exploit synergies between civil protection, situation assessment, conflict

management and conflict prevention, peace-keeping and post-crisis stabilisation operations. The development of crisis management capabilities shall be encouraged where complementarities have been identified, so as to quickly close capability gaps whilst avoiding unnecessary duplication, creating synergies and supporting standardisation.

6.a.6. (deletion) Enhancing the societal dimension of security and ensuring privacy and freedom in the Internet

Any new security solution and technology needs to be acceptable to the society, comply with Union and international law, be effective and proportionate in identifying and addressing the security threat. Better understanding the socioeconomic, cultural, and anthropological dimensions of security, the causes of insecurity, the role of media and communication and the citizen's perceptions, are therefore essential. Ethical issues and protection of human values and fundamental rights compliance will be ensured.

Safeguarding the human right of privacy in the digital society will require the development of privacy-by-design frameworks and technologies since the conception of products and services. Technologies will be developed **empowering** users to control their personal data and its use by third parties; as well as tools to detect and block illegal content and data breaches and to protect human rights on-line preventing that people's behaviours individually or in groups is limited by unlawful searching and profiling.

6a.7. Enhancing standardisation and interoperability

Pre-normative and standardisation activities will be supported across all mission areas. Focus will be on identified standardisation gaps and the next generation of tools and technologies. Activities across all mission areas will also address the integration and interoperability of systems and services, including aspects such as communication. This also requires integrating civilian and military capabilities in tasks ranging from civil protection to humanitarian relief, border management or peace-keeping. This will include technological development in the **(deletion)** area of **bridging** dual-use technologies to guarantee interoperability between civil protection and military forces and amongst civil protection forces worldwide, as well as reliability, organisational, legal and ethical aspects, trade issues, protection of confidentiality and integrity of information and traceability of all transactions and processing **without infringing the fundamental rights to privacy and protection of personal data.**

6.a9. Specific implementation aspects

(...)

CA 27A - EPP - S&D - ALDE - Greens - ECR
157 - 158 - 984 - 985 - 986 - 987 - 988 - ENVI111 - ENVI112 - ENVI115 -
ENVI118 - ENVI119 - ENVI120 - FEMM23 - FEMM24 - FEMM25

Annex II **Performance indicators**

Additionally to the performance indicators for assessing progress against the general objectives of Horizon 2020, set out in Annex I of Regulation (EU) No XX/2012 [Horizon 2020], the following table specifies for the specific objectives of Horizon 2020 a limited number of key indicators for assessing results and impacts.

1. PART I. PRIORITY 'EXCELLENT SCIENCE'

Specific objectives:

- (...)
- Future and Emerging Technologies
 - Publications in peer-reviewed high impact journals
 - Patent *and utility model* applications in Future and Emerging Technologies
- Marie Curie actions on skills, training and career development
 - Cross-sector and cross-country circulation of researchers, including PhD candidates *as well as number of publications in peer-reviewed journals and participation in research and innovation projects inspired by that circulation.*
- **European research infrastructures (including eInfrastructures)**
 - Research infrastructures *developed across the whole Europe* which are made accessible to all researchers in Europe and beyond through Union support

2. PART II. PRIORITY 'INDUSTRIAL LEADERSHIP'

Specific objectives:

- **Leadership in enabling and industrial technologies** (ICT, Nanotechnologies, Advanced Materials, Biotechnologies, Advanced manufacturing and Space)
 - Patent *and utility model* applications obtained in the different enabling and industrial technologies
 - *Number of inventions commercialised*

- *Number of SMEs participating*
- **Access to risk finance**
 - Total investments mobilised via debt financing and Venture Capital investments
 - *Number of SMEs participating*
- **Innovation in SMEs**
 - Share of participating SMEs introducing innovations new to the company or the market (covering the period of the project plus three years)
 - *Number of start-ups created*

3. PART III. PRIORITY 'SOCIAL CHALLENGES'

Specific objectives:

(...)

Additional performance indicators are:

Publications in peer-reviewed high impact journals in the area of the different Societal Challenges

- Patent *and utility model* applications in the area of the different Societal Challenges
- *Number of SMEs participating*
- Number of Union pieces of legislation referring to activities supported in the area of the different Societal Challenges
- *Number of Innovation Union objectives achieved*

(...)