

Scoping Paper for
Horizon 2020 work programme 2018-2020
Future and Emerging Technologies (FET)

Important Notice: Working Document

This scoping paper will guide the preparation of the work programme itself. It is a working document not formally endorsed by the Commission, and its content does not in any way prejudge the final decision of the Commission on the work programme.

The adoption and the publication of the work programme by the Commission are expected in October 2017. Only the adopted work programme will have legal value.

Scoping paper for the Horizon 2020 work programme 2018-2020 Future and Emerging Technologies (FET)

1. Context

The mission of FET is to turn Europe's excellent science base into a competitive advantage by uncovering radically new technological possibilities. It helps Europe to grasp leadership early on in new and emerging technology areas that promise to renew the basis for European competitiveness and growth and that will make a difference for society in decades to come.

With its work programme for 2018-2020, FET responds to the following main political drivers of the Commission:

Disruptive and Open Innovation: Europe needs a modernised industrial base supported by cutting-edge key enabling technologies, and more companies that produce breakthrough innovations that are radical, disruptive, capable of rapid scale-up, and ready for expansion in new and global markets. In particular, open innovation and cross-industry innovation will allow achieving these goals.

Therefore, the FET work programme 2018-2020 aims to:

- Consolidate FET as a science and technology driven high-risk / high-gain innovation engine to inspire new and potentially disruptive directions for society, industry and entrepreneurship.
- Attract new high-potential actors, in particular young researchers and high-tech SMEs, and help them to become the research and business leaders of tomorrow.
- Offer pathways for open innovation from FET project results and stimulate the emergence of new innovation eco-systems and industries around future and emerging technologies (start-ups, greenhousing, linking to users, investors, industry, citizens...).
- Create optimal integration in, or interfaces with a future European Innovation Council (EIC). Parts of FET may play a role in the EIC pilot phase (2018-2020).

Digital Single Market (DSM) – Digitising European Industry: We stand on the brink of a new industrial revolution, driven by technological breakthroughs such as the Internet of Things, cloud computing, artificial intelligence, big data analytics, robotics and 3D printing. The EU's Digital Single Market (DSM) initiative now puts in place a forward looking strategy to bring these technologies to European Industry and society – in a big way.¹

For many years FET has been spearheading the technology research for High-Performance Computing (HPC) and for Quantum Technologies, two cornerstones of the DSM strategy². This FET work programme will further capitalise on European research excellence for **achieving European leadership** in both these future and emerging digital technologies:

- Achieving European independence and capacity for **high-performance computing** as a strategic resource for digitising European industry and society.^{3, 4}

¹ See the DSM strategy on digitising the European industry, http://europa.eu/rapid/press-release_IP-16-1407_en.htm

² European Cloud Initiative - Building a competitive data and knowledge economy in Europe (COM(2016) 178 final) http://ec.europa.eu/newsroom/dae/document.cfm?doc_id=15266

³ Staff working document on Implementation of the Action Plan for the European High-Performance Computing strategy, SWD(2016) 106 accompanying COM(2016) 178 http://ec.europa.eu/newsroom/dae/document.cfm?doc_id=15269

- Capitalising on European Excellence in **Quantum technologies** for a radical future ICT, driven by an emerging European quantum industry with global standing.⁵

Physical meets digital – digitization of the researching/learning, working and living environment offers huge opportunities for additional growth with disruptive changes in areas like health, food, water, agriculture, energy, transport, manufacturing and others.

Therefore the FET work programme 2018-2020 aims to:

- Stimulate open and **cross disciplinary science and innovation**, aimed at creating new digitally enabled disruptive technologies and contributing to the European next generation industries.
- Advance ICT for creating **user-centric** HPC systems, simulation, artificial intelligence and data-analytics ('big-data') solutions in specific areas of great societal interest (e.g., focus areas and societal challenges).

The three O's. The FET Work programme will contribute significantly to the three O's:

- **Open Innovation** through its collaborative spirit, interdisciplinarity, and stimulation of a broad and diverse mix of stakeholders with particular attention to early innovation steps.
- **Open Science** through its essential contribution to open-data, digital science and innovation, and the European Science Cloud.
- **Open to the world** by welcoming participation from across the world, by benchmarking itself against the best, and by the active collaboration with relevant large scale initiatives worldwide, for instance in the FET Flagships.

The orientations outlined below were identified from the following inputs:

- the reports of the FET Advisory Group⁶ (FETAG) and discussions with the ERC-FET- MSCA Programme Committee;
- three public consultations (February-April 2016) aimed at gathering ideas for research directions for the FET Proactive and FET Flagships schemes, and for Mathematics for Excellence in Science in Horizon 2020;⁷
- FET portfolio analysis (including the results of FET-funded CSAs);
- the research priorities of the cPPP on High Performing Computing (ETP4HPC)⁸;
- political orientations, in particular the Cloud Communication, as part of the DSM initiative and input from a series of activities with member states, industry and

⁴ The European Council of 28 June 2016 in its conclusions called for "swift and determined progress ... to create the right conditions for stimulating new business opportunities by ... coordinating EU efforts on high-performance computing. In this context the European Council looks forward to the launch of an important project of common European interest in this field;" (<http://www.consilium.europa.eu/en/press/press-releases/2016/06/28-euco-conclusions/>)

⁵ Staff working document on Quantum Technologies, SWD(2016) 107 accompanying COM(2016) 178 http://ec.europa.eu/newsroom/dae/document.cfm?doc_id=15270

⁶ https://ec.europa.eu/futurium/en/system/files/ged/the_future_of_fet.pdf

⁷ <https://ec.europa.eu/digital-single-market/en/news/have-your-say-future-and-emerging-technologies-and-mathematics-horizon-2020>

⁸ See <http://www.etp4hpc.eu/strategy/strategic-research-agenda/>

researchers around the topic of Quantum Technologies, in particular the Commission staff working document on Quantum Technologies⁹ and the Quantum manifesto¹⁰;

- the input from ongoing activities in the two FET Flagships (Graphene¹¹ and HBP¹²);
- the early inputs from the Horizon 2020 interim evaluation, including the FET Flagships Interim Evaluation panel.

The **FETAG** highlights the power of the combined bottom-up top-down model of FET, the potential for seeding innovation from FET, the risk of sustained oversubscription in FET-Open. It further highlights the need for flexible use of instruments to allow for serendipity, to accommodate innovative outcomes, for fast reaction times and sustained support to promising directions. FETAG also advocates the integration of (part of) FET in a future European Innovation Council (EIC).

The public consultation on **FET Proactive** has gathered 59 contributions (and some 300 comments) for future proactive initiatives. They cover a broad range of topics: decentralised media and information services, bio-medical technologies, new components (notably spin-based), complex adaptive systems, science and art, global systems science, new computational paradigms, energy, sustainability, geology, cosmology, smart materials, robotics, HPC and HCI. With few exceptions they have the potential for proactive initiatives.

In total, 24 ideas for new **FET Flagships** were submitted to the consultation. The large majority of these ideas reflect or represent the views of large research communities and scientific societies, networks of Universities, research institutions, and private organisations. They address emerging grand challenges in a broad range of S&T fields. Most of them consider ICT either as an underpinning technology for addressing grand challenges in areas such as health, energy, earth-sciences and climate change, the life sciences, etc., or as a still emerging technology area with its own grand challenges. Several of the submitted ideas have the S/T excellence, ambition, scale and level of maturity required for a Flagship.

From the **mathematics** consultation¹³ we retain the importance of mathematics as an enabler for advanced ICT (algorithms, big-data, fundamentals) and applications (modelling, simulation, optimisation, data analytics). Fundamental issues in modelling, as well as new developments needed for a 'mathematics of life' could be included in some specific FET initiatives as well.

➤ Gaps identified in gap analysis (please mention if none are found)

The different FET work programmes have so far addressed the elements of the Horizon 2020 specific programme. However, the extreme oversubscription which is observed in the programme indicates that the opportunities offered are too limited in terms of available funding to satisfy high demand and do not match the demand of the R&I community. This is

⁹ Staff working document on Quantum Technologies SWD(2016) 107 accompanying COM(2016) 178, http://ec.europa.eu/newsroom/dae/document.cfm?doc_id=15270

¹⁰ <http://quope.eu/system/files/u567/Quantum%20Manifesto.pdf>

¹¹ www.graphene-flagship.eu

¹² www.humanbrainproject.eu

¹³ The consultation report is available here

https://ec.europa.eu/futurium/en/system/files/ged/finalreport_maths.pdf

particularly the case for FET-Open in which the acceptance rate is currently at 4%, leaving many excellent ideas for renewing Europe's technological base unexplored.

2. Strategic orientations for 2018-2020 and translation into calls

FET has three main lines of activity – Open, Proactive and Flagships – that contribute, each in their own way, to achieving its mission.

- I. **FET Open** supports early-stage high-risk / high-gain joint science and technology research around new ideas for radically new future technologies. It explores an open range of new and disruptive technological possibilities, inspired by cutting-edge science, unconventional collaborations and pioneering new ways to stimulate serendipity. As a creative powerhouse for new technologies, it has each of the **three O's** at its heart. Horizon 2020 allocates 40% of the FET budget to FET-Open.

Increase the support to FET-Open. The FET-Open budget for 2018-2020 will double in comparison to the period 2014-17, reaching around 200MEuro per year, on average (and the 40% target for Horizon 2020 overall). We will maintain FET-Open as a light-and-fast open call in a continuous spirit, with a single stage submission of relatively short RIA proposals (15 pages) and a top-class evaluation, selection and implementation process¹⁴.

Address oversubscription. FET-Open is one of the most oversubscribed parts of Horizon 2020. The increasing budget will reduce oversubscription. In addition, a mix of other measures are needed such as flexible size of projects, reducing resubmission, careful planning of cut-off dates while maintaining the continuous character of the call, crisp definition of scope (the FET gatekeepers) while respecting the thematic openness.

Renewing participation and stimulating continuity with other parts of Horizon 2020. FET-Open caters to a wide range of high-potential actors, including young researchers, start-ups, high-tech SMEs and entrepreneurs that are best placed to realise the disruptive potential from FET research. We will design measures to address the funding gap for promising projects and to foster links with the rest of Horizon 2020 by cross-pillar exposure of projects and stimulating cross-over of participants between different parts of the programme.

FET-Open and EIC. While no firm decisions are made on EIC, an EIC pilot during 2018-2020 can include a bottom-up high-risk/high gain research pillar based on FET-Open. FET-Open is already taking up its science-driven technological innovation role. This WP will maintain the high-risk high-gain science driven character of FET and bring to the fore the specific character of disruptive innovation which is inherent in the visionary orientations and interdisciplinary collaborations within its projects.

Stimulate innovation from FET projects. Although FET-Open projects are not initially market oriented, they do provide fertile ground for disruptive innovation, often as a serendipitous result. Following on the previous WP, we will continue developing flexible tools for innovation from results of FET research¹⁵, such as the FET Innovation Launchpad

¹⁴ FET-Open is being implemented through the Research Executive Agency (REA)

¹⁵ As other parts of Horizon 2020, and EIC in particular, are developing innovation oriented topics in their Work Programmes we will take care not to duplicate efforts in FET. For instance, a Launchpad type (or Proof-of-Concept) of extra funding possibility could be offered as an EIC type of grant in general. Complementarity with ODI and the SME scheme, which both target close to market SME activities, will be assured as before.

and open review. The FETAG will continue playing a guiding role, as nucleus for a full-fledged EIC Advisory body.

- II. **FET Proactive** nurtures emerging themes and communities by addressing a number of promising exploratory research themes with the potential to generate a critical mass of research that, together, make up a broad and multifaceted exploration of the themes and build a European pool of knowledge and excellence.

FET Proactive – Emerging themes and communities: we will develop FET Proactive around a balanced range of new topics that emerge from the public consultations on [FET Proactive](#) and the FET portfolio, among others. We will further diversify the range of topics, in line with the FET mandate, possibly including ambitious and concrete challenges (FETAG advice) and the use of inducement prizes, where appropriate, to diversify impacts.

In line with FETAG, FET-Proactive will support a mixture of **prestigious both smaller scale and larger scale grants for paradigm-changing inter-disciplinary collaborative research on future technologies**. These projects will serve as **references** in the field. They will **stimulate the innovation ecosystem around** them for take-up of results well beyond FET and the research world, thus contributing to **Open Science and Open Innovation**.

Enhance articulation with FET-Open, FET-Flagships and other parts of the programme. FET Proactive has the strategic role to mature promising future and emerging technology areas, detected and continuously challenged by FET-Open, that can find their way into other programmes (including national ones) and to **new, future and emerging industries**, some through FET-Flagships. This interplay between bottom up and top down is an essential part of the concept and success of FET.

The Proactive initiative on HPC implements part of the commitment for the contractual Public Private Partnership with the European Technology Platform in HPC (ETP4HPC). It supports the implementation of the **European HPC strategy**¹⁶, within the broader context of the **European Cloud Initiative**¹⁷. This strategy combines three elements: (a) developing HPC towards energy-efficient exascale (including architecture, hardware, software, mathematical models, algorithms, etc.); (b) providing access to the best supercomputing facilities and services; and (c) achieving excellence in HPC applications. The Strategic Research Agenda of ETP4HPC¹⁸ frames the implementation, partly in this FET initiative, of elements (a) and (c).

The advanced HPC technology development activities in FET will be **coordinated with other parts of Horizon 2020**, notably the relevant topics within **LEIT-ICT** (integration work, development of low-power chips) and with the **e-Infrastructure** part of the Excellent Science pillar for supporting the HPC strategy towards exascale capacity in technology and services and for widening the user base. FET also seeks to work with user communities for the co-design of 'Extreme Scale Demonstrators' (see HPC SRA) to meet the real needs of

¹⁶ High Performance Computing: Europe's place in a Global Race COM(2012)45) and Council Conclusions of 29/30 May 2013, http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/intm/137344.pdf

¹⁷ European Cloud Initiative - Building a competitive data and knowledge economy in Europe (COM(2016) 178 final) http://ec.europa.eu/newsroom/dae/document.cfm?doc_id=15266

¹⁸ See <http://www.etp4hpc.eu/strategy/strategic-research-agenda/>

users of strategic societal applications, and by opening up to other players. The HPC activities will also support the required synergy with the Important Project of Common European Interest (IPCEI) on HPC and Big Data Enabled Applications.¹⁹

III. **FET Flagships** support ambitious large-scale, science-driven research aimed at grand interdisciplinary S&T challenges.

Provide sustained support for the implementation of the two ongoing Flagships, Graphene and HBP, in the period 2020-2022. This WP will permit them to continue to execute the 3rd phase of their research and innovation roadmap and action plan as these are established in the Framework Partnership Agreements (FPA), which they signed with the Commission in 2015. Both Flagships are significantly contributing to the 3 O's, and in particular to open science and open to the world.²⁰ Their expected impacts are described in their respective FPAs. The work programme 2018-20 will also ensure the continuation of the FLAG-ERA II Cofund action (launched under the work programme 2016-17) in order to continue to mobilise the Member States support for the Flagships through transnational calls.

Provide support for the definition and implementation of new Flagships: Although HBP and Graphene are still in a rather early phase of the implementation of their roadmap and action plan, they start already delivering their promises as game-changers by converting scientific advances into concrete technology and innovation opportunities of benefit to Europe's economy and society.²¹ Given the positive impacts that can already be observed – common roadmap and action plan, broad stakeholder involvement, joint support from Commission and Member States, synergies with national and regional programmes, attracting best brains worldwide, stimulating entrepreneurship and innovation, visibility and global partnerships – this work programme will support the **preparation and launch of new Flagships**.

A new **Quantum Flagship** aims to bootstrap a world-class quantum industry in Europe to unlock the full potential of quantum technologies and bring products to markets. It is in line with the objectives set out in the Cloud communication²². The implementation and governance model will consider the specificities of this area. The Flagship will focus on ambitious long-term challenges of its S&T agenda, while the more downstream parts of its S&T agenda could be supported by other parts of Horizon 2020.

Other new Flagship initiatives will be based on the ideas received from the public consultations on [FET Flagships](#) and further discussions that will take place with the Member States. This Work Programme will permit to launch a few preparatory actions for candidate

¹⁹ See http://ec.europa.eu/commission/2014-2019/oettinger/blog/luxembourg-launches-supercomputing-project_en

²⁰ For example, HBP aims to deliver a world-class open research infrastructure for neurosciences, brain medicine and future computing that will stimulate a more open, more sharing, and more participative and collaborative research in neurosciences; and, Graphene has already established significant international research collaboration activities with the USA, Japan and Korea in graphene and related 2D materials.

²¹ For example, see the Graphene Flagship highlights of its ramp-up phase: http://graphene-flagship.eu/news/Pages/RampUp_Phase_Highlights_GrapheneFlagship.aspx

²² European Cloud Initiative - Building a competitive data and knowledge economy in Europe (COM(2016) 178 final) http://ec.europa.eu/newsroom/dae/document.cfm?doc_id=15266 and the staff working document on Quantum Technologies, SWD(2016) 107 accompanying COM(2016) 178 http://ec.europa.eu/newsroom/dae/document.cfm?doc_id=15270

Flagships. Without prejudging the next EU MFF, their final selection and full implementation will fall under the next research framework programme.

Call working title (indicate 'FA' if proposed as a focus area)	Brief description of the scope of the call including information if it is cPPP. If a focus area please show how the criteria have been met.	Possible contribution from and to other work programme parts (mandatory for focus areas)
FET-Open – novel ideas	The FET-Open Call is a bottom-up, non-thematic (technology neutral), light-and-fast open call in a continuous spirit (regular cut-off dates throughout 2018-2020), with a single stage submission of relatively short RIA proposals (15 pages). The call also has topics for CSA to enhance impacts, build communities and to boost innovation from FET (RIA, CSA).	Possible element of EIC pilot.
FET-Proactive – Emerging themes and communities	The main FET Proactive call RIA, ERANET Cofund, Prizes. One or two call deadlines on selected promising areas for future and emerging technologies.	
FET-Proactive – High-Performance Computing	cPPP on HPC. Implementation of the next stages of the HPC Strategic Research Agenda with a focus on the high-risk technology development. Probably one topic per year throughout 2018-2020. Promotion of excellence in HPC academic research and coordination actions will be included.	LET-ICT.
FET-Flagships – Quantum Technologies	A call for first core project of the Quantum flagship ramp-up phase could be launched early 2018. This activity could be complemented by work done in other parts of Horizon 2020 (in particular with LEIT-ICT) ²³ and ensure the continuation of the ERANET Cofund action from WP2016-17 on Quantum Technologies.	LEIT ICT for quantum areas within higher maturity level.
FET Flagships – HBP and Graphene	Ensures the continuation of the two Flagships, Graphene and HBP for their next phase, covering the period 2020-22 by inviting proposals for a third SGA under their respective FPA ('Other Actions'). It will also include topic for ERANET Cofund projects for helping MS continue their support to the Flagships.	
FET Flagships – new flagships beyond 2020	The call could be launched early 2018 for a few Flagship preparatory actions to help research communities develop a full research roadmap and build their consortia for candidate flagships. Their final selection and full implementation will fall under the next research framework programme.	

²³ for topics of higher technological maturity