

Update on European HPC – March 2018



Useful links:

Please check ETP4HPC current presentation at:

<http://www.etp4hpc.eu/pujades/files/ETP4HPC%20in%20a%20Nutshell%20-%2030%20May%202017%20-Public%20copy-%201.pdf>

Please also check the **European HPC Handbook – descriptions of all European HPC technology and application projects:**

<http://www.etp4hpc.eu/euexascale.html>

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2 Glossary

BD - Big Data

BDEC - Big Data and Extreme Computing, www.exascale.org

BoF - Birds-of-a-Feather

CoE - Centres of Excellence in Computing Applications

EOSC - European Open Science Cloud

EPI – European Processor Initiative

EsD - Extreme-scale Demonstrators

ETP4HPC - European Technology Platform for High Performance-Computing, www.etp4hpc.eu

EU - European Union (of 28 Member States)

EU+ - European Union (28 Member States) plus Norway and Switzerland

EXDCI - European Extreme Data & Computing Initiative, www.exdci.eu

FP7 - Framework Programme 7, https://ec.europa.eu/research/fp7/index_en.cfm

FP9 - Framework Programme 7

HiPEAC - High Performance and Embedded Architecture and Compilation, <https://www.HiPEAC.net/>

HPC - High Performance Computing

HPDA - High-Performance Data Analytics

I/O - Input/Output

ICT - Information and Communication Technologies

IPCEI HPC-BDA - an Important Project of Common European Interest in the area of HPC and Big Data, https://ec.europa.eu/commission/commissioners/2014-2019/oettinger/blog/luxembourg-launches-supercomputing-project_en

ISC - International Supercomputing Conference, <http://isc-hpc.com/>

PRACE – Partnership for Advanced Computing in Europe, www.prace-ri.eu

ROI - Return on Investment

SC – Supercomputing Conference, www.supercomputing.org

SHAPE - SME HPC Adoption Programme in Europe

SME - Small and Medium-size Enterprise(s)

SRA – Strategic Research Agenda, www.etp4hpc.eu/sra

WG - Working Group

3 Executive Summary

This document outlines the landscape of the European HPC Eco-system. An emphasis is placed on the current European ambitions in the development of Exa-scale level supercomputers and related solutions. It also identifies the areas of HPC technology that demonstrate a potential for international collaboration.

ETP4HPC, the European High-Performance Computing Technology Platform represents the European HPC technology Value Chain and issues a Strategic Research Agenda (SRA), a multi-annual roadmap for HPC technology development in Europe, the guidelines of which serve as the basis of the European Commission's research projects. The current European research programme, Horizon 2020 comprises projects aiming to develop cutting-edge HPC technology. These projects create a number of opportunities for international collaboration.

4 The European HPC strategy

4.1 The value of HPC for Europe

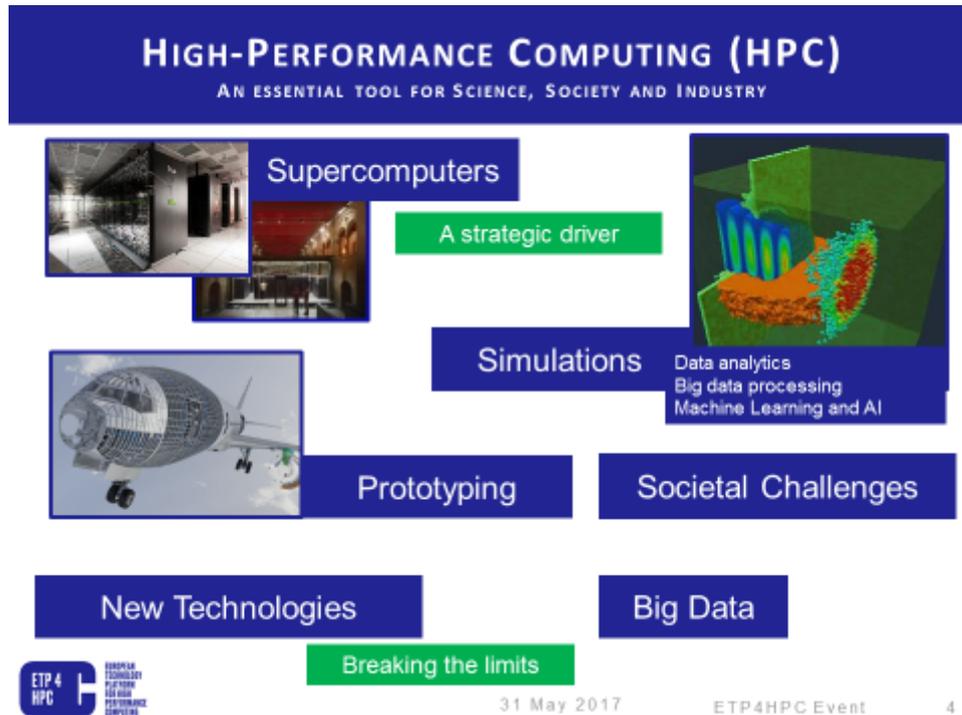


Figure 1 - The role of HPC.

The current European HPC Strategy was first defined by the European Commission in a publication titled: ‘High Performance Computing: Europe's place in a Global Race’¹ issued in 2012 and adopted by the European Union as an official strategy document in 2013².



Figure 2 - The first EC document outlining the European HPC Strategy.

This document recognises the value of HPC for the European economy and society. The European HPC Ecosystem aims to develop world-class HPC technologies, platforms and applications, leading to exascale systems and their advanced use, thus creating jobs, new products and more efficient companies as well as enabling scientific discoveries. This will

¹ <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2012:0045:FIN:EN:PDF>

² <https://ec.europa.eu/digital-agenda/en/news/conclusions-high-performance-computing-europes-place-global-race>

contribute to the economic competitiveness of the European economy as a whole and also to the well-being of the European citizen by equipping our scientists, economists, sociologists, agriculturalists, politicians and engineers to address the Grand Societal Challenges that the continent faces.

The strategy defined stipulates the need for the balanced development of the European HPC Eco-system based on three pillars.

- HPC Infrastructure (represented by Partnership for Advanced Computing in Europe, PRACE³)
- HPC Technology (represented by ETP4HPC, the European HPC Technology Platform⁴)
- Application expertise (represented by the Centres of Excellence of Computing Applications⁵)

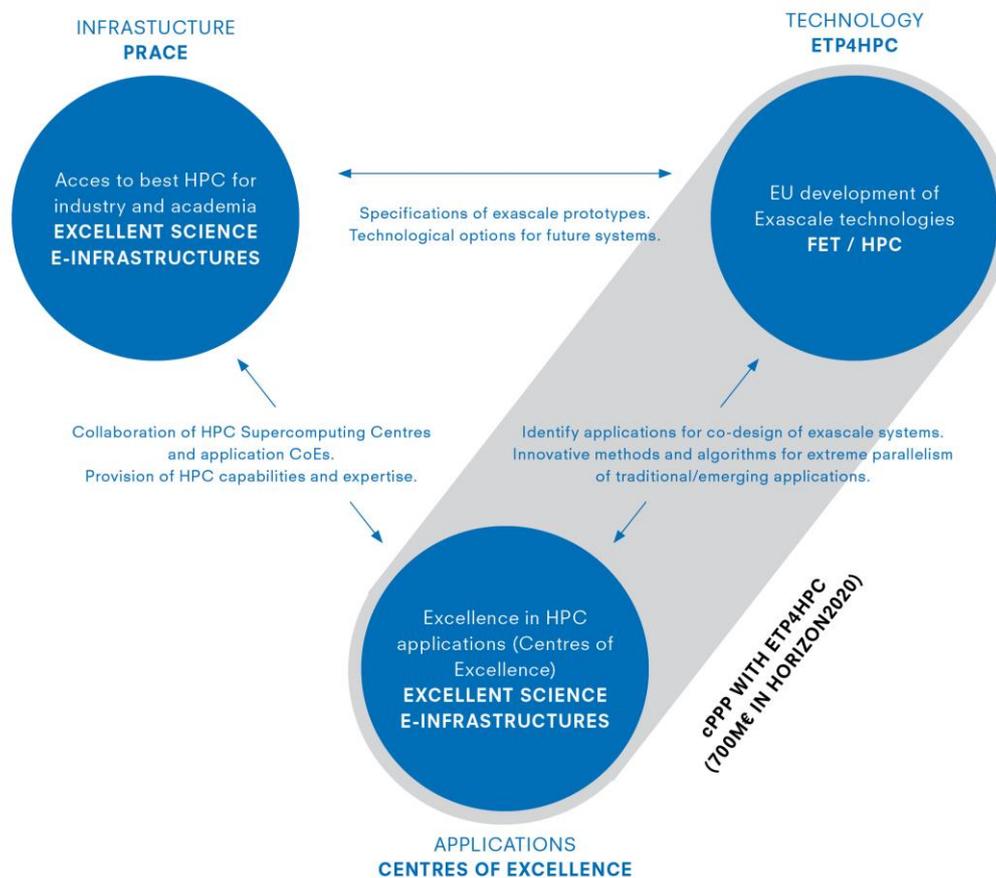


Figure 3 - The European HPC ecosystem, its tree pillars and their roles.

³ www.prace-ri.eu

⁴ www.etp4hpc.eu

⁵ A summary of the Centres of Excellence in Computing Applications is available at: <http://ec.europa.eu/programmes/horizon2020/en/news/eight-new-centres-excellence-computing-applications>

Figure 1 – The three pillars of the European HPC Eco-system and the interactions between them. The HPC cPPP covers the areas of technology provision and application excellence. The FETHPC⁶ programme of the EC supports the development of European HPC technology while the EINFRA⁷ calls include the operation of the Centres of Excellence in Computing Applications. The separately funded EXDCI project provides mechanisms for the coordination of the entire strategy.

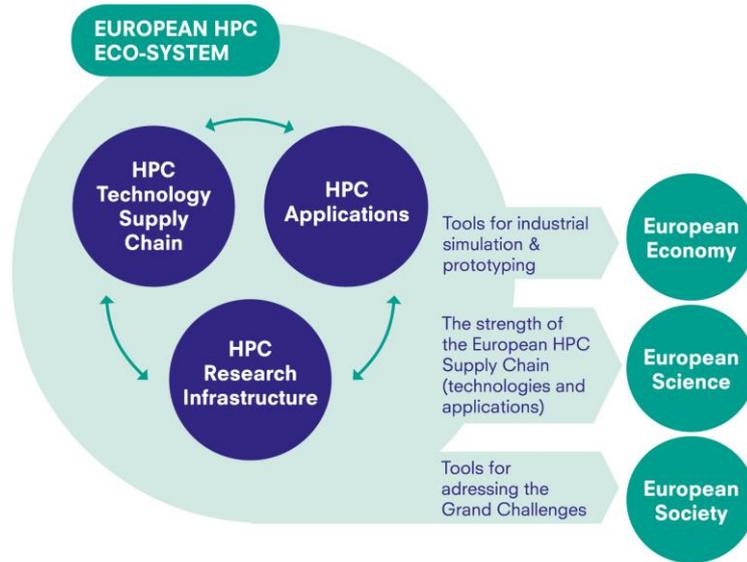


Figure 4 - The interactions between the three pillars of the European HPC Eco-system and the European economy, science and society.

5 The European Cloud Initiative⁸

As part of the package of measures for Digitising European industry, the "European Cloud Initiative – Building a competitive data and knowledge economy in Europe" aims to strengthen Europe's position in data-driven innovation, improve its competitiveness and cohesion, and help create a Digital Single Market in Europe.

This initiative will provide European science, industry and public authorities with:

- a world-class data infrastructure to store and manage data;
- high-speed connectivity to transport data; and
- ever more powerful High Performance Computers to process data.

⁶ The H2020-FETHPC-2016-2017 call text is available at: <http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/calls/h2020-fethpc-2016-2017.html#c.topics=callIdentifier/t/H2020-FETHPC-2016-2017/1/1/1&callStatus/t/Forthcoming/1/1/0&callStatus/t/Open/1/1/0&callStatus/t/Closed/1/1/0&identifier/desc>

⁷ The EINFRA-21-2017 call text is available at: <http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/2122-einfra-21-2017.html>

⁸ <https://ec.europa.eu/digital-single-market/en/%20european-cloud-initiative>

The Cloud Initiative will make it easier for researchers, businesses and public services to fully exploit the benefits of Big Data by making it possible to move, share and re-use data seamlessly across global markets and borders, and among institutions and research disciplines.

Making research data openly available can help boost Europe's competitiveness, especially for start-ups, SMEs and companies who can use data as a basis for R&D and innovation, and can even spur new industries.

5.1 What the Initiative proposes?

A European Open Science Cloud (EOSC) will offer Europe's 1.7 million researchers and 70 million science and technology professionals a virtual environment to store, share and re-use the large volumes of information generated by the big data revolution.

This will be underpinned by the European Data Infrastructure (EDI), deploying the high-bandwidth networks and the supercomputing capacity necessary to effectively access and process large datasets stored in the Cloud. Focusing initially on the scientific community, the user base will over time be enlarged to the public sector and to industry. This EDI will also enable to reduce the costs of data storage and high-performance analysis.

5.2 High Performance Computing and quantum

High Performance Computing (HPC) uses powerful supercomputers to solve complex computational problems or data intensive tasks. Scientists, engineers and financial analysts are among the major users of HPC for modelling and simulation, advanced data analytics and visualization. HPC is involved in huge number of industrial applications and scientific domains and can improve the productivity and competitiveness of industries and SMEs.

Therefore, HPC is essential for the European Data Infrastructure and for the European Open Science Cloud, as it will provide the capacity to analyse vast amounts of data.

The European Cloud Initiative calls for the support of EU Member States to develop a High Performance Computing ecosystem based on European technology, including low power chips, setting an ambitious European exascale High-performance computing strategy. The goal is to have exascale supercomputers based on European technology in the global top 3.

The Commission intends as well to launch an ambitious, long-term and large-scale flagship initiative to unlock the full potential of quantum technologies and accelerate their development and take-up into commercial products in Europe. Read more on the staff working document on quantum technologies.

5.3 Financing

The public and private investment needed to implement the European Cloud Initiative is estimated at €6.7 billion. The Commission estimates that, overall, €2 billion in Horizon 2020 funding will be allocated to the European Cloud initiative. The estimation of the required additional public and private investment is €4.7 billion in the period of 5 years.

The Political Priorities



European Cloud Initiative [COM(2016) 178 of 19/4/2016]

■ **European Open Science Cloud (EOSC)**

- Integration and consolidation of e-infrastructures
- Federation of existing research infrastructures and scientific clouds
- Development of cloud-based services for Open Science
- Connection of ESFRIs to the EOSC

■ **European Data Infrastructure (EDI)**

- Development and deployment of large-scale European HPC, data and network infrastructures + full HPC ecosystem for European technology

■ **Widening access**

- SMEs, Industry at large, Government

"Building a European Data Economy" [COM in Jan 2017]

6 Europe's Extreme-Scale Computing Ambitions

6.1 EuroHPC Declaration⁹

Ministers from seven European countries (France, Germany, Italy, Luxembourg, Netherlands, Portugal and Spain) have signed in Rome a declaration to support the next generation of computing and data infrastructures, a European project of the size of Airbus in the 1990s and of Galileo in the 2000s.

They plan to establish EuroHPC for acquiring and deploying an integrated world-class high-performance computing infrastructure capable of at least 10¹⁸ calculations per second (so-called exascale computers). This will be available across the EU for scientific communities, industry and the public sector, no matter where the users are located.

High-performance computing (HPC) involves thousands of processors working in parallel to analyse billions of pieces of data in real time. HPC allows to design and new drugs and simulate their effects, and provide faster diagnosis, better treatments and personalised health care. It can make our communications and online financial transactions more secure and can help clean-energy production, by making for example, wind farm operations based on accurate weather forecasts.

World-class infrastructure will also support [the European Open Science Cloud](#), which will offer Europe's 1.7 million researchers and 70 million science and technology professionals a virtual environment to store, share and re-use their data across disciplines and borders. Focusing initially on the scientific community, the user base of the cloud will over time be enlarged to the public and to businesses.

The EU Member States which signed the EuroHPC declaration agree to work towards the establishment of a multi-government cooperation framework for acquiring and deploying an integrated supercomputing infrastructure of the next generation. Other Member States are encouraged to join in the future to work together and with the European Commission in this initiative.

The challenge ahead is for Member States in coordination with the European Commission to prepare an implementation roadmap to deploy the European exascale supercomputing infrastructure. This roadmap should address aspects involved in the HPC supply chain from operational requirements to the development of high-quality competitive European technology. It will also tackle the pooling of public and private resources for acquiring and operating the infrastructure. The target is to have by 2020 at least two pre-exascale computers and reach full exascale performance by 2023. The objective is also to define test-beds for HPC and big data applications that make use of these supercomputers for scientific, public administration and industrial purposes.

⁹ <https://ec.europa.eu/digital-single-market/en/news/eu-ministers-commit-digitising-europe-high-performance-computing-power>

6.2 How HPC can help

HPC is developing to cope with the constant increase in data volumes and flows. A recent report projects that annual global IP traffic will reach 2.3 zettabytes by 2020 – or 504 billion DVDs per year. For example EU's Copernicus programme produces vast amounts of rich Earth observation data used both in science and in environmental monitoring and agricultural planning. HPC is essential to make use of that data to improve the reliability of weather predictions and extreme events such as tropical cyclones.

HPC has also a pivotal role in supporting the digital industrial revolution, which is deeply transforming traditional industries, how engineers collaborate and explore new design and technical solutions. For example, in the automotive and aerospace industries, Computer Aided Engineering and design of new aircrafts and cars is carried out through large scale simulation instead of or in addition to physical testing. HPC has enabled European automakers to increase productivity by reducing the time for the development of new vehicle platforms from an average 60 months to 24 months while greatly improving safety (so reducing fatalities), environmental friendliness, and passenger comfort. HPC plays a key role in reducing the environmental impact of planes. The design of the Airbus A380 has used aerodynamics simulation and HPC to carry twice as many passengers for the same noise level, using less than 3 litres of fuel per person per 100 km and less than 75g of CO₂ per person per km. With access to HPC, small and medium enterprises have also the possibility to reduce development costs in specialised areas, including through modelling and simulation.

6.3 EuroHPC Joint Undertaking¹⁰

The European High-Performance Computing Joint Undertaking (EuroHPC JU) will pool European resources to develop top-of-the-range exascale supercomputers for processing big data, based on competitive European technology.

The EuroHPC Joint Undertaking (JU) is a legal and funding entity which will enable pooling of the Union's and national resources on High-Performance Computer (HPC) with the aim of:

- acquiring and providing a world-class pre-exascale supercomputing infrastructure to Europe's scientific and industrial users, matching their demanding application requirements by 2020,
- developing exascale supercomputers based on competitive EU technology that the Joint Undertaking could acquire around 2022/2023, and that would be ranking among the top three places in the world.

The EuroHPC Joint Undertaking builds on [the declaration launched in Rome in March 2017](#) and signed by several European countries that are committed to upgrading European computing power.

¹⁰ <https://ec.europa.eu/digital-single-market/en/eurohpc-joint-undertaking>

6.3.1 State of play of High Performance Computing in Europe

Currently, the computing and data needs of European scientists and industry are not matching the computation time available in the EU. Moreover, the EU does not have the most powerful machines that some of their applications require.

At the moment, EU industry provides about 5% of HPC resources worldwide, but consumes one third of them. In April 2016 in the European Cloud Initiative – part of the EU's strategy to digitise European industry – the Commission urged Member States to step up cooperation in HPC to boost Europe's scientific capabilities and industrial competitiveness. It also committed to develop a high-performance computing ecosystem based on European technology, including low power chips. The goal is to have exascale supercomputers based on European technology in the global top 3 by 2022.

Therefore, the European HPC users are increasingly processing their data outside the EU. This situation may create problems related to:

- privacy,
- data protection,
- commercial trade secrets,
- ownership of data.

None of the EU supercomputers are currently in the global top 10 and the existing ones depend on non-European technology. This brings an increasing risk for the Union of being deprived of strategic or technological know-how for innovation and competitiveness.

6.3.2 Benefits of the HPC Joint Undertaking

The EuroHPC Joint Undertaking will enable Member States to coordinate together with the Union their supercomputing strategies and investments.

We need to ensure the development in Europe of a whole exascale supercomputing capability covering the whole value chain (from technology components to systems and machines, and to applications and skills) and coordination and pooling. This action will avoid long term negative effects, both on the digital economy but also for Europe's data sovereignty and scientific and industrial leadership.

The EuroHPC Joint Undertaking will develop a clear strategy for innovation procurement of exascale machines based on competitive European technologies. By developing the prospect of creating a lead market for exascale technology in Europe, the EuroHPC JU will help the European suppliers to take the risk to develop such machines on their own.

6.3.2.1 Members

The EuroHPC Joint Undertaking will be composed of public and private members:

- the European Union (represented by the Commission),
- the 14 Member States and associated countries which have already signed the EuroHPC Declaration,
- the representatives from the supercomputing and big data stakeholders, including academia and industry.

Other countries can join the Joint Undertaking at any moment, provided they contribute financially to its objectives.

6.3.2.2 Governance

The governance structure of the EuroHPC Joint Undertaking will be composed of:

- The Governing Board (representatives of the public members): will be responsible for the Joint Undertaking decision making, including funding decisions related to all the procurements and Research & Innovation (R&I) activities. Voting rights will be proportional to the financial contributions of its members.
- The Industrial and Scientific Advisory Board (representatives of the private members - academia and industry): will be responsible for elaborating the R&I agenda on technology, applications, and skills development.

6.3.2.3 Next steps

The EuroHPC Joint Undertaking is foreseen to start operating in 2019 and will remain operational until the end of 2026.

Its budget will consist of EUR 486 million from the present budgetary framework of the Union, and more specifically in both Horizon 2020 and Connecting Europe Facility (CEF) programmes. The budget will be matched by a similar amount from the participating countries. The private entities should also provide in-kind contributions. The Joint Undertaking will provide financial support in the form of procurement or research and innovation grants to participants following open and competitive calls.



- **Acquisition** (in 2020-2021) of 2 operational **pre-exascale** and (in 2022-2023) two full **exascale** machines (of which one based on European technology)
- **Interconnection and federation** of national and European HPC resources and creation of an HPC and Big Data service infrastructure facility
- **Establishment of a complete European HPC ecosystem** to secure its own independent HPC technology and system supply
- **Demonstrating and testing** technology performance towards exascale through scientific & industrial compute-intensive applications



Towards the world top HPC powers: EuroHPC Joint Undertaking

Co-invest on a leading HPC and data infrastructure
for our scientists, industry and the public sector and support the development of technologies and applications across a wide range of fields

- Coordinate EC/MS activities
- Pool public and private resources at EU level
- Procure world-class infrastructure
- Close the chain from R&D to procurement
- Become lead Users
- Create a competitive supply industry
- Lead in Applications

A world-class European HPC, Big Data and Cloud Ecosystem



EuroHPC JU in a nutshell



- Follows underlying model of JUs (legal base, reporting, establishment, staff issues, auditing, ...)
- Tripartite partnership: EC + Participating States + Private Members
- Implements H2020 + Connecting Europe Facility
- Infrastructure Acquisition AND R&I activities
- Open to in-kind contributions by MS
- Governance adapted to the EuroHPC objectives
- Participating countries entrust JU with their financial contributions
- JU running costs shared → EC, Participating States, Private Members
- Seat = Luxembourg

 **The EuroHPC JU**
A two-phase Approach



Phase 1: 2019-2020 (Present EU Financial Framework)

[Pillar 1] Pre-exascale machines and petascale machines

[Pillar 2] Applications; technologies for exascale

→ The JU operates until 2026 with ~1 B€ budget (50% Union; 50% participating countries)



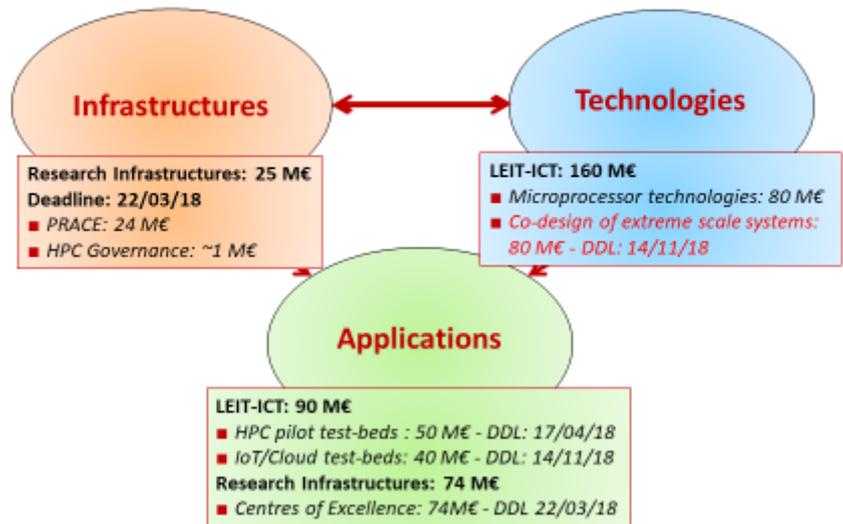
Phase 2: 2021-2028 (Next EU Financial Framework)?

[Pillar 1] Exascale and post-exascale machines + first hybrid HPC / Quantum Computing infrastructures

[Pillar 2] Applications; technologies for post-exascale

→ JU operates until 2030+

 **EuroHPC Agenda for 2018**
H2020 Calls for proposals in WP 2018



Next Steps

JU establishment

- 1. JU Start Date: 1.1.2019**
- 2. Council negotiations**
 - Agreement by end May'18
 - Adoption: Austrian Presidency (September?)
- 3. Sherpa meetings**
 - 20 March, 20 April, 15 May, 19 June
- 4. Working Groups**
 - "In-kind contributions" 19 March
 - "HPC & SMEs" 20 March
- 5. Transitional phase: Q3 2018 – Q4 2019 (?)**

EuroHPC Sherpa's Body

Work with Sherpa's for defining the EuroHPC JU 2019-2020 activities, the calls for proposals and the MS budget contributions

Figure 5 - Above - information on EuroHPC.

HPC/EDI in Horizon 2020 Work Programmes

DRAFT – under discussion with the H2020 Programme Committees

2014-2015	2016-2017	2018-2020								
LEIT ICT WP → Microprocessor, integration, test-beds & demonstration										
	<div style="border: 1px solid #ccc; padding: 2px; font-size: x-small;">ICT-15: (Big data PPP): Large Scale Pilot actions</div>	<table style="width: 100%; border-collapse: collapse;"> <tr> <td style="padding: 2px;">Low-power processor design and development</td> <td style="text-align: right; padding: 2px; background-color: #f0e0f0;">120m€</td> </tr> <tr> <td style="padding: 2px;">Co-design of extreme scale demonstrators</td> <td style="text-align: right; padding: 2px; background-color: #f0e0f0;">80m€</td> </tr> <tr> <td style="padding: 2px;">HPC/BD/Cloud: Large scale test-beds</td> <td style="text-align: right; padding: 2px; background-color: #f0e0f0;">50+40m€</td> </tr> </table>	Low-power processor design and development	120m€	Co-design of extreme scale demonstrators	80m€	HPC/BD/Cloud: Large scale test-beds	50+40m€		
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HPC/BD/Cloud: Large scale test-beds	50+40m€									
FET WP → Key components & concepts: preparing next generation & beyond										
<div style="border: 1px solid #ccc; padding: 2px; font-size: x-small;">Components: Towards pre-exascale</div>	<div style="border: 1px solid #ccc; padding: 2px; font-size: x-small;">system architectures SW</div>	<table style="width: 100%; border-collapse: collapse;"> <tr> <td style="padding: 2px;">extreme scale HPC compute & data technologies and co-designed prototypes for (post-) exascale</td> <td style="text-align: right; padding: 2px; background-color: #f0e0f0;">170m€</td> </tr> </table>	extreme scale HPC compute & data technologies and co-designed prototypes for (post-) exascale	170m€						
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eINFRA WP and Connecting Europe Facility (CEF): Infra support & Procurement										
	<div style="border: 1px solid #ccc; padding: 2px; font-size: x-small; background-color: #e0e0e0;"> CEF 2017 WP HPC-enabled cross-border services for citizens, enterprises and supporting decision-making for public authorities – 6 M€ </div>	<table style="width: 100%; border-collapse: collapse;"> <tr> <td style="padding: 2px;">PRACE, Centres of Excellence, widening use</td> <td style="text-align: right; padding: 2px; background-color: #f0e0f0;">24+74+8m€</td> </tr> <tr> <td style="padding: 2px;">PPI Pre-exascale systems</td> <td style="text-align: right; padding: 2px; background-color: #f0e0f0;">80m€</td> </tr> <tr> <td style="padding: 2px;">Data nodes, Interconnectivity</td> <td></td> </tr> <tr> <td style="padding: 2px;">CEF 2018 ~15m€?</td> <td style="padding: 2px;">CEF 2020 ~100m€?</td> </tr> </table>	PRACE, Centres of Excellence, widening use	24+74+8m€	PPI Pre-exascale systems	80m€	Data nodes, Interconnectivity		CEF 2018 ~15m€?	CEF 2020 ~100m€?
PRACE, Centres of Excellence, widening use	24+74+8m€									
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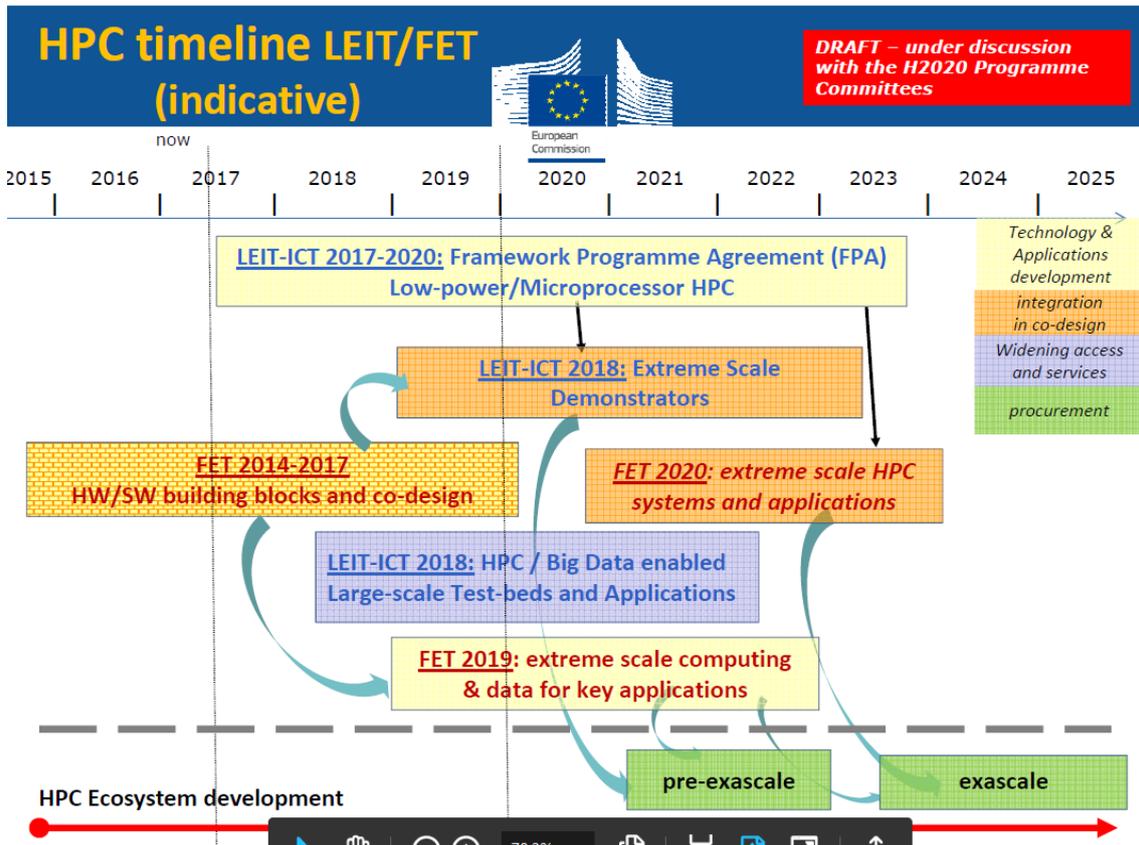


Figure 6 - The two slides above - the role and timelines of the various EC HPC programmes.

Full [EC's presentation on EuroHPC](#) – March 2018

7 The European Processor Initiative (EPI)¹¹

The European Processor Initiative (EPI) gets together 23 partners from 10 European countries, with the aim to bring to the market a low power microprocessor.

It gathers experts from the High Performance Computing (HPC) research community, the major supercomputing centres, and the computing and silicon industry as well as the potential scientific and industrial users. Through a co-design approach, it will design and develop the first European HPC Systems on Chip and accelerators. Both elements will be implemented and validated in a prototype system that will become the basis for a full Exascale machine based on European technology.

The main objectives of the EPI are to:

- Develop low-power processor technology to be included in a European pre-exascale system (capable of around 10^{16} calculations per second) and in European exascale systems (a billion billion or 10^{18} calculations per second),

¹¹ <https://ec.europa.eu/digital-single-market/en/news/european-processor-initiative-consortium-develop-europes-microprocessors-future-supercomputers>

- Guarantee that a significant part of that technology is European,
- Ensure that the application areas of the technology are not limited only to HPC, but cover other areas such as the automotive sector or the data centres, thus ensuring the overall economic viability of the initiative. One specific objective for the automotive sector is for instance to develop customized processors able to meet the performance needed for autonomous cars.

EPI will provide to the European industry and research a competitive HPC platform and data processing solutions at world class level in the best interest of data security and ownership.

8 The European HPC Eco-system

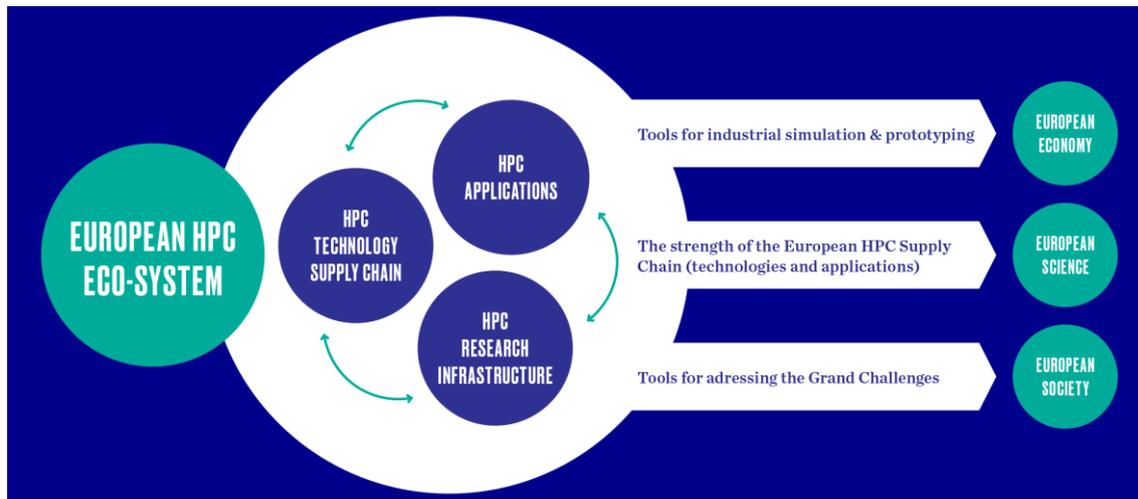
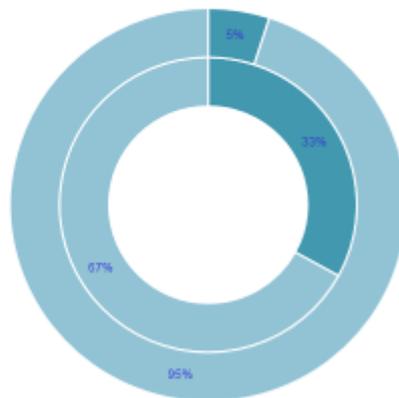


Figure 7 - The European HPC ecosystem, its three pillars (Technology, Applications and Infrastructure) and their impact on Europe.

8.1 What is ETP4HPC?

WHY DO WE NEED TO ACT NOW?

Europe consumes 33% of global HPC resources



However, supplies less than 5% of them



31 May 2017

ETP4HPC Event

8

ETP4HPC (European HPC Technology Platform, www.etp4hpc.eu) is an industry-led organization – an association of companies and research centres involved in HPC technology research in Europe. It aims to build a world-class HPC Supply Chain and increase the global market share of European HPC vendors. It issues a Strategic Research Agenda to define the EU HPC research priorities in the area of HPC Technology and the guidelines of which are used by the EU to define its HPC Technology research programme with the Horizon2020 framework.

ETP4HPC is also the EC's partner in the HPC contractual Public-Private Partnership, one of the eight of this type in Europe. Its scope covers Technology Provision and Application Expertise. Its aim is to develop HPC technology and applications, leading to Exa-scale systems and their advanced and pervasive use, thus creating jobs, new products and companies as well as enabling scientific discoveries. This will contribute to the economic competitiveness of Europe and also to the well-being of the European citizen by addressing the Grand Societal Challenges.

ETP4HPC is managed by a Steering Board of fifteen organisations (European HPC Technology vendors, SMEs, International companies and European research centres) elected by its General Assembly, i.e. all active members who are able to demonstrate research activities in Europe. Any organisation with an interest in the development of HPC technology can become an associated member.

8.2 Centres of Excellence in Computing Applications (CoEs)

The CoEs represent the European Application expertise. The current CoEs are a result of a €40M EC H2020-EINFRA-2015-1¹² Call, which specifies the establishment of 'a limited number of Centres of Excellence (CoEs) necessary to ensure EU competitiveness in the application of HPC for addressing scientific, industrial or societal challenges. CoEs are user-focused, developing a culture of excellence, both scientific and industrial, placing computational science and the harnessing of 'Big Data' at the centre of scientific discovery and industrial competitiveness.' The CoEs are expected to be:

- User-driven, with the application users and owners playing a decisive role in governance;
- Integrated: encompassing not only HPC software but also relevant aspects of hardware, data management/storage, connectivity, security, etc.;
- Multi-disciplinary: with domain expertise co-located alongside HPC system, software and algorithm expertise;
- Distributed with a possible central hub, federating capabilities around Europe, exploiting available competences, and ensuring synergies with national/local programmes;

Each CoE is expected to deliver a tangible return on investment to its customers, with a view to develop a semi-sustainable operational model in the following call.

The first round of the CoEs^{13,14} includes the following projects (together with links to their summaries and project websites):

¹² <https://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/329-einfra-5-2015.html>

¹³ A list and summary of the Centres of Excellence in Computing Applications is available at: <http://ec.europa.eu/programmes/horizon2020/en/news/eight-new-centres-excellence-computing-applications>

¹⁴ The EINFRA-5-2015 call text including the Centres of Excellence in Computing Applications is available at: <http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/329-einfra-5-2015.html>

- [EoCoE](#) - Energy oriented Centre of Excellence for computer applications - [project website](#)
- [BioExcel](#) - Centre of Excellence for Biomolecular Research - [project coordinator website](#)
- [NoMaD](#) - The Novel Materials Discovery Laboratory - [project website](#)
- [MaX](#) - Materials design at the eXascale - [project website](#)
- [ESiWACE](#) - Excellence in Simulation of Weather and Climate in Europe - [project website](#)
- [E-CAM](#) - An e-infrastructure for software, training and consultancy in simulation and modelling - [project website](#)
- [POP](#) - Performance Optimisation and Productivity - [project website](#)
- [COEGSS](#) - Center of Excellence for Global Systems Science - [project website](#)
- [CompBioMed](#) - A Centre of Excellence in Computational Biomedicine - [project website](#)

A second round of CoEs is expected to be launched in the 2018/19 call with an objective to retain the most successful proposals or its parts and ensure the long-term sustainability of the projects.

ETP4HPC will be working to include the CoEs in the processes of the contractual Public-Private Partnership for HPC and synchronise their efforts with those of the other two pillars of the European HPC Ecosystem (i.e. ETP4HPC and the FETHPC projects, PRACE).

8.3 Partnership for Advanced Computing in Europe (PRACE¹⁵)



The mission of PRACE is to enable high impact scientific discovery and engineering research and development across all disciplines to enhance European competitiveness for the benefit of society. PRACE seeks to realise this mission by offering world class computing and data management resources and services through a peer review process. PRACE also seeks to strengthen the European users of HPC in industry through various initiatives.

PRACE has been in operation since 2010 and it has now 25 member-states. The computer systems and their operations accessible through PRACE are provided by 4 PRACE members (BSC representing Spain, CINECA representing Italy, GCS representing Germany and GENCI representing France) who committed a total funding of €400 million for the initial PRACE systems and operations. The total performance of the 6 PRACE supercomputers is nearly 15 Pflop/s. PRACE has established a common operation procedure between 35 HPC centres in Europe. In total, the achievements of PRACE include:

- 8 billion hours granted since 2010 (an equivalent of a system with 990k cores for a full year)
- 303 scientific projects enabled from 38 countries

¹⁵ www.prace-ri.eu

- Over 20 SME and other industrial access projects in the first year of running an industry programme
- 2734 trained people
- 170 applications enabled
- 22 prototypes evaluated
- 169 papers produced
- 166 thesis papers
- 183 HPC community building events

PRACE issues 'PRACE Scientific Case for HPC in Europe 2012 – 2020' – a publication that documents the needs to HPC-supported research and its value for society.

A second phase of PRACE (call PRACE 2) is currently under discussion by the PRACE members. This new phase will be announced in 2016.

8.3.1 ETP4HPC's relationship with PRACE

A PRACE representative is invited to partake in the meetings of the ETP4HPC Steering Board. Also, the opinion of PRACE and the findings of its Scientific Case are taken into account when preparing the SRA.

8.4 Contractual Public-Private Partnership for HPC (cPPP)

A strong cooperation with the HPC stakeholders is key for the success of the HPC strategy. A contractual Public-Private Partnership on HPC (cPPP¹⁶ on HPC) entered into force in January 2014 to develop an ambitious R&I HPC strategy. The HPC cPPP is based on the Contractual Arrangement (CA) signed in December 2013, by European Commission (EC) Vice-President and European Commissioner for Digital Agenda on behalf of the public side, and the European Technology Platform for High Performance Computing (ETP4HPC) Association representatives on behalf of the private side.

The HPC cPPP's main goals and high-level objectives are to:

- Develop the next generation of HPC technologies, applications and systems towards exascale
- Achieve excellence in HPC applications delivery and use

The EC has pledged €700 million from Horizon 2020 Programme budget, and it is expected that the cPPP will leverage a similar amount of resources in the private side.

- Under the FET work programme 2014-15, the EC committed €93.4 million to support the development of core technologies and an additional €4 million for ecosystem development. Additional €85 million are budgeted in the FET work programme 2016-2017.

¹⁶ A summary of the cPPP for HPC is available at: <https://ec.europa.eu/digital-agenda/en/high-performance-computing-contractual-public-private-partnership-hpc-cppp>

- The EC also committed €40 million for Centres of Excellence and €2 million for a Network of PC competence centres for SMEs under the e-infrastructure work programme 2014-2015.

Additionally, in the overall effort of the EC in High Performance Computing, the PRACE e-infrastructure is also supported:

- The fourth implementation phase of PRACE received €15 million in 2015, and €15 million more are budgeted in the work programme 2016-2017.
- The EC has committed €26 million in 2016-2017 to support a public call for innovation (PPI) for advanced (sub)systems to be used in the frame of PRACE.

8.5 European HPC Strategy Coordination - Extreme Data and Computing Initiative (EXDCI)



EXDCI¹⁷ is a coordination and support action (CSA) project is led by PRACE, in close partnership with ETP4PC. It embodies the expertise and experience of EESI¹⁸ and a portfolio of independent experts aims to specifically stimulate and coordinate the European HPC strategy. It is scheduled to operate from September 2015 for two and a half years. Its mission is to monitor, coordinate and support this strategy of the European HPC Ecosystem, providing tools for: technology ‘roadmapping’, analysing academic needs, international collaboration and education and training across the three pillars of European HPC (Infrastructure, Technology and Applications). EXDCI 1 (the first round of this project) finished in Feb 2018 and EXDCI 2 will commence in 2018.

A separate coordination project Eurolab-4-HPC¹⁹, will operate in parallel with EXDCI and will focus on Excellence in High-Performance Computing Systems and longer-term research in computing architectures and HPC beyond 2020.

¹⁷ <http://www.exdci.eu/>

¹⁸ <http://www.eesi-project.eu/>

¹⁹ http://cordis.europa.eu/project/rcn/197540_en.html

9 Strategic Research Agenda (SRA) – the European HPC Technology Roadmap

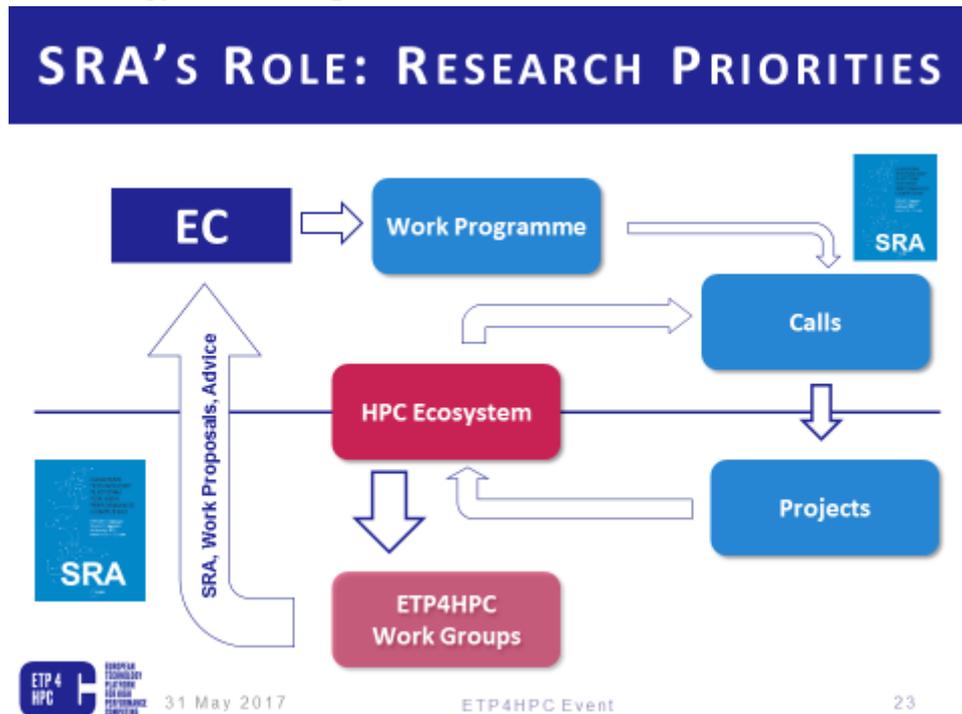


Figure 8 - The role of the SRA in defining the contents of the EC HPC Research programmes and project proposals. The SRA provides input for the Work Programme. Any project submitted should refer to the milestones included in the SRA.

The main deliverable of ETP4HPC is the Strategic Research Agenda²⁰ (SRA), multi-annual roadmap outlining the technological milestones on the way towards European Exa-scale HPC system capabilities. We issued the first edition of our SRA in 2013 (SRA1) and it was used by the EC to define the contents of the first round of FETHPC calls in the Horizon2020 programme.



Figure 9 - The ETP4HPC SRA is written in an interactive, workshop-style manner with each of the Working Groups developing its own area and collaborating with all other stakeholders.

²⁰ <http://www.etp4hpc.eu/strategic-research-agenda/>

SRA 3 (its second full version and its third edition /SRA 2 was an update on SRA 1/) was issued in Dec 2018. In this process, various internal ETP4HPC Working Groups contribute to the technological chapters of the document. This Roadmap includes the following areas:

- HPC System Architecture and Components
- System Software and Management
- Programming Environment
- Balance Compute, I/O and Storage Performance
- Energy and Resiliency
- Big Data and HPC usage Models
- Mathematics and algorithms for extreme scale HPC systems
- Extreme scale demonstrators

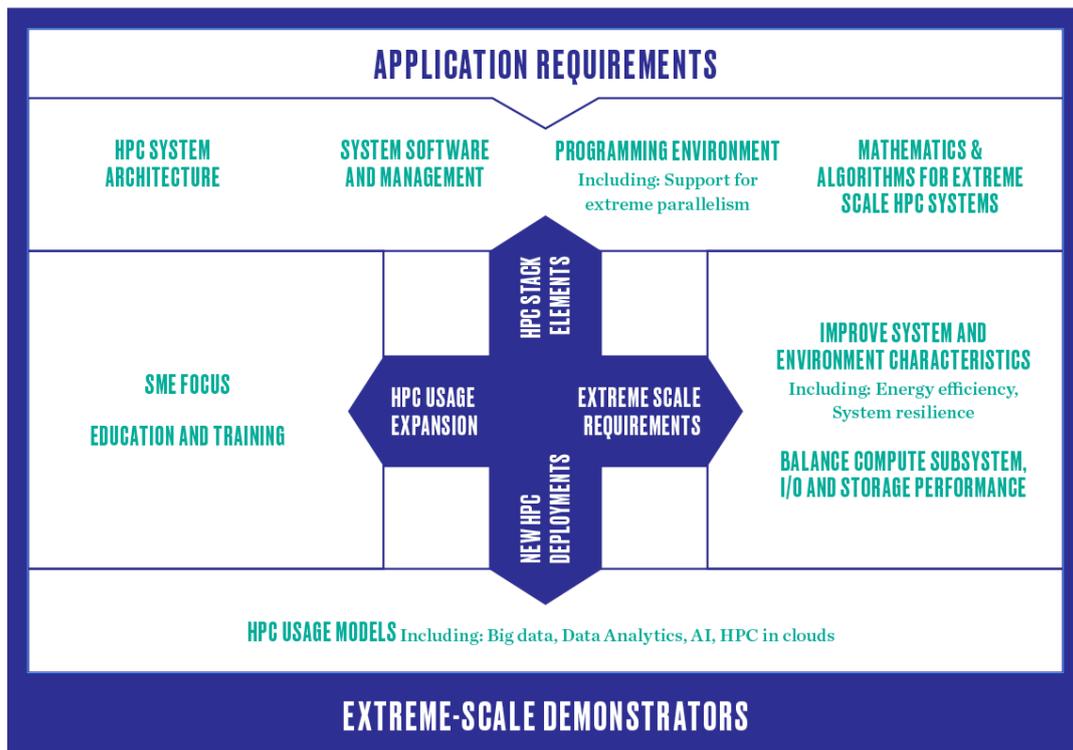


Figure 10 - The ETP4HPC SRA 3 Model - the areas addressed by the document.

10 The European Commission’s calls and the structure of Horizon2020

The European Commission’s current Horizon 2020²¹ research programme includes public calls for the development of HPC technology in its ‘FET Proactive HPC’ (Future and Emerging Technologies – HPC) section and calls for the implementation of research infrastructures and

²¹ <https://ec.europa.eu/programmes/horizon2020/>

application expertise in its 'Infrastructures' section. The projects submitted in the FETHPC programme are required to reflect the guidelines of the SRA developed by ETP4HPC.

The following table summarises the details of the past and current HPC-related calls:

Call Name	Topic	Link	Funding (Euro 000)	Closing Date
H2020-FETHPC-2014	FETHPC-1-2014:HPC Core Technologies, Programming Environments and Algorithms for Extreme Parallelism and Extreme Data Applications	https://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/calls/h2020-fethpc-2014.html	97,400,000	25 November 2014
	FETHPC-2-2014:HPC Ecosystem Development			
H2020-FETHPC-2016-2017	FETHPC-01-2016:Co-design of HPC systems and applications	https://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/calls/h2020-fethpc-2016-2017.html#c,topics=callIdentifier/t/H2020-FETHPC-2016-2017/1/1/1&callStatus/t/Forthcoming/1/1/0&callStatus/t/Open/1/1/0&callStatus/t/Closed/1/1/0&+identifier/desc	41,000,000	27 September 2016
	FETHPC-02-2017:Transition to Exascale Computing		40,000,000	26 September 2017
	FETHPC-03-2017:Exascale HPC ecosystem development		4,000,000	26 September 2017
H2020-EINFRA-2014-2015	EINFRA-4-2014:Pan-European High Performance Computing infrastructure and services	https://ec.europa.eu/research/participants/portal4/desktop/en/opportunities/h2020/topics/329-einfra-5-2015.html	15,000,000	02 September 2014
	EINFRA-5-2015:Centres of Excellence for computing applications		8 centres have been founded with a budget of 4-5 million Euro each.	14 January 2015
H2020-FETHPC-2016-2017	FETHPC-01-2016: Co-design of HPC systems and applications	https://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/calls/h2020-fethpc-2016-2017.html#c,topics=callIdentifier/t/H2020-FETHPC-2016-2017/1/1/1/default-group&callStatus/t/Forthcoming/1/1/0/default-group&callStatus/t/Open/1/1/0/default-group&callStatus/t/Closed/1/1/0/default-group&+identifier/desc	41,000,000	27 Sept 2016
	FETHPC-02-2017: Transition to Exascale Computing		40,000,000	26 Sept 2016
	FETHPC-03-2017: Exascale HPC ecosystem development		4,000	26 Sept 2016
H2020-FETHPC-2018-2020	FETHPC-02-2019: Extreme scale computing technologies, methods and algorithms for key	https://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/calls/h2020-fethpc-2018-	64,000,000	24 Sept 2019

	applications and support to the HPC ecosystem	2020.html#c,topics=callIdentifier/t/H2020-FETHPC-2018-2020/1/1/1/default-group&callStatus/t/Forthcoming/1/1/0/default-group&callStatus/t/Open/1/1/0/default-group&callStatus/t/Closed/1/1/0/default-group&+identifier/desc		
ICT-14-2019	Co-designing Extreme Scale Demonstrators (EsD)	http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/ict-14-2019.html	80,000,000	14 Nov 2018
H2020-INFRAEDI-2018-2020	INFRAEDI-02-2018: HPC PPP - Centres of Excellence on HPC	https://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/calls/h2020-infraedi-2018-2020.html#c,topics=callIdentifier/t/H2020-INFRAEDI-2018-2020/1/1/1/default-group&callStatus/t/Forthcoming/1/1/0/default-group&callStatus/t/Open/1/1/0/default-group&callStatus/t/Closed/1/1/0/default-group&+identifier/desc	72,000,000	22 March 2018
ICT-11-2018-2019	HPC and Big Data enabled Large-scale Test-beds and Applications	http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/ict-11-2018-2019.html	50,000,000	17 April 2018 and 14 Nov 2018
ICT-12-2018-2020	Big Data technologies and extreme-scale analytics	http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/ict-12-2018-2020.html	30,000,000	17 April 2018

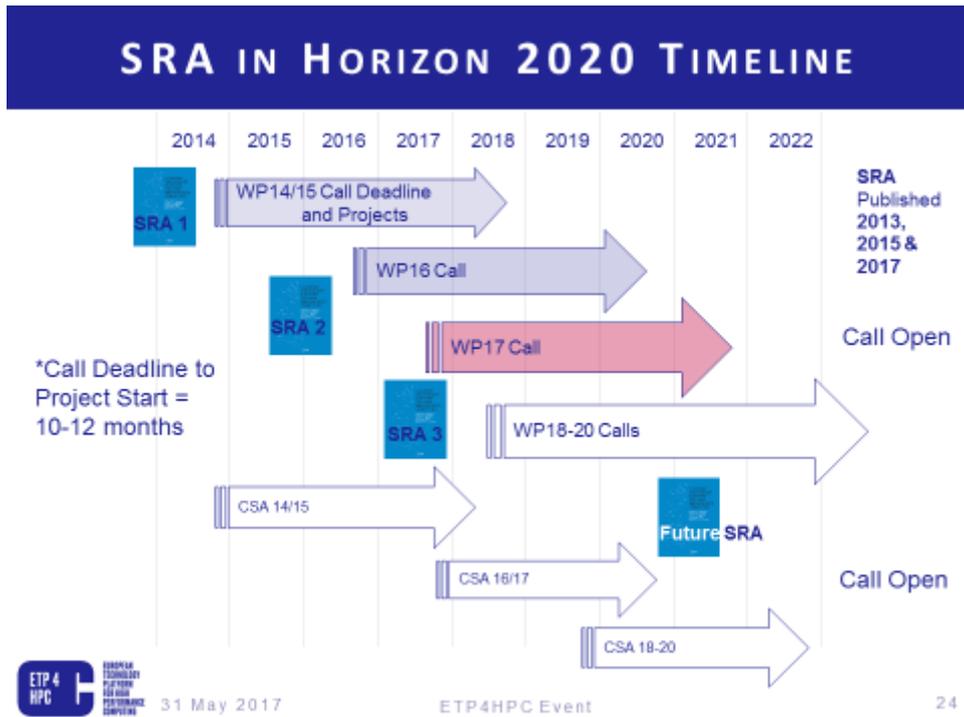


Figure 11 - There is a valid SRA place for any part of the Work Programme.

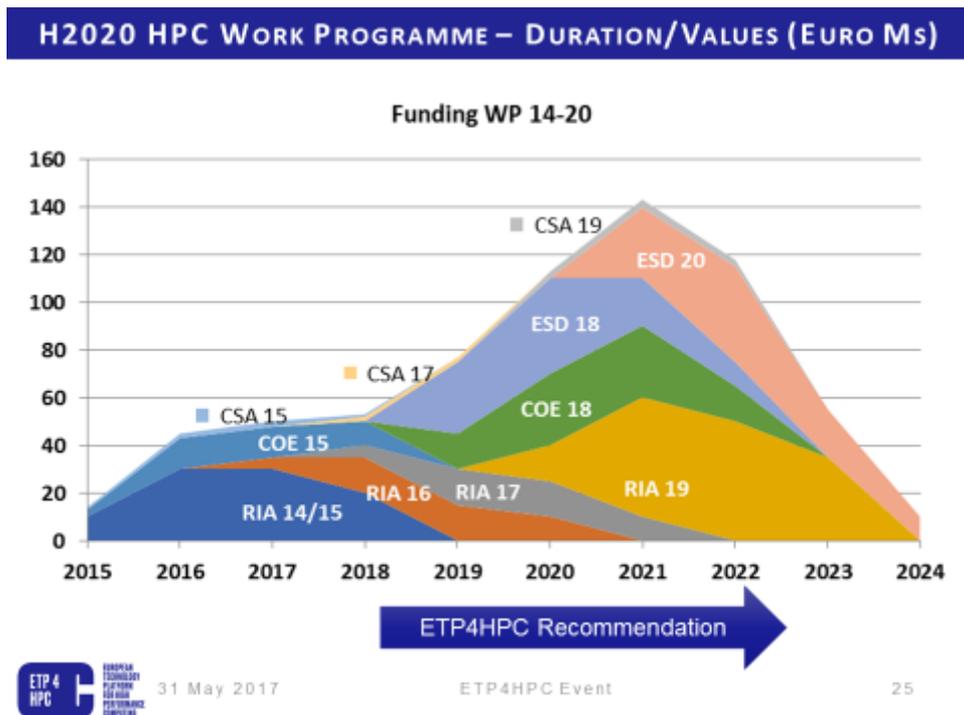


Figure 12 - The funding committed in various parts of Horizon 2020 in millions of Euros.

11 Extreme-Scale Demonstrators (EsDs)²²

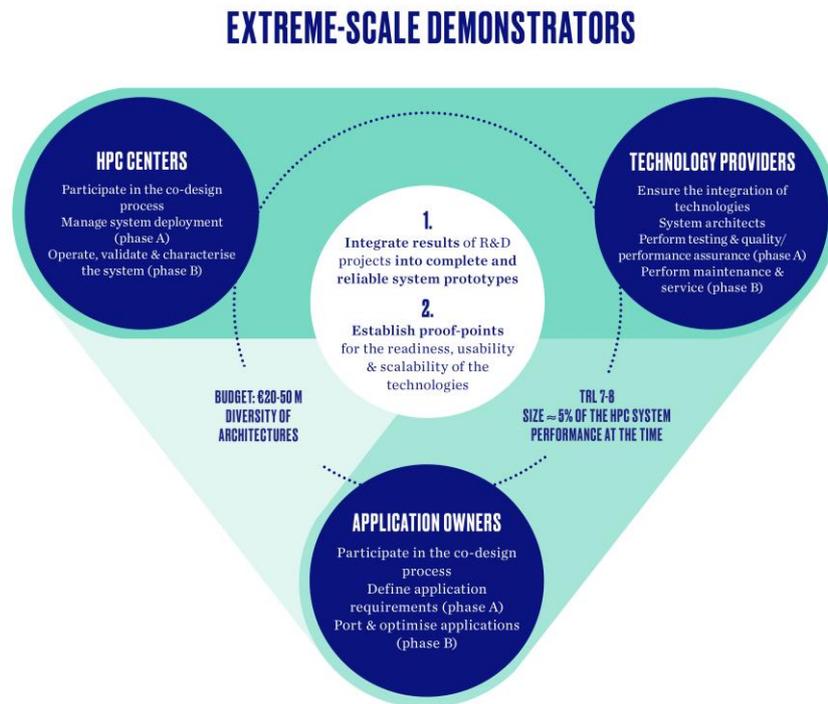


Figure 13 - The role and composition of the EsDs.

The technologies produced by the European exa-scale projects should be used to build prototypes of HPC systems in order to validate the performance of the technologies applied and their market preparedness. ETP4HPC suggests the implementation of Extreme-scale Demonstrators (EsDs) as a means of testing the readiness of the European HPC Technology Value Chain and the entire European HPC eco-system to produce globally competitive HPC systems, meeting the needs of the European academic and industrial end-user.

The EsDs are research projects aimed at integrating European HPC Technology and Application expertise into fully operational world-class HPC systems. This concept is included in our current EC Work Programme 2018-20 draft and forms the core of the further development of HPC technology in Europe.

The European Technology (FETHPC and other FP) projects, application owners (EXDCI WP3), the Centres of Excellence in Computing Applications (CoEs), technology providers, HPC centres/PRACE and HPC System Integrators will play a pivotal role in this process.

²² <http://www.etp4hpc.eu/esds.html>

12 European HPC Technology and Application Projects

The first **FETHPC** (Future and Emerging Technologies – HPC) technology research projects²³ with a total value of almost 100M Euro are now in operation. The implementation of these technology projects will lead to the development of innovative and globally competitive HPC technology solutions in Europe. It will increase the global market share of European HPC vendors and help Europe achieve independent Exa-scale system capabilities. 19 HPC technology projects involving European HPC industry and research centres address the topics of:

- HPC core technologies and architectures,
- Programming methodologies, environments, languages and tools,
- APIs and system software for future extreme scale systems, and
- New mathematical and algorithmic approaches.

These projects represent the first part of a 700M Euros investment package committed by the European Commission within the Horizon 2020 Research and Development Programme. There will be three more HPC technology calls, with an emphasis on system prototypes, meeting the needs of academic and industrial end-users and ensuring market viability. Many ETP4HPC members²⁴ participate in the FETHPC Technology projects. This programme is based on the Strategic Research Agenda roadmap prepared by ETP4HPC.

There are also projects in operation from the EC's previous programmes²⁵. The entire landscape of the European HPC Technology projects is shown below:

²³ A summary of the FETHPC projects is available at:
http://cordis.europa.eu/search/result_en?q=contenttype%3D%27project%27%20AND%20%27FETHPC%27&p=1&num=10&srt=/project/contentUpdateDate:decreasing or at
http://cordis.europa.eu/projects/home_en.html (search for FETHPC)

²⁴ www.etp4hpc.eu/members/members-list/

²⁵ <http://exascale-projects.eu/>

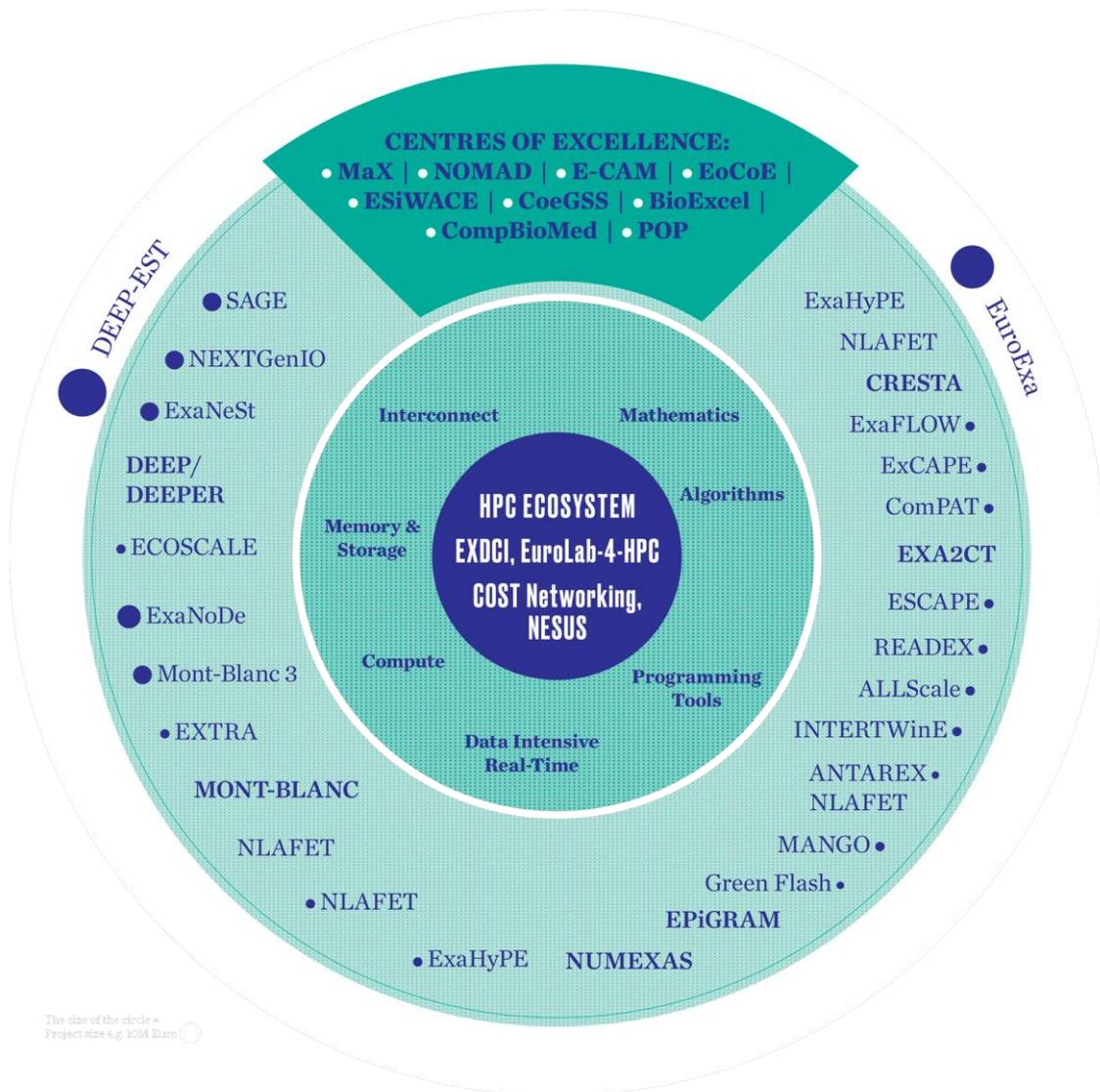


Figure 14 - The landscape of European HPC Technology and Application Projects as of June 2017. The top row are the Centres of Excellence in Computing Applications whilst the Projects in the circle deal with technology development. The size of the dots correspond

These and next projects open areas of international collaboration with mature regions, where similar or complementary work takes place. ETP4HPC has prepared a Handbook²⁶ of the European HPC technology projects. It also organised a Bird-of-a-Feather²⁷ (BOF) session at Supercomputing'16 in order to initiate a discussion on the international collaboration potential of the European HPC technology projects and the mechanisms needs to stimulate this process. The effort is being supported within a separate task in the EXDCI project. ETP4HPC will continue this initiative.

²⁶ <http://www.etp4hpc.eu/wp-content/uploads/2015/11/European-HPC-Technology-Handbook-SC15-BOF.pdf>

²⁷ <http://www.etp4hpc.eu/european-exascale-projects-2/>

13 ETP4HPC's view on international cooperation



Figure 15 - ETP4HPC organises annual Birds-of-a-Feather sessions at the Supercomputing Conference in order to present the latest developments in the European HPC Ecosystem (www.etp4hpc.eu/euexascale).

To achieve HPC leadership, Europe must engage in international cooperation. This cooperation should target two objectives:

- Develop synergies with the most active areas in HPC technologies research and their optimal usage. Priority should be given to developing links with Japan and the US, which demonstrate the longest experience in HPC and the most structured and mature related programmes;
- Collaborate with some of the countries developing their HPC strategies in order to utilise the expertise and capabilities of the European HPC ecosystem. This cooperation should not only focus on HPC technologies but also on policies to develop wider use of HPC within the scientific and industrial communities.