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Toward a European Exascale Ecosystem: The EuroHPC Joint Undertaking

HIGH-PERFORMANCE COMPUTING (HPC, also known as supercomputing) is indispensable in the new global data economy. The dramatic increase in the volume and variety of big data is creating new possibilities for sharing knowledge, carrying out scientific research, doing business, and developing public policies.

In almost every scientific discipline, researchers are using complex HPC modeling and simulation techniques and big data analytics approaches to answer fundamental questions and make new discoveries and breakthroughs. Representative examples include: in biology and the life sciences, understanding the dynamics of biomolecules and proteins and genome sequencing and genome assembly; in materials science and pharmaceuticals,

designing new materials and discovering new drugs; and in cosmology and astrophysics, understanding dark matter. HPC also provides solutions to complex problems (such as understanding the organization and functioning of the human brain, developing new treatments based on personalized medicine, and predicting and managing the effects of climate change).

In industry, HPC paves the way for new businesses and innovative applications in high-added-value areas (such as manufacturing and engineering, particularly automotive and aeronautical engineering, oil and gas exploration, bioengineering and mo-

lecular chemistry, agri-food and precision agriculture, and developing and managing renewable and clean energies). In all these areas, HPC helps reinforce industrial innovation capabilities, particularly in small and medium-size enterprises (SMEs).

HPC is also becoming a key tool for public decision making in an increasing number of areas (such as in cybersecurity and defense, including developing efficient encryption technologies, and understanding and responding to cyberattacks and cyberwars, in nuclear simulations, in the fight against terrorism and crime, and in understanding and managing natural hazards and biological risks, in-

cluding earthquakes, flooding, failure of dams or power plants, and health pandemics).

HPC in Europe

In combination with artificial intelligence, HPC is set to become the engine to power the new global digital economy, where to out-compute is to out-compete. In this context, European supercomputing infrastructures represent a strategic resource for understanding and responding to the increasing challenges European citizens will face in the years to come, as well as for the future of European industry, SMEs, and the creation of new jobs. They are also key to ensuring European

scientists reap the full benefit of data-driven science.

However, today the European Union (EU) is not investing enough in HPC infrastructures and technologies to match its economic and knowledge potential, showing an annual funding gap of more than €500 million compared with the U.S. and China.

Europe needs an integrated leading-class HPC and data infrastructure with exascale computing performance that can compete worldwide. This infrastructure is absolutely necessary to ensure data produced in Europe by academia, industry, and SMEs is processed with its own su-

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percomputing and data capabilities. This would reduce Europe's dependence on facilities in third countries and encourage innovation to stay in Europe.

Europe's Strategic Objectives

One of the priorities of the European Commission is to place Europe in the first three supercomputing powers of the world.^a To achieve this ambition, in October 2018 the EU, together with 24 EU member states and Norway, established the European High Performance Computing Joint Undertaking (EuroHPC JU),^b a public-private partnership between the EU, the 25 participating countries, and two European HPC and big data industrial associations—ETP4HPC^c and BDVA.^d

The EuroHPC JU is a legal and funding entity that makes it possible to combine EU and national funding with private resources. Its mission will be to develop, deploy, extend, and maintain in the EU an integrated world-class supercomputing and data infrastructure and develop and support a highly competitive and innovative HPC ecosystem. EuroHPC will enable the EU and the participating countries to coordinate their supercomputing research agendas and investments and pool national and EU resources to close the funding gap with global competitors. The overall goals of the EuroHPC JU will be:

Acquire world-class supercomputers. To acquire world-class supercomputers available to European users from academia, industry, SMEs, and the public sector, including two pre-exascale systems by 2020, two exascale systems by 2022/2023 (at least one with European technology), and post-exascale supercomputers;

Maintain EU leadership. To maintain the EU's leadership in scientific and industrial applications, including HPC Competence Centres facilitating access to the HPC ecosystem, particularly for SMEs, and developing advanced digital skills; and

Independent and competitive HPC technology. To secure an independent

and competitive HPC technology supply for the EU, including future computing technologies (such as quantum).

Beside ETP4HPC and BDVA associations, other key European stakeholders in HPC and data infrastructures (such as PRACE^e and GEANT^f) are also expected to collaborate closely with the EuroHPC JU to establish a leading-class HPC, data, and communication infrastructure in Europe.

The EuroHPC JU will also establish a wide consultation process to inform and involve interested European stakeholders who can contribute to the realization of the EuroHPC strategy. In particular, the contribution of the European computer science and software communities and the participation of large scientific and industrial HPC user communities will be fundamental to realizing the strategic objectives of European world leadership in HPC applications and development of a competitive HPC technology-supply industry.

EuroHPC JU Ramp-Up Phase, 2019–2020

The EuroHPC JU will need substantial investments in order to achieve its goals. In the period 2019 and 2020, the EuroHPC JU will invest €1.4 billion, of which €1 billion will be public and €0.4 billion will be private investments. The EuroHPC JU will acquire and install two top-five pre-exascale machines and several mid-range supercomputers by 2020 and support activities across the full European HPC ecosystem, including:

Develop a European microprocessor and European exascale systems. The European Processor Initiative (EPI)^g partnership was recently established to implement a technology roadmap

e <http://www.prace-ri.eu/>

f <https://www.geant.org/>

g EPI is coordinated by ATOS/Bull and brings together 23 partners from 10 European countries, gathering experts from the HPC research community, the major European supercomputing centers, and the computing and silicon industry, as well as potential scientific and industrial users with an additional specific emphasis on automotive applications; <https://ec.europa.eu/digital-single-market/en/news/european-processor-initiative-consortium-develop-europes-microprocessors-future-supercomputers>

a <https://ec.europa.eu/digital-single-market/en/high-performance-computing>

b <https://eurohpc-ju.europa.eu/>

c <http://www.etp4hpc.eu/>

d <http://www.bdva.eu/>

for future European low-power micro-processors for extreme-scale computing, big data, and emerging applications with a specific focus on exascale HPC and automotive computing for autonomous driving. Taking a co-design approach, EPI will design and develop the first European HPC systems on a chip and accelerators. Both elements will be implemented and validated in a prototype system that will become the basis for a full exascale supercomputer based on European technology.

Develop exascale software and applications. Exascale software and applications and their integration in extreme-scale prototypes will help ensure EU leadership in the application of HPC for scientific, industrial, and societal challenges. These activities will support development, optimization (including re-design), and scaling-up of HPC application codes toward exascale computing, as in HPC Centres of Excellence^h (CoEs). CoEs are also inherently committed to co-designing activities to ensure future HPC architectures are well suited for applications and their users, providing them with a high-performance, scalable application base.

Widen use of HPC and address the HPC-related skills gap. Widening the use of HPC and addressing the HPC-related skills gap will increase knowledge and human capital and boost HPC capabilities, including through creation of national HPC Competence Centresⁱ and their networking and coordination across the EU. These competence centers can gather the necessary resources and expertise to provide a single local entry point for customized HPC services, ranging from, for example, highly specialized scientific and technical HPC users to

SMEs with little or no experience in this domain.

EuroHPC JU in the Next EU Budgetary Period, 2021–2027

This is only the beginning, since in the EU's next Multiannual Financial Framework, covering the period 2021 to 2027, the aim is to continue supporting the EuroHPC JU via two different programs recently proposed by the European Commission—Horizon Europe^j and Digital Europe.^k

Horizon Europe is the EU's next Framework Program for Research and Innovation, the continuation of Horizon 2020,^l supporting the HPC research and innovation agenda and addressing exascale and post-exascale technologies.

The European Commission is also proposing to support the EuroHPC JU via the Digital Europe program with an additional €2.7 billion. This will cover acquisition of exascale supercomputers (at least one with European technology in 2022/2023) and post-exascale systems (around 2027), including integration and deployment of the first hybrid HPC/quantum infrastructure in Europe; and actions to develop advanced HPC skills and further facilitate access to industry, academia, and public administrations to the HPC ecosystem, and more. The program will also exploit the synergies between HPC and other digital priorities, including artificial intelligence, cybersecurity, digitizing public-sector services, and digital skills.

Conclusion

The EuroHPC JU is an ambitious initiative that will enable European countries to coordinate with the European Union their supercomputing strategies and investments. We thus need to reduce the fragmentation of HPC investments across Europe and align strategies and investments that are key for European innovation and competitiveness. We need to secure access to

world-class data and supercomputing facilities across Europe, ensuring development in Europe of an integrated exascale supercomputing capability accessible throughout Europe and covering the whole value chain, from technology components to systems and machines to applications and skills. This will avoid long-term negative effects on Europe's data sovereignty and scientific and industrial leadership and on Europe's place in the digital economy at large.

Today, the EU has put HPC very high in the political agenda, and we are confident this will remain the case for a long time. We are witnessing an exceptional surge of positive dynamics contributing to the success of the EuroHPC JU, including wide political support at both the national and EU levels, very strong support from public and private stakeholders, and the convergence of HPC with other critical disciplines for the data economy (such as big data and artificial intelligence). This is a unique opportunity for Europe to reap the benefits of mastering these converging technologies for our future. Only by joining forces can we mobilize substantial European and national efforts, both public and private, to place Europe in a leading position in the global digital economy.

Disclaimer. The views expressed in this article are the sole responsibility of the author and in no way represent the view of the European Commission and its services.

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^h <https://ec.europa.eu/digital-single-market/en/news/eu-funded-hpc-research-projects-and-centres-excellence-nutshell>

ⁱ A national HPC Competence Centre is a legal entity established in a participating state that is a member state associated with the national supercomputing center of that member state, providing users from industry, including SMEs, academia, and public administrations, with access on demand to supercomputers and to the latest HPC technologies, tools, applications, and services, and offering expertise, skills, training, networking, and outreach.

^j https://ec.europa.eu/info/designing-next-research-and-innovation-framework-programme/what-shapes-next-framework-programme_en

^k http://europa.eu/rapid/press-release_IP-18-4043_en.htm

^l <https://ec.europa.eu/programmes/horizon2020/en/>