European Commission

Leading the way in European Supercomputing

A PROJECTS INFO PACK BY CORDIS

Research and Innovation

SECOND EDITION

FOREWORD

"By joining the forces of many different partners, the EuroHPC Joint Undertaking aims to place Europe in a leading position in the global supercomputing race. The world-class supercomputing ecosystem developed by the EuroHPC JU is improving citizens' quality of life, advancing science and boosting the innovation potential of enterprises."

Anders Dam Jensen
Executive Director of the EuroHPC Joint Undertaking

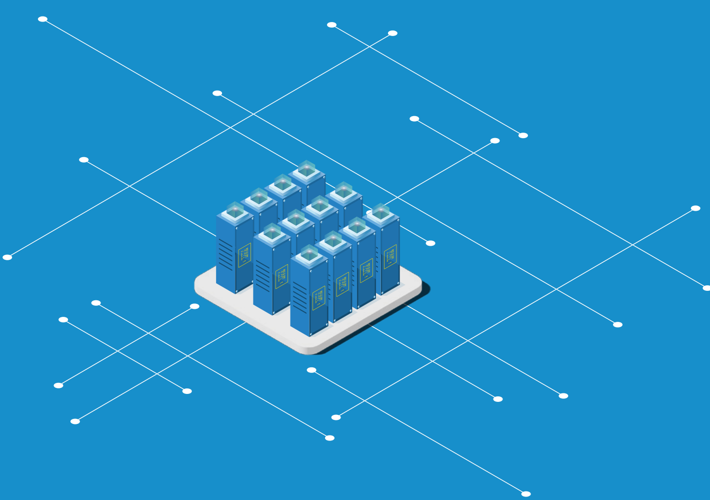
Supercomputers are advanced systems with extremely high computational capabilities. They are able to solve problems and perform calculations which require more speed and power than traditional computers are capable of.

High Performance Computing (HPC) services offered by supercomputers are critical for discovering new drugs, speeding up the diagnosis and treatment of diseases, anticipating severe weather conditions, increasing cybersecurity and developing more sustainable products.

The European High Performance Computing Joint Undertaking (EuroHPC JU) is a joint initiative created in 2018. It pools together the resources of the European Union, 33 European countries and three private partners with the ambition of making Europe a world leader in supercomputing.

To this end, the EuroHPC JU is procuring and installing supercomputers across Europe. No matter where in Europe they are located, European scientists and users from the public sector and the industry can benefit from these EuroHPC supercomputers, which rank among the world's most powerful. In parallel, the EuroHPC JU is funding an ambitious research and innovation programme to develop a full European supercomputing supply chain: from processors and software to applications to be run on these supercomputers and know-how to develop strong European expertise.

In this specially commissioned Projects Info Pack, you'll discover 12 selected EuroHPC JU projects that are promoting green computing and contributing to the technological and digital autonomy and leadership of Europe.



EuroHPC
Joint Undertaking

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EDITORIAL

Supercomputers are changing the lives of European citizens. Machines many thousands of times more powerful than a desktop computer are making breakthroughs in climate modelling, personalised medicine, energy saving strategies, and epidemic control. This Projects Info Pack showcases the European High Performance Computing Joint Undertaking (EuroHPC JU) and its work in developing Europe's supercomputer capabilities.

No European country has the capacity to develop world-class supercomputing resources individually. Cooperation, knowledge-sharing and the pooling of resources at European level are essential. The EuroHPC JU brings together the resources and expertise of 33 European countries and partners for building a leading European supercomputing ecosystem. The aim is to offer every participating country more opportunities than they would otherwise have, and lead the way in the global supercomputing race.

Since its creation in 2018, the Joint Undertaking has substantially increased overall investments in HPC at European level and has started to restore Europe's position as a leading HPC power globally. The Joint Undertaking is not only procuring supercomputers, but investing in research to develop innovative and competitive supercomputing technologies, applications, skills and expertise, based on a supply chain that is reducing Europe's dependency on foreign suppliers.

From the 39 research projects currently managed by the EuroHPC JU, this Projects Info Pack highlights 12 that reflect the diverse range of topics addressed by the Joint Undertaking.

A central objective of the Joint Undertaking is developing innovative, home-grown and sustainable HPC technologies, such as a low-power microprocessor **(EPI SGA2)**, a pilot platform integrating as many European technologies as possible **(EUPEX)**, an accelerator designed and deployed in Europe **(The European PILOT)** and also a unique incubator for quantum-HPC hybrid computing **(HPCQS)**.

Another objective of the EuroHPC JU is to develop applications, algorithms and software to be run on the supercomputers by public and private users. These include not only frameworks to improve overall efficiency and performance **(SPARCITY)**, and improved data handling **(ADMIRE)**, but also systems optimised for specific applications such as climate science **(MAELSTROM)**, fluid dynamics **(exaFOAM)** and plasma physics **(Plasma-PEPSC)**.

A third objective is to develop the skills to widen the use of HPC across a large number of public and private users, wherever they are located in Europe. **EuroCC** is creating a network of national HPC Competence Centres to ease access to European HPC opportunities in different sectors, while **FF4EuroHPC** supports SMEs which want to benefit from the use of HPC services to develop innovative products and services. Finally, **EUMaster4HPC** has set up a pioneering pan-European HPC Master of Science programme to educate the next generation of HPC experts across Europe.

Currently, the EuroHPC JU has already procured eight supercomputers located across Europe: in Bulgaria, Czechia, Finland, Italy, Luxembourg, Portugal, Slovenia and Spain. The construction of an additional two supercomputers is underway in Germany and Greece, with more systems planned for the near future. The investment delivered by the Joint Undertaking is of critical importance to develop a world-class supercomputing ecosystem in Europe, which will boost European competitiveness and innovation, and improve the quality of life of European citizens.

Upgrading Europe

Quick, think of a number. Now multiply it by 7. That sort of mental arithmetic is exactly what a computer does, except it can juggle numbers 19 digits long. And a supercomputer can perform trillions of these floating-point operations (or FLOPs) at once. One hundred top-of-the-line laptops working together might be able to achieve a single petaflop (*), and Europe's supercomputers are significantly more powerful than that. When all 10 EuroHPC systems are operational, the EuroHPC JU will provide more than 1 906 petaflops to European users.

(*) One petaflop equals 1 000 000 000 000 000 calculations per second.
Numbers in the following infographic indicate the number of petaflops available.

Source data: EuroHPC JU

HARDWARE

"Europe needs to grow its ability to develop HPC components, especially high-end processors. If we don't, we'll remain dependent on foreign imports."

Etienne Walter, EPI general manager

PROJECT ID CARD

Full name: European Processor Initiative

Project dates: 1 January 2022 – 31 December 2025

Coordinated by: Bull SAS in France

Funded under: Horizon 2020-Science with and for Society

CORDIS factsheet: cordis.europa.eu/project/id/101036168 (page to be made available on the CORDIS website)

Project website: european-processor-initiative.eu

Total budget: EUR 70 000 000

EU contribution: EUR 35 000 000

EPI SGA2

Equipping the EU with home-grown supercomputing technology

Phase 2 of the European Processor Initiative aims to develop and validate a general-purpose processor for high performance computing, as well as an accelerator using the open standard RISC-V.

HPC has the capability to complete extreme-scale simulations that are simply impossible to do with a single system. As such, they have the potential to transform research and business – and countries and regions with a strong HPC value chain will have a substantial competitive advantage.

Currently Europe is not considered as a major global player in high-end general-purpose and accelerator microprocessors. Projects such as the EU-funded European Processor Initiative (EPI SGA2) intend to contribute to a more autonomous European supply chain for HPC.

"Europe needs to grow its ability to develop HPC components, especially high-end processors," explains EPI general manager Etienne Walter. "If we don't, we'll remain dependent on foreign imports, which not only raises security and sovereignty concerns, but also impacts the European balance of payments and the competitiveness of European industry."

EPI is tackling the design of two types of components: a general-purpose processor (GPP) and accelerators.

During its first phase, the project designed a GPP chip called Rhea. The chip will now be commercialised by SiPearl, an EU-microprocessor start-up that began as a spin-off of the EPI project.

"With its high performance, energy-efficient Arm Neoverse V1 architecture, this first-generation processor will support legacy applications and meet the demands of a wide range of supercomputing workloads," says Walter.

In 2022, EPI manufactured an updated version of its EPAC test chip, a major technological accomplishment for the project. The EuroHPC Joint Undertaking has since launched two pilot projects, EUPEX and The European PILOT, both of which are focused on advancing these chips towards the commercial market.

"Working on high-range chip design at scale represents a key step to achieving the goals outlined by the EU Chips Act," adds Walter.

As the project continues to move forward, it is turning its attention to a new generation of GPP chips, designated Rhea2. It also looks to further develop and test RISC-V accelerators, which will be part of the EPAC test chip.

According to Walter, the goal is to develop and validate systems that integrate EPI's GPP into data centres and to position RISC-V as an open alternative to proprietary chip standards. "Achieving this will be a huge step towards equipping the EU with its own world-class supercomputing technology," he concludes.

"Being able to out-compute is the key to being able to out-compete."

Jean-Robert Bacou, EUPEX project coordinator

PROJECT ID CARD

Full name: European Pilot for Exascale

Project dates: 1 January 2022 – 31 December 2025

Coordinated by: Bull SAS in France

Funded under: Horizon 2020-LEIT-ICT

CORDIS factsheet: cordis.europa.eu/project/id/101033975

Project website: eupex.eu

Total budget: EUR 40 760 066

EU contribution: EUR 20 380 033

EUPEX

Paving the way towards European-made supercomputers

The EUPEX project is contributing to Europe's digital and technological sovereignty with a modular exascale-ready prototype system that is close to market-ready.

While Europe is home to a significant portion of the world's HPC resources, only a fraction of HPC technology and infrastructure is being developed here. According to Jean-Robert Bacou, project manager at Atos, this not only leaves the EU at a competitive disadvantage, it also makes it overly dependent on foreign imports.

"Being able to out-compute is the key to being able to out-compete," he says. "This is why Europe must develop a self-reliant HPC industry capable of manufacturing and delivering exascale-class supercomputers."

With the support of the EU-funded EUPEX project, Bacou is leading an effort to co-design a European modular exascale-ready pilot system. "This project is the culmination of more than a decade of European HPC research and development," he explains. "EUPEX will crystallise the research efforts and technological outcomes of many previous projects while also validating the processors developed by the European Processor Initiative, all with the goal of transforming these European technologies into a coherent modular pilot HPC platform."

To do this, the project will deploy a pilot hardware and software platform that integrates as many European technologies as possible. This includes the Atos BullSequana X3000 platform, SiPearl's Rhea processors, and Atos' BXI interconnect network. In terms of architecture, it will build upon the OpenSequana standard and the Modular Supercomputer Architecture initiated by the Jülich Research Centre. The project will also define a European software stack of reference.

"EUPEX will build a 'real' supercomputer, a production-grade prototype that will be very close to commercialisation and capable of demonstrating the market-readiness and scalability of these technologies," remarks Bacou.

Beyond the technology, EUPEX also intends to ensure that its innovative research is quickly translated into European-grown industrial solutions that can reduce Europe's dependence on foreign supercomputing technologies. "EUPEX will pave the way to the availability of European-made supercomputers – in particular European chips," concludes Bacou. "In doing so, we will help ensure Europe's digital and technological sovereignty while also preserving highly skilled jobs for European citizens."

"World-class competitiveness, leadership and self-reliance in industry and science are more important than ever for Europe."

Alba Vila Casademunt, The European PILOT project coordinator

PROJECT ID CARD

Full name: Pilot using Independent Local & Open Technologies

Project dates: 1 December 2021 – 31 May 2025

Coordinated by: Barcelona Supercomputing Center in Spain

Funded under: Horizon 2020-LEIT-ICT

CORDIS factsheet: cordis.europa.eu/project/id/101034126

Project website: eupilot.eu

Total budget: EUR 29 999 925

EU contribution: EUR 14 999 963

The European PILOT

Demonstrating European leadership in high performance computing

The European PILOT project will deliver the first pilot to demonstrate accelerator technology for high performance computing completely designed in Europe, boosting the EU's digital industry and technical sovereignty.

Imagine a future where the full HPC value chain is available in the EU using European sources. This is the future that the EU-funded European PILOT project hopes to make a reality.

"From microchip design to the systems incorporating them and their eventual deployment in data centres, The European PILOT aims to promote European leadership and strategic autonomy across the digital field," says Alba Vila Casademunt, research project manager at the Barcelona Supercomputing Center.

To do this, the project intends to be the first to demonstrate two accelerators, one for HPC and one for high performance data analytics (HPDA). Both accelerators will be completely designed and deployed in Europe.

"If these technologies are fully developed in Europe, the know-how and intellectual property stay in the EU, contributing to a sustainable exascale supply ecosystem and ensuring European digital autonomy," adds Vila Casademunt.

Using open-source software (SW) and open and proprietary hardware (HW), the project will deliver the first 100 % European full-stack software, accelerator and integrated ecosystem based on RISC-V accelerators coupled to any general-purpose processor. The accelerators will be manufactured in 12 nm advanced silicon technology, a significant achievement in integration and density.

"The European PILOT combines cutting-edge research with SW/HW co-design to demonstrate HPC and HPDA accelerators running key applications and libraries in a full SW stack, including middleware, runtimes, compilers and tools for the emerging RISC-V ecosystem," she explains.

According to Vila Casademunt, one key challenge in achieving this will be delivering power density and scaling at pre-exascale levels of performance. To overcome this potential roadblock, the project intends to demonstrate the advanced liquid immersion cooling technology required for the high-power densities of the system.

In addition to producing a full-stack research prototype, the project also looks to design computationally intensive applications in the fields of molecular and climate modelling, genomics, biomechanics and geophysics – among others.

"World-class competitiveness, leadership and self-reliance in industry and science are more important than ever for Europe," concludes Vila Casademunt. "By developing new HPC technologies, we'll help pave the way towards new digital innovations for a number of scientific domains."

"The information technology being developed by the project will place Europe at the vanguard of quantum computing."

Kristel Michielsen, HPCQS project coordinator

PROJECT ID CARD

Full name: High Performance Computer and Quantum Simulator hybrid
Project dates: 1 December 2021 – 30 November 2025
Coordinated by: Jülich Research Centre in Germany
Funded under: Horizon 2020-LEIT-ICT
CORDIS factsheet: cordis.europa.eu/project/id/101018180
Project website: hpcqs.eu
Total budget: EUR 12 000 000
EU contribution: EUR 6 000 000

HPCQS

Preparing Europe for a future of quantum computing

Sometimes even a supercomputer isn't super enough to get the job done. That's why this EU-funded project is making the leap towards quantum computing.

Across industry and science, there is an array of essential computing tasks that classical supercomputers struggle to solve. Examples of such complex problems include the optimisation of traffic flows and fundamental numerical problems in chemistry and physics for the development of new drugs and materials.

That's where quantum computing can help.

"The system and application-oriented development of quantum computing opens the door to new approaches to solving these hard-to-compute problems," explains Kristel Michielsen, a professor at the Jülich Research Centre in Germany. "Because many of these problems have important research and economic consequences, there's a sense of urgency that currently surrounds quantum computing."

With the support of the EU-funded HPCQS project, Michielsen is leading an effort to prepare European research, industry and society for a future of quantum computing. "The project is developing, deploying and coordinating a federated, European quantum computing infrastructure," she says.

To build this infrastructure, HPCQS, part of the EuroHPC Joint Undertaking, is using what are called quantum simulators, or QS. "A QS can be viewed as an analogue version of a quantum computer that, because it does not require complete control of each individual component, is simpler to build," notes Michielsen.

The project will procure and coordinate two pilot QS – each capable of controlling over 100 qubits – one located at GENCI/CEA in France and the other at the Jülich Supercomputing Centre. The two sites will integrate the QS into their respective data centres and operate them throughout their lifetime. Special attention will be given to understanding if essential HPC services can be shared. Researchers will also study the effective utilisation of the QS by scientists and engineers.

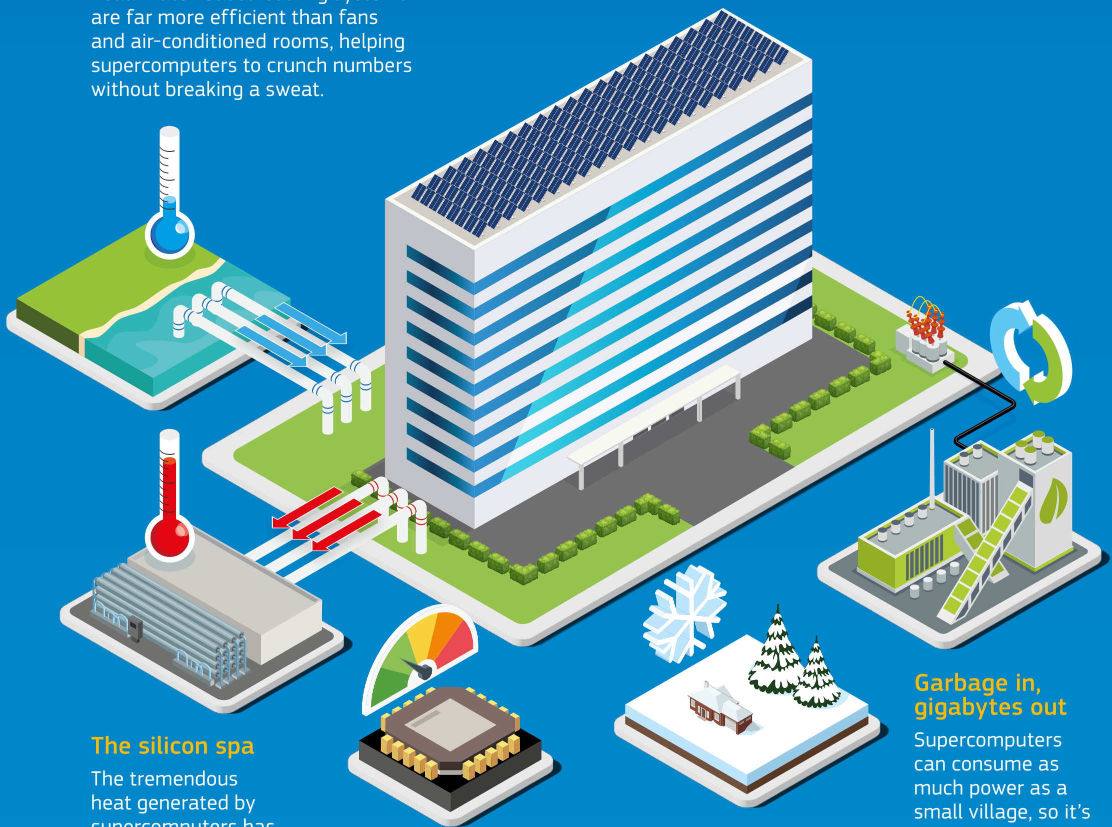
"The information technology being developed by the project will place Europe at the vanguard of quantum computing," concludes Michielsen. Once finalised, the HPCQS infrastructure will be made readily available via the cloud to public and private European users on a non-commercial basis.

Lean, green, numbers machine

Power isn't everything. In line with the EU's ambitious plans to achieve carbon neutrality by 2050, the EuroHPC JU has been instrumental in supporting the development of supercomputers that are big on power and low on environmental impact.

A series of tubes

Supercomputers generate a lot of heat. Water-based cooling systems are far more efficient than fans and air-conditioned rooms, helping supercomputers to crunch numbers without breaking a sweat.



The silicon spa

The tremendous heat generated by supercomputers has to go somewhere. Instead of venting it into the environment, LUMI in Finland uses water warmed up by the supercomputer to heat the surrounding buildings.

Low-energy chips

The EuroHPC JU is also helping to redesign supercomputers from the inside out. The energy-efficient microchips being developed by EPI SGA2 will help reduce power consumption even further.

Northern exposure

Another way to help supercomputers keep their cool is to build them in suitable climates. Ambient temperatures in Kajaani rarely exceed 16° C, the perfect place for Finland's LUMI.

Garbage in, gigabytes out

Supercomputers can consume as much power as a small village, so it's essential to make sure that electricity is sustainably sourced. In Bissen, Luxembourg, a local power station burns wood waste to keep MeluXina's lights on.

Source data: EuroHPC JU

SOFTWARE

“We will deliver a robust, well-supported and documented framework to end users in industry and academia.”

Didem Unat, SPARCITY project coordinator

PROJECT ID CARD

Full name: An Optimization and Co-design Framework for Sparse Computation

Project dates: 1 April 2021 – 31 March 2024

Coordinated by: Koç University in Türkiye

Funded under: Horizon 2020-LEIT-ICT

CORDIS factsheet: cordis.europa.eu/project/id/956213

Project website: sparcity.eu

Total budget: EUR 2 605 473

EU contribution: EUR 1 302 736

SPARCITY

Opening up the next frontier in supercomputing

The SPARCITY project will create a framework to provide efficient algorithms and coherent tools, aiming to maximise performance and energy efficiency of sparse computations on emerging high performance computing systems.

Exascale computers are able to perform over 10^{18} operations per second, allowing them to analyse vast amounts of data and simulate extremely complex processes. These HPC systems will be at the forefront of future scientific and technological innovations.

For major scientific innovations, a large fraction of the data that needs to be processed, managed and analysed is embedded in matrices where most of the elements are zero. So-called sparse computations are at the heart of many key applications. They are characterised by low amounts of computational work yet high levels of memory use. Memory resources therefore lag behind on many modern computing platforms, making existing HPC systems inefficient.

"Getting high performance for sparse computations is of great importance due to the widespread use of such computations in real-world applications," explains Didem Unat, an associate professor at Koç University and SPARCITY project coordinator.

In the EU-funded SPARCITY project, researchers are building a new supercomputing framework that will maximise both performance and energy efficiency of sparse computations on emerging HPC systems. SPARCITY aims to enhance computing in four critical fields: computational cardiology, social networks, bioinformatics and autonomous driving.

"There are numerous large-scale applications in these fields that can have significant societal and economic impact on our daily lives," says Aleksandar Ilic, a researcher at the computer research centre INESC-ID Lisbon. "Also, the data to be processed, and thus the amount of computing required, can be huge."

So far, SPARCITY has been developing a comprehensive set of tools to analyse application performance, and creating a preprocessing library for sparse algorithms known as SparseBase. The team have also created 'SuperTwin', a digital replica of a supercomputer and visualisation tool that lets users monitor and analyse HPC performance under different situations.

All SPARCITY tools will be made open-source to help the European community achieve the goals set out under the EuroHPC JU initiative.

"We will deliver a robust, well-supported and documented framework to end users in industry and academia," says Unat. "The project will strengthen scientific leadership and the competitiveness and innovation potential of European industry, contributing to a sustainable exascale HPC supply ecosystem in Europe and ensuring European technological autonomy."

"The sheer pace of advances in chip technology, architectures and cloud computing means that software providers need to be constantly innovating."

Fred Mendonça, exaFOAM project coordinator

PROJECT ID CARD

Full name: Exploitation of Exascale Systems for Open-Source Computational Fluid Dynamics by Mainstream Industry

Project dates: 1 April 2021 – 31 March 2024

Coordinated by: ESI Group in France

Funded under: Horizon 2020-LEIT-ICT

CORDIS factsheet: cordis.europa.eu/project/id/956416

Project website: exafoam.eu

Total budget: EUR 5 425 619

EU contribution: EUR 2 401 805

exaFOAM

Supercomputing software that goes with the flow

Updated open-source fluid dynamics software called OpenFOAM will usher in a new era of powerful computing technology, bringing operational and efficiency benefits to a range of industries.

Computational fluid dynamics (CFD) is a field of computer-aided engineering that addresses challenges related to fluid flows. Industries such as aerospace, chemical processing and power generation use CFD to improve energy efficiencies, reduce emissions and enhance user experiences.

"The sheer pace of advances in chip technology, architectures and cloud computing means that software providers need to be constantly innovating, while remaining cost-competitive and quality assured," explains exaFOAM project coordinator Fred Mendonça from ESI Group in France. "These industries all need efficient new computer technologies to keep increasing throughput."

The EU-funded exaFOAM project aims to address this need, with a focus on open-source CFD software. The goal is to harness advanced HPC architectures, and usher in a new era of innovation supported by accessible and powerful modelling technology.

"HPC enables huge reductions in design cycles – years to months even – by reducing compute time from weeks and days to hours," says Mendonça. "This is due to increased computational power and the possibility of solving evermore complex problems."

The exaFOAM project team will use code profiling to identify HPC-compute and input/output bottlenecks, and assess new algorithms and data structures. The goal is to maximise HPC performance across architecture and chipsets, using a unified codebase.

These new architectures, algorithms, data structures and HPC utilities will then be demonstrated within OpenFOAM, one of the most powerful open-source projects in the area of CFD, with a large industrial and academic user base.

"Several industrial end users will validate the project's outcomes in their fields of application," adds Mendonça. "Chip architects, HPC assemblers and cloud providers will also provide assessments of the project's contributions in different chipsets and architectures."

In this way, the project hopes to contribute to the quality-assessed availability of high-utility software, and achieve order-of-magnitude performance improvements.

"Our hope is that this project demonstrates the ongoing value of European collaboration when it comes to exploiting fast-evolving HPC technologies, for the benefit of both industry and the general public," notes Mendonça.

"We also hope that we can show how open-source software can unite experts in collaborative research."

"While computers are getting more powerful, storage systems remain fixed. The ratio between computing nodes and I/O resources is completely unbalanced."

Jesus Carretero, ADMIRE project coordinator

PROJECT ID CARD

Full name: Adaptive multi-tier intelligent data manager for Exascale

Project dates: 1 April 2021 – 31 March 2024

Coordinated by: Carlos III University of Madrid in Spain

Funded under: Horizon 2020-LEIT-ICT

CORDIS factsheet: cordis.europa.eu/project/id/956748

Project website: admire-eurohpc.eu

Total budget: EUR 7 963 286

EU contribution: EUR 3 981 643

ADMIRE

Intelligent, flexible storage boosts HPC potential

The ADMIRE project will develop an adaptive storage system that will allow high performance computing systems to deliver very high throughput, resulting in increased application performance.

Processing vast amounts of data – a critical operation for complex tasks such as weather forecasting, fluid dynamics modelling and artificial intelligence – is a key driving force behind the demand for HPC. However, conventional storage systems handling data input and output (I/O) have simply been unable to keep pace with this need.

"Traditional I/O systems tend to be very rigid and hierarchical," explains ADMIRE project coordinator Jesus Carretero from Carlos III University of Madrid in Spain. "This means that while computers are getting more powerful, storage systems remain fixed. As a result, the ratio between computing nodes and I/O resources is almost always completely unbalanced."

The EU-funded ADMIRE project addresses this by turning things around, adapting the back-end system to suit current HPC application data needs. "One idea is to develop and deploy ad hoc file systems for each application," adds Carretero. "We then provide synchronised connectivity with the back-end file system."

Storing data by using local devices and computing networks is many times faster than using the I/O network. Using local resources also avoids unnecessary information transit, helping to achieve energy efficiencies.

"Another thing we want to achieve is greater malleability," says Carretero. "This means being able to dynamically adjust computing processes and I/O servers, depending on the behaviour of any given application."

Algorithms and tools are being developed to adjust program resources in such a way that individual program runtimes and processing capacities are optimised. Carretero sees two key benefits from these approaches.

Firstly, HPC users will be able to run data-heavy programs and applications with significantly reduced execution times. And secondly, system administrators will be able to better allocate resources to increase system throughput. "There are benefits on both sides," he says.

The ADMIRE project will go on to validate its approach with end-user cases – including large-scale simulations, distributed learning applications and search engine indexing – as well as system administrators, who will ultimately have to deploy the system.

“Machine learning and hardware for machine learning have developed at a breathtaking pace, and have outrun the development of scalable machine learning tools in the weather and climate domain.”

Peter Dueben, MAELSTROM project coordinator

PROJECT ID CARD

Full name: MAchinE Learning for Scalable meTeoROlogy and cliMate

Project dates: 1 April 2021 – 31 March 2024

Coordinated by: European Centre for Medium-Range Weather Forecasts in the United Kingdom

Funded under: Horizon 2020-LEIT-ICT

CORDIS factsheet: cordis.europa.eu/project/id/955513

Project website: maelstrom-eurohpc.eu

Total budget: EUR 4 312 413

EU contribution: EUR 2 156 206

MAELSTROM

Boosting Europe’s ability to forecast extreme weather

The MAELSTROM project is facilitating the use of machine learning to advance meteorology, helping to evaluate future climate impacts.

Climate change will be one of the greatest threats humanity has to face. Scientists rely on complex computer programs to better model its potential impacts and to prepare the general public for extreme weather events.

In the EU-funded MAELSTROM project, researchers are designing a new software framework based on machine learning to boost Europe’s computer infrastructure and improve evaluations of future climate impacts and extreme weather.

“Machine learning and hardware for machine learning have developed at a breathtaking pace, and have outrun the development of scalable machine learning tools in the weather and climate domain,” explains Peter Dueben, head of the Earth System Modelling Section at the European Centre for Medium-Range Weather Forecasts (ECMWF).

“We need to understand what machine learning solutions are best for weather and climate applications, what hardware is best to perform efficient inference and training, and what hardware needs can be addressed by customised computer system design,” adds Dueben.

The MAELSTROM team is aiming to build machine learning applications that run efficiently on next-generation HPC hardware. They are focusing on six specific application areas for machine learning in weather and climate science that represent the vast majority of applications within the scientific domain.

“To make the most out of these applications, we need the tools and a software framework that allow for the easy use and comparison of machine learning architectures,” notes Dueben. “Both need to be applicable on single computer nodes and at scale on large supercomputers.”

The project is focusing on one work package for application development, one for the development of software tools and one for the development of computer system designs. These three work packages work in a co-design cycle so the researchers can improve applications, software and hardware at the same time, enabling immediate feedback between the various development teams.

The applications will also be published with benchmark machine learning data sets that will allow external machine learning scientists to get engaged and help to improve the programs. The data sets are already used by vendors to test the performance of their hardware in comparison to other hardware configurations.

“MAELSTROM is developing new machine learning solutions that will improve weather and climate applications with a large impact on society,” says Dueben.

"Our aim is to provide computing support for the whole European plasma physics community."

Stefano Markidis, Plasma-PEPSC project coordinator

PROJECT ID CARD

Full name: Plasma Exascale-Performance Simulations Centre of Excellence (CoE) - Pushing flagship plasma simulation codes to tackle exascale-enabled Grand Challenges via performance optimisation and codesign

Project dates: 1 January 2023 – 31 December 2026

Coordinated by: KTH Royal Institute of Technology in Sweden

Funded under: Horizon Europe – Digital, Industry and Space

CORDIS factsheet: cordis.europa.eu/project/id/101093261

Project website: plasma-pepsc.eu

Total budget: EUR 7 919 659

EU contribution: EUR 3 957 329

Plasma-PEPSC

Cutting-edge code to support plasma science

Developing software that helps scientists unravel mysteries from fusion to cancer medicine is at the heart of the groundbreaking Plasma-PEPSC project.

Often referred to as the 'the fourth state of matter' alongside solids, liquids and gases, plasma is a soup of charged particles. Its behaviour is of critical interest to scientists across a range of disciplines.

To help address this, the EU-funded Plasma-PEPSC project is working to improve and optimise their simulation codes for exascale computing and extreme-scale data analytics. All four codes being developed are related to specific challenges that involve the simulation of plasmas.

"The first code will simulate plasma behaviour in a fusion machine," explains the project's coordinator Stefano Markidis from the KTH Royal Institute of Technology in Sweden.

"There are major fusion experiments, such as ITER, currently going on in Europe. What we are doing is optimising a computing code that can be used to better understand the plasma physics going on within these experimental machines."

The project team will also study plasma accelerators, which have important medical applications. These can be used, for instance, to kill cancer cells. A third scientific driver is to develop code to model plasma material interaction. "This is important in industrial applications, for example in chip design," says Markidis.

And finally, there is space. As much as 99 % of the visible universe is thought to consist of plasma. The project plans to develop code that enables scientists to more accurately model and forecast space weather.

"In the near-Earth environment, the solar wind interacts with Earth's magnetosphere," explains Markidis. "This can cause problems for spacecraft."

The ultimate aim of Plasma-PEPSC is to establish a centre of reference when it comes to coding, and make these codes available to all European plasma physicists.

In fact, the Plasma-PEPSC team plans to have all four codes running on all EuroHPC supercomputers by project completion, in order to reach as many scientists as possible. "Our aim is to provide computing support for the whole European plasma physics community," says Markidis.

Putting EuroHPC JU on the map

The EuroHPC JU includes 33 countries working together to build Europe's supercomputing resources.

The EuroHPC JU has procured eight supercomputers located across Europe: in Bulgaria, Czechia, Finland, Italy, Luxembourg, Portugal, Slovenia and Spain. The construction of additional two supercomputers is underway in Germany and Greece, including an exascale system (which can provide thousands of petaflops), with plans for more, including revolutionary quantum computers.

Source data: EuroHPC JU

SKILLS

"By working together on topics of common interest, NCCs are creating a thriving HPC ecosystem, with the two-way exchanges between the European and national levels."

Bastian Koller, EuroCC project coordinator

PROJECT ID CARD

Full name: National Competence Centres in the framework of EuroHPC

Project dates: 1 September 2020 – 31 December 2022

Coordinated by: University of Stuttgart in Germany

Funded under: Horizon 2020-LEIT-ICT

CORDIS factsheet: cordis.europa.eu/project/id/951732

Project website: eurocc-access.eu

Total budget: EUR 56 329 834

EU contribution: EUR 27 936 679

EuroCC

National one-stop shops for HPC competencies

EuroCC's National Competence Centres act as hubs to promote and facilitate high performance computing and related technologies across a range of industries, increasing access to opportunities and offering tailored solutions for this fast-evolving field.

While there have been previous European initiatives to encourage the adoption of HPC and associated technologies, many exercised a national focus, resulting in a landscape of varying competence.

"To truly develop a globally competitive European HPC skills base – with a clear impact on society, industry and scientific excellence – European countries should be at comparable levels of competence," says Bastian Koller, project coordinator of the EU-funded EuroCC project.

In its first funding period, EuroCC set up 33 National Competence Centres (NCCs), the first initiative within EuroHPC to bring so many countries together. Each NCC comes with a commitment of support from its Member State, including 50 % cost-sharing, and is guided by the objectives of consolidation, integration and exchange.

By first identifying their available competencies, individual countries can maximise synergies to build national competence portfolios. To ensure these benefit the whole network, European-level activities are coordinated through a complementary project CASTIEL. The NCC network also cooperates with external bodies such as Centres of Excellence, the ETP4HPC and PRACE.

As some countries have already benefited from significant national HPC investment, one of the biggest challenges for EuroCC is to develop and harmonise competence levels across the network. In response, an NCC twinning and mentoring programme, financed by CASTIEL, has been established to share knowledge and skills.

But as Koller explains, "The disparities actually help by highlighting specific areas for impactful collaboration and guiding the network's collective trajectory and vision."

The disparities also generated a catalogue of various tried-and-tested solutions to problems encountered across the network. And new fields, such as quantum computing and AI, are being explored to identify future NCC priority topics.

"By working together on topics of common interest, NCCs are creating a thriving HPC ecosystem, with the two-way exchanges between the European and national levels that raise everyone's game," concludes Koller.

The work continues under EuroCC 2, funded under the Digital Europe programme. Running from January 2023 until the end of 2025, this will further support and develop 32 NCCs across Europe.

"HPC can now help SMEs solve problems that they simply couldn't before, often igniting new business models."

Guy Lonsdale, FF4EuroHPC project team member

PROJECT ID CARD

Full name: FF4EuroHPC: HPC Innovation for European SMEs

Project dates: 1 September 2020 – 31 August 2023

Coordinated by: University of Stuttgart in Germany

Funded under: Horizon 2020-LEIT-ICT

CORDIS factsheet: cordis.europa.eu/project/id/951745

Project website: ff4eurohpc.eu

Total budget: EUR 9 998 475

EU contribution: EUR 9 998 475

FF4EuroHPC

Access to cutting-edge technology boosts business

By supporting experiments that connect businesses with high performance computing resources, FF4EuroHPC's success stories are inspiring small and medium-sized enterprises to embrace cutting-edge technologies.

SMEs account for 99 % of all European businesses, forming the backbone of Europe's economy. But to grasp the opportunities offered by the pace and scope of digitalisation, many need better access to computing resources.

The EU-supported FF4EuroHPC helps SMEs access funds and expertise to both increase their own commercial potential and boost European innovation and competitiveness.

With a background in simulation software, Guy Lonsdale from the project team has watched HPC use evolve from computer-aided design to cutting-edge data analytics and machine learning.

"The field is now coming of age as technological advances converge with business needs," says Lonsdale. "HPC can now help SMEs solve problems that they simply couldn't before, often igniting new business models."

FF4EuroHPC follows two previous EU-supported projects, Fortissimo and Fortissimo 2. Both reached out to SMEs through open calls to fund 18-month experiments demonstrating the business benefits of HPC. Project partners supported the consortia with access to computing resources through a cloud-based infrastructure.

The result was 79 success stories showcasing a wide range of innovations, from simulations for light-aircraft aerodynamics to assessments of pre-existing drug compounds for potential treatments beyond current prescriptions.

Guided by the same approach, FF4EuroHPC has undertaken two funding calls for 15 month long experiments.

The first call resulted in EUR 3 million being released for 16 proposals, involving 53 organisations, 27 of which are SMEs. The second call released almost EUR 5 million to 26 funded proposals, involving 79 organisations, including 47 SMEs.

As before, FF4EuroHPC's selections represent a wide spectrum of applications.

"There are always surprises with these calls, such as using HPC and machine learning techniques, combined with sensors and an internet of things platform, for next-generation hen farming," explains Lonsdale.

To help build a fast-evolving and diverse HPC ecosystem, FF4EuroHPC encourages knowledge exchange between experiments, such as through workshops. "Our new experiments are on track to deliver more pioneering business-oriented success stories to promote further HPC take-up by European SMEs," concludes Lonsdale.

“Students will graduate from the programme equipped with the skills and confidence they need to drive Europe’s digital transformation.”

Pascal Bouvry, EUMaster4HPC project coordinator

PROJECT ID CARD

Full name: European Master for High Performance Computing

Project dates: 1 January 2022 – 31 December 2025

Coordinated by: University of Luxembourg in the Grand-Duchy of Luxembourg

Funded under: Horizon 2020-LEIT-ICT

CORDIS factsheet: cordis.europa.eu/project/id/101051997

Project website: eumaster4hpc.uni.lu

Total budget: EUR 7 000 000

EU contribution: EUR 7 000 000

EUMaster4HPC

Mastering the science of high performance computing

A new Master's programme aims to provide Europe with the skilled workforce it needs to leverage the opportunities presented by high performance computing.

HPC is a key component in Europe's digital transformation. "HPC is a rapidly growing field of research and development that has a strong potential for driving economic growth," says Pascal Bouvry, a professor at the University of Luxembourg.

However, leveraging HPC's full potential first requires the availability of a highly skilled workforce. "Without professionals educated in HPC and such related fields as data science and artificial intelligence, Europe risks missing this unique opportunity to advance its Digital Single Market," adds Bouvry.

While basic computer science and programming languages are included in many university curricula, these skills fail to meet the demands of the rapidly developing HPC technology ecosystem. That's why, with the support of the EU-funded EUMaster4HPC project, the University of Luxembourg is coordinating an effort to develop a European Master of Science (MSc) in HPC.

"Our goal is to gather all the expertise and knowledge that currently exist across European universities, research centres, industry, businesses, public administrations and SMEs and consolidate this into a single, pan-European graduate-level programme," explains Bouvry, who serves as project coordinator.

The 2-year Master's programme will start with a focus on HPC fundamentals before transitioning to specialisations during the second year of study. The programme will also include a mentorship initiative and an internship at a European HPC centre, research laboratory or company. To complete the degree, students will be required to write a thesis and defend it in front of a jury of experts.

"Students will graduate from the programme equipped with the skills and confidence they need to lead the adoption of HPC technologies and drive Europe's digital transformation," adds Bouvry.

The new MSc programme will be rolled out and piloted across several leading European universities. While some pilots will use existing programmes and courses in HPC, others will use new material prepared by the project. Based on these pilots, the project plans to create a coordinated, systemic approach to HPC training that they will make available for use by other universities.

The EuroHPC Joint Undertaking

The European High Performance Computing Joint Undertaking was established on 28 September 2018 by Council Regulation (EU) 2018/1488, and is currently regulated by Council Regulation (EU) 2021/1173. Drawing together countries, industry and public bodies to lead the way in European supercomputing, the EuroHPC JU has a combined budget of EUR 7 billion, drawn from the Digital Europe Programme, Horizon Europe, and Connecting Europe Facility 2.0 as well as contributions from participating countries and private members.

Supercomputers are vital tools needed to meet Europe's climate, energy and transport goals. They are also essential for national security, defence and sovereignty. The EuroHPC JU complements the aims of the European Chips Act to boost Europe's competitiveness and resilience in semiconductor technologies and applications, as chips are critical components of a supercomputer.

A central objective of the EuroHPC JU is to promote green and sustainable technologies as part of the EU's goals of carbon neutrality laid out in the European Green Deal. It is building some of the world's greenest supercomputers, drawing on technologies such as water cooling, waste heat recycling and next-generation energy-efficient microprocessors.

The EuroHPC JU contributes to the EC priority A Europe fit for the digital age, which aims to make the digital transition work for people and businesses.

Glossary

Accelerator refers to a hardware device or a software program with a main function of enhancing the overall performance of the computer. Various types of accelerators exist to enhance different aspects of a computer's function.

Algorithms are a finite sequence of well-defined instructions, typically used to solve a class of specific problems or to perform a computation. Algorithms are used in mathematics and computer science for performing calculations and data processing.

Application codes are software that address specific tasks for users, e.g. to solve a numerical problem.

Artificial intelligence (AI) is a field of computer science that endows systems with the capability to analyse their environment and take decisions with a degree of autonomy to achieve set goals. AI systems are used to perform complex tasks in a way that is similar to how humans solve problems.

Big data refers to large amounts of data that cannot be processed by traditional applications. Data can either be created by people or generated by machines, such as satellite imagery, digital pictures and videos, GPS signals, and more.

Chip means an electronic device comprising various functional elements on a single piece of semiconductor material, typically taking the form of memory, logic, processor and analogue devices, also referred to as an integrated circuit.

Cloud computing is a technology which allows internet users to store or use software on a server run over the internet. The stored information can then be accessed on any device from any location as long as internet access is available.

Exascale supercomputers are capable of executing more than 10^{18} (one billion billion) operations per second. By comparison, a laptop achieves around 1 000 billion operations per second.

HPC ecosystem refers to all the elements of the high performance computing value chain: the communities and stakeholders, and also the systems and the technologies, software and hardware elements which underpin these systems: from processors, accelerators, software, algorithms and applications to skills and expertise.

Hybrid computing blends the best of quantum and classical high performance computing technologies to perform even greater numbers of operations in parallel.

Machine learning is a type of artificial intelligence that allows software applications to become more accurate without being explicitly programmed to do so.

Mid-range supercomputers are defined as those in the petascale range, i.e. executing at least 10^{15} (one million billion) operations per second.

Pre-exascale supercomputers are capable of executing more than 10^{17} (100 million billion) operations per second.

Processors are the electronic circuitry that carry out the instructions that drive a computer. Processors are the building block of supercomputers.

Quantum computing uses quantum technologies to compute millions of possibilities in parallel, instead of one at a time as standard computers do.

Quantum simulators are quantum computers that manipulate quantum bits (qubits) as an ensemble rather than addressing individual qubits.

RISC-V is an open standard for the design of microprocessors. It allows the unrestricted, royalty-free development and commercial exploitation of chip designs for a wide range of applications.

Software is a collection of instructions that tell a computer how to work. This is in contrast to hardware, from which the system is built and actually performs the work.

SMEs are small and medium-sized enterprises.

Published
on behalf of the European Commission by CORDIS at the
Publications Office of the European Union
2, rue Mercier
L-2985 Luxembourg
LUXEMBOURG

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This Projects Info Pack is a collaboration between CORDIS and the European High Performance Computing Joint Undertaking.

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Print	ISBN 978-92-78-43469-4	doi:10.2830/53989	ZZ-05-23-064-EN-C
HTML	ISBN 978-92-78-43470-0	doi:10.2830/424845	ZZ-05-23-064-EN-Q
PDF	ISBN 978-92-78-43468-7	doi:10.2830/311685	ZZ-05-23-064-EN-N

Luxembourg: Publications Office of the European Union, 2023

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