Barcelona Supercomputing Center
Centro Nacional de Supercomputación

SUMMARY 2021

Who **we are**

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

Barcelona Supercomputing Center – Centro Nacional de Supercomputación (BSC) is the leader in supercomputing in Spain and an international centre of reference in this field.

We are a multidisciplinary research centre of reference. We host high-performance computing infrastructures, which are at the service of the international scientific community.

We are tier-1 members of the European Partnership for Advanced Computing in Europe (PRACE) research infrastructure. We manage the Spanish Supercomputing Network (RES), a Singular Scientific and Technical Infrastructure and support the international biomedical community, coordinating the Elixir and INB-ISCIII infrastructures.

Created in 2005 based on the experience of fruitful collaborations between the public authorities and private companies, such as CEPBA and CIRI, we have quickly grown from a staff of 60 people to around 800, thanks to the continuous commitment of our trustees and our ability to raise competitive funds from companies and institutions.

We have installed four consecutive versions of the MareNostrum supercomputer and we are currently preparing the fifth version.

BSC's missions

Supercomputing services for Spanish and European researchers

R&D in Computer, Life, Earth and Engineering Sciences

Knowledge transfer (education, tech transfer and public engagement)

BSC is a public consortium made up of:

Generalitat de Catalunya
Departament de Recerca i Universitats

GOBIERNO DE ESPAÑA
MINISTERIO DE CIENCIA E INNOVACIÓN

50 ANYS sense limits

BSC in **numbers**

RESEARCH

57 Research groups

6 ERC projects in progress

8 ICREA researchers

67 Researchers with personal grants

HORIZON 2020 — **€124 M**

The third-largest Spanish recipient of H2020 program funds

138 H2020 projects in progress

32 H2020 projects started in 2020

19 H2020 projects coordinated by BSC

Involvement in the **15** European centres of excellence for HPC applications

We participate in **12**

We lead **4**

304 Articles in scientific journals — **232** In Q1

3 Chapters in published books

13 Doctoral theses

68 Papers in conference proceedings — **30** In A and A* conferences

175 Open-access publications

TECHNOLOGY TRANSFER

Technologies transferred or licensed

5 Patents

3 Methodologies

20 Software

11 Spin-offs created

Bilateral collaborations with companies

21 In progress

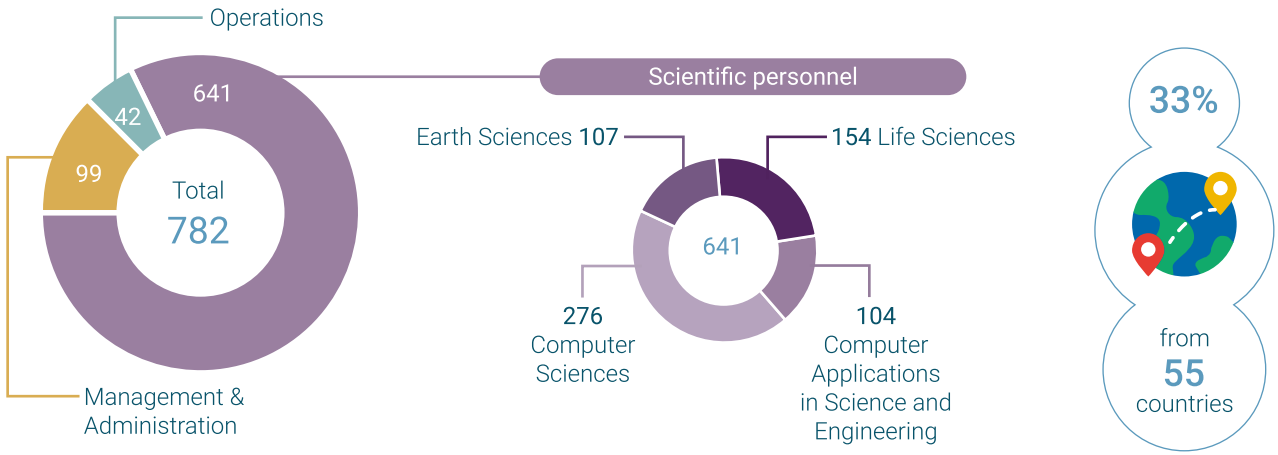
20 Started in 2021

26 Patents approved or pending approval

SUPERCOMPUTING

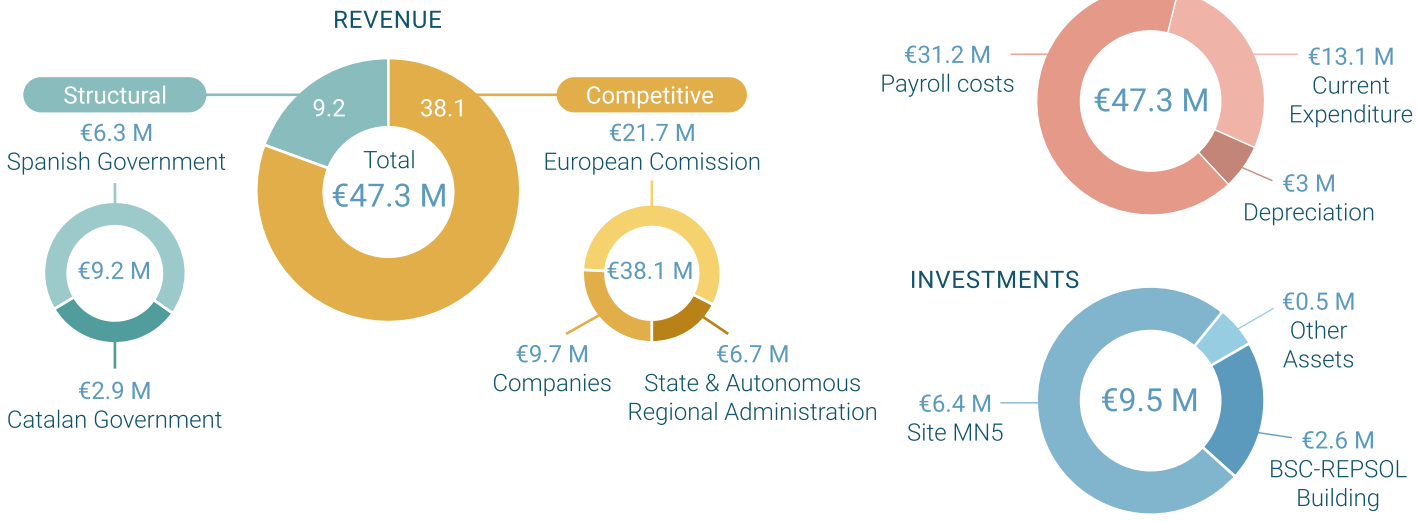
PEOPLE

Data as of December 31, 2021



RESOURCES

2021 executed budget



UPC contributes, in terms of assigned staff and room space, the equivalent of 10% structural funds.

Revenue and expenses according to finance criteria. Investments according to budgetary criteria.

Where **we are**, Where **we are going**

Mateo Valero and Josep M. Martorell
Director and associate director of BSC

2021 was a year marked by the continuation of the COVID-19 pandemic. There were months of virtual normality and phases in which working from home was the general rule. Despite the difficulties, both professional and personal, on balance the year could not have been more positive.

So the first thought that springs to mind this year is "thank you". Thank you, first and foremost, to all BSC employees, because their continued effort has enabled a record-breaking year in almost every possible aspect. And thank you to our patrons (who place their trust in us just as they did on the first day) and to the various funding agencies and companies that continue to support our research.

We will end 2021 with very close to 800 people working at BSC, having spent a budget that for the first time exceeds €45 million, 80% of which comes from competitive funds. We currently manage a portfolio of more than 250 projects, including 30 coordinated European projects. These figures consolidate our growth and once again position us as one of the best supercomputing centres in Europe.

This was also the year we inaugurated our new corporate headquarters, thanks to the support of our patrons and the Repsol Foundation. This beautiful building, which we have been eagerly awaiting for years, allows us to bring two thirds of our team together under one roof and will be the home of our future supercomputing infrastructures. It is here that we will install the future MareNostrum 5, which we expect to arrive in 2022 and which will consolidate our leading role on the European supercomputing map.

At the end of this financial year, we are leading a large part of the projects for the development of future European computing technology, and we are one of the most active institutions in the European centres of excellence for supercomputing applications. Our continental leadership in various areas of research has been consolidated with examples that you can see in this Summary, such as the new advanced computing hub for EUROfusion, coordination of the European health data strategy, and our active participation in the 2021 climate summit.

This was also the year that the "European Recovery and Resilience Mechanism", better known as Next Generation, was launched. Over the next few years, our country will receive a very large amount of funds to finance R&D-related activities. This could be a great opportunity for the R&D system as a whole and for BSC in particular. In its first year, these funds have already financed BSC's participation in the research programs promoted by the EuroHPC Joint Undertaking and the launch of Quantum Spain, an ambitious project that will strengthen the quantum computing ecosystem in our country and allow for the installation of our first quantum computer.

As we said at the beginning, despite the continuous uncertainty as the pandemic progressed, our activity has carried on as usual, performing research, serving the Spanish and European HPC community with our computing and data infrastructures, and transferring our knowledge to society. Regarding the last aspect, the year was particularly productive in terms of outreach, as can be seen at the end of this summary.

Finally, we would like to acknowledge and express our gratitude for the good work of our Scientific Committee, who visited us in the autumn as they do every three years. The visit was very fruitful and allowed us once again to present our strategy to a panel of renowned international scientists who work in the various fields of supercomputing. We will end with a brief quote from their final report: "There has been a substantial improvement in the Centre's activities since 2018 despite the impact of the Covid pandemic". Their recommendations are tremendously useful in better facing our future and their acknowledgements are an encouragement to go even further. We trust they will also be so for the entire BSC team, its patrons and all those institutions and companies that have always been by our side.

The three BSC trustees have appointed new representatives to BSC's Governing Board.

Raquel Yotti
President
Secretary General of Research

Esther Morales
Vice-president
Secretary General of Research and Universities

Gonzalo Arévalo Nieto
Director General of Research Planning

José Ignacio Doncel
Deputy Director General of Large Scientific and Technical Facilities

Joan Gómez Pallarès
Director General of Research

Dani Marco
Director General of Innovation and the Digital Economy

Daniel Crespo
Vice-chancellor

Jordi Llorca
Deputy Vice-chancellor for Research

Generalitat de Catalunya
Departament de Recerca i Universitats

GOBIERNO DE ESPAÑA
MINISTERIO DE CIENCIA E INNOVACIÓN

UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH

New BSC corporate headquarters

The new BSC corporate headquarters, the BSC-REPSOL Building, is now a reality. The building is 12,000 m² in size with four floors of offices, 530 workstations, 35 meeting rooms, two training rooms, an auditorium and various meeting points to promote the exchange of knowledge between research teams. Two thirds of BSC's staff work at the headquarters and the rest in nearby buildings, in and around the Torre Girona gardens.

The BSC-REPSOL Building cost €19.6 million and was financed with contributions from the centre's trustees (Spanish Ministry of Science and Innovation, Catalan Government Department of Research and Universities and the Polytechnic University of Catalonia) and with the collaboration of the Repsol Foundation and the European Regional Development Fund (ERDF).

The new BSC building is connected, by a walkway, to what until now has been the centre's most icon place, the Torre Girona chapel, which currently houses the MareNostrum 4 supercomputer.

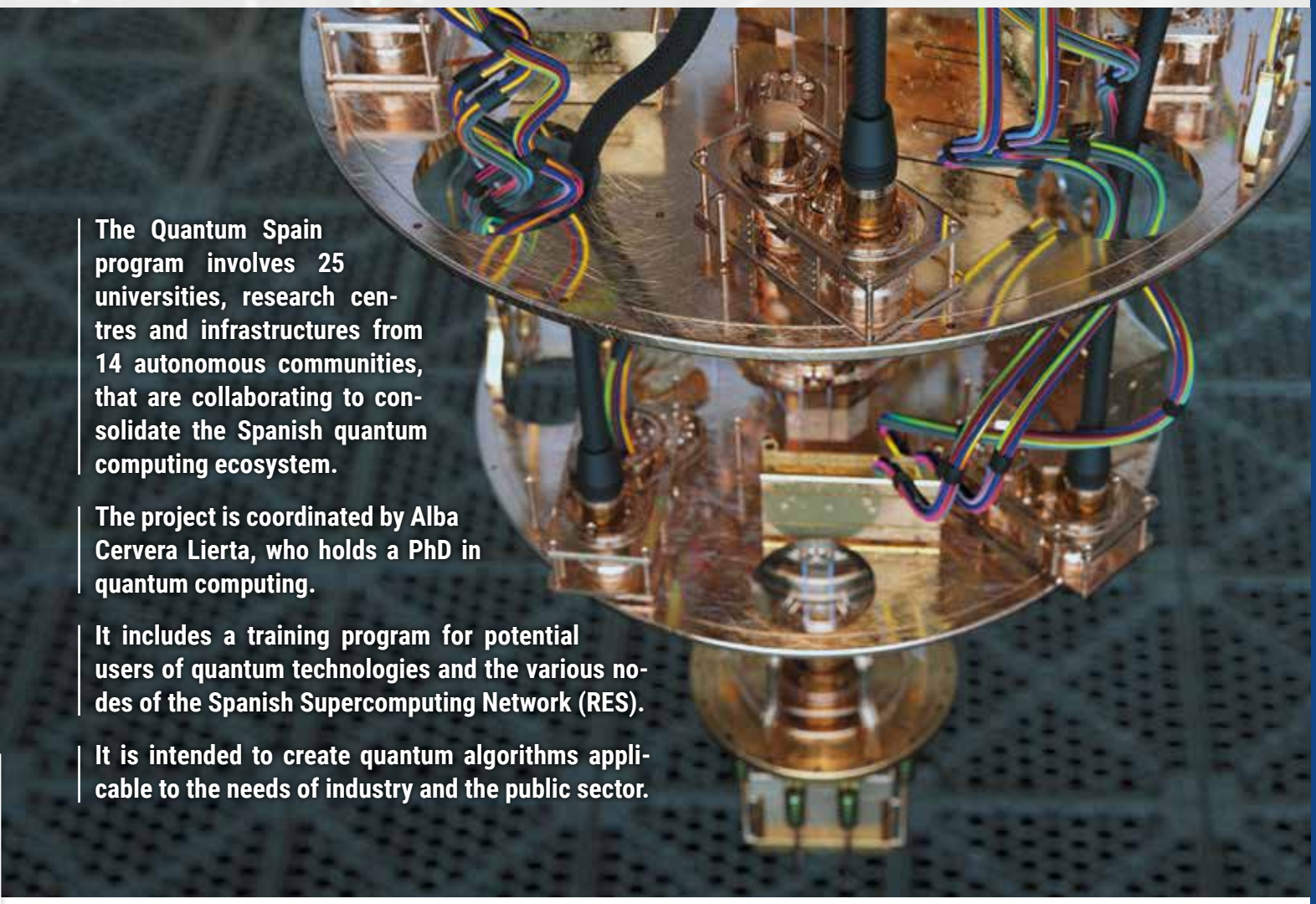
A new supercomputer room is being built in its basements, which will allow the installation of larger and higher-capacity supercomputing infrastructures, such as the future MareNostrum 5.

When this happens, the Torre Girona chapel will remain an iconic and visitable space and will house world-class supercomputing and data infrastructures.

Generalitat de Catalunya
Departament de Recerca i Universitats

EUROPEAN UNION
European Regional Development Fund

The Quantum Spain project kicks off



The Quantum Spain program involves 25 universities, research centres and infrastructures from 14 autonomous communities, that are collaborating to consolidate the Spanish quantum computing ecosystem.

The project is coordinated by Alba Cervera Lierta, who holds a PhD in quantum computing.

It includes a training program for potential users of quantum technologies and the various nodes of the Spanish Supercomputing Network (RES).

It is intended to create quantum algorithms applicable to the needs of industry and the public sector.

BSC is coordinating the Quantum Spain project, which involves building and installing the first quantum computer based on European technology. The goal of Quantum Spain, funded by the Secretariat of State for Digitalization and Artificial Intelligence, is to create a robust quantum computing ecosystem in Spain.

The project involves building a quantum computer to be installed at the BSC headquarters, which will be progressively equipped with chips of different generations and numbers of qubits. It will use qubits based on superconductor circuit technology and the hardware will be built in collaboration with specialized companies in this emerging sector.

The computer is initially expected to have a two-qubit chip operational by the end of 2022. It will progressively incorporate new chip versions, reaching 20 qubits by 2025.

Quantum Spain also plans to develop quantum algorithms applicable to the problems of companies and public bodies, to create a remote access system to experiment with the new algorithms, and to implement a training program to enhance the skills of potential users and nodes in the Spanish Supercomputing Network (RES).

At the service of science

From Galileo's handcrafted telescopes to the particle accelerator in Geneva, scientific instruments have undergone an enormous technological evolution.

They have also changed the kinds of questions science seeks to answer. We want to answer questions about phenomena that cannot be observed with the naked eye or with the help of optical instruments.

What is supercomputing?

Supercomputing allows us to carry out scientific experiments by simulating the behavior of the object of study in silico. Bringing together all the knowledge about this object in a computer simulation and experimenting with it makes it possible to cut costs, avoid suffering and perform experiments that could not be done in the real world, because they would be too expensive, too dangerous or simply impossible.

Supercomputers are also necessary to analyze large amounts of data, such as those provided by large-scale modern scientific instruments (particle accelerators, large telescopes, interferometers, genome sequencing platforms, etc.) or the ever-increasing number of devices in the Internet of Things.

It has been demonstrated for years now that supercomputing is also the great ally of artificial intelligence, since its great calculation capacity aids the training of algorithms and drawing of conclusions from large amounts of data.

High-performance computing has already become a great accelerator for science and engineering. Most scientific disciplines use it to expand their frontiers of knowledge.

Research in MareNostrum 4

MareNostrum 4 provided 1,219 million processor hours in 2021. 80% of these were used by researchers who gained access to the supercomputer through the European Partnership for Advanced Computing in Europe (PRACE) infrastructure network or the Spanish Supercomputing Network (RES).

Daniel Nóbrega Siverio
Coronal Bright Points on the Sun: a study from the photosphere to the corona

Sascha Husa
Compact binary coalescence modelling toward LIGO/ Virgo design sensitivity and next generation detectors

Xavier Luri Carrascoso
Gaia: Image parameters determination and cross match of observations for the fourth Data Reduction Cycle (DRC-04)

Horacio Pérez-Sánchez
Discovery of SARS-CoV-2 inhibitors through large-scale Virtual Screening methods

Emilio Artacho
Radiation damage on realistic DNA models via first-principles methods

Jazmin Aguado Sierra
Validation of an in-silico clinical trial in a cardiac population for the assessment of pro-arrhythmic risk of repurposed drugs

Vicent Moliner
Computer Design of Double Acting Inhibitors of SARS-CoV-2 Mpro by QM/MM Simulations: Towards the Design of COVID-19 Antiviral Drugs

Mr. Clément Bricaud
SWOP: the Submesoscale-permitting World Ocean Project

Mireia Peral Millán
Geodynamic modeling of subduction zones. Case studies: Western and Central Mediterranean and Andes Cordillera

Research in MareNostrum 4

TÉCNICO LISBOA

Dr. Jorge Vieira
Acceleration control and superradiance in laser-plasma accelerators

TOR VERGATA

Prof. Roberto Verzicco
TORNADO - Rotating double diffusive and Rayleigh-Bénard convection

IFAE Institut de Física d'Altes Energies

Andres Pacheco Pages
Monte Carlo Simulation for the ATLAS Experiment at the CERN LHC at the MareNostrum by IFAE/PIC Tier-1

Ciemat
Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

José Hernández
MC Simulation for the CMS Experiment at the CERN LHC

Maria Veronica Ganduglia-Pirovano
Study of Methane Steam Reforming on Ceria-based Bimetallic Ni/Cu Catalysts

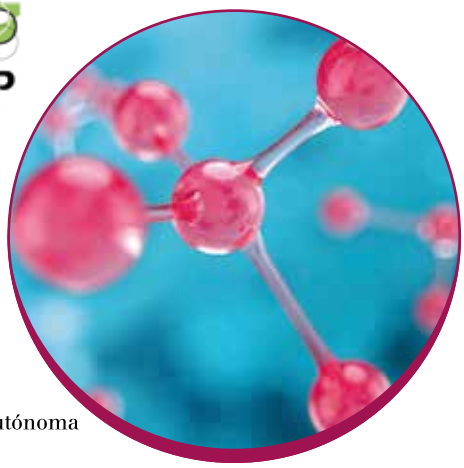
ICP

Nuria Lopez
Dynamic behavior of Earth-abundant heterogeneous (electro)-catalysts

ICIQ Institut Català d'Investigació Química

Inés Corral Pérez
Photophysical and photochemical validation of alien genetic building blocks and N-nucleobases ancestors

UAM Universidad Autónoma de Madrid



Providing a service for researchers all around Europe

The MareNostrum 4 supercomputer is available to researchers all around Europe. The Spanish Supercomputing Network (RES) and the European PRACE network share 80% of its calculation capacity. This is assigned through open application processes in which researchers present their proposals, which are then assessed by scientific committees who are experts in the different disciplines. The remaining 20% of the supercomputer's capacity is assigned to BSC.

MareNostrum 4 has a maximum power of 13.9 petaflops or, in other words, 13,900 trillion operations per second

MareNostrum 4 is co-financed by the Intelligent Growth Operating Program 2014-2020 of the European Regional Development Fund (ERDF)

Unión Europea
Fondo Europeo de Desarrollo Regional "Una manera de hacer Europa"

GOBIERNO DE ESPAÑA MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

Research Acknowledgements

Rosa M. Badia receives the HPDC Achievement Award 2021

Rosa M. Badia, leader of the Workflows and Distributed Computing group, received the HPDC Achievement Award 2021 for her innovations in task-based parallel programming models, applications and workflow systems and for her leadership in the high-performance computing research community. Badia has also been appointed as a distinguished member of the Association for Computing Machinery (ACM), for her outstanding scientific contributions in the area of computing, and a director of ACM-Europe.

Markus Donat appointed as an ICREA Professor and AXA Climate Science Prizewinner

Markus Donat, co-leader of the Climate Prediction group, has been appointed as an ICREA Professor and received the AXA Climate Science Award, which aims to recognize and reward researchers for their outstanding contribution to scientific understanding and adaptation to climate change.

Toni Gabaldón, new member of EMBO

Toni Gabaldón, an ICREA professor and leader of the IRB Barcelona/BSC group, has been appointed as a member of EMBO (European Molecular Biology Organization). EMBO is a community of more than 1,800 renowned researchers, promoting excellence in life sciences in Europe and beyond.

Josep Lluís Gelpí, new Prof. of Biochemistry and Molecular Biology at UB

Josep Lluís Gelpí has been appointed as a new Professor of Biochemistry and Molecular Biology at the University of Barcelona (UB). Gelpí is the director of the Computational Bioinformatics Node and leader of the computational team at the National Institute of Bioinformatics (INB) / ELIXIR-ES.

Mateo Valero receives the Honorary Award from the Galician Association of Computer Engineering

The director of BSC, Mateo Valero, has received the Honorary Award from the Galician Professional Association of Computer Engineering (CPEIG) for his role in promoting supercomputing in Spain and Europe and for being one of the most award-winning researchers in his field worldwide.

Asun Lera St. Clair, member of the Expert Group of the Citizens' Climate Assembly

Asun Lera St. Clair, a senior advisor in the Department of Earth Sciences, has been appointed as a member of the independent Expert Group of the Citizens' Climate Assembly, whose members were announced by the Ministry for Ecological Transition and the Demographic Challenge.

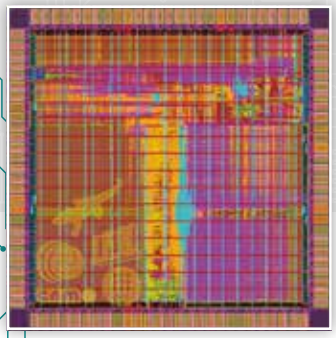
Salvador Capella becomes vice-president of the Spanish Society of Bioinformatics

Salvador Capella, the leader of the National Bioinformatics Institute group at BSC, has been appointed as the vice-president of the Spanish Society of Bioinformatics and Computational Biology (SEBiBC), whose honorary president is BSC's Director of Life Sciences, Alfonso Valencia.

Luis Gascó receives the Extraordinary Doctoral Thesis Award from UPM

Luis Gascó, a researcher at BSC's Text Mining unit, has received the Extraordinary Doctoral Thesis Award from the Polytechnic University of Madrid for the 2019/20 academic year for his research entitled "Exploitation of ICTs in Noise Management and its Influence on Public Perception of Noise".

On the way to an Open HPC ecosystem



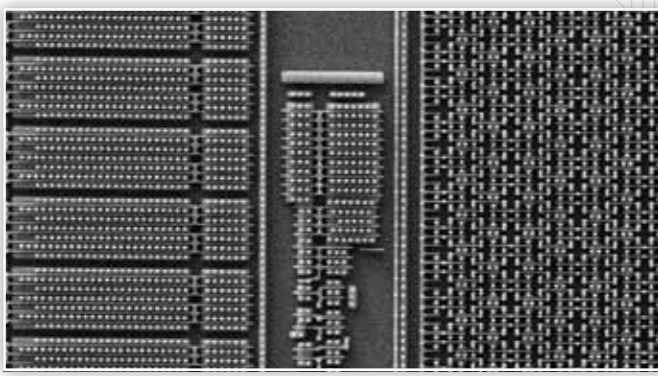
The BSC is implementing its High-Performance Computing (HPC) vision, creating an open HPC ecosystem based on open-source software and hardware.

While open-source software is not new, open-source hardware is and is gaining tremendous momentum based on the foundation that BSC and our partners are building.

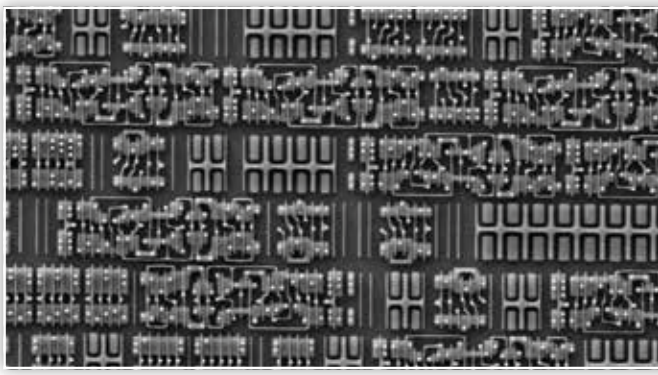
In the new technology environment, some of the rules have changed. This has produced a shift from abundant transistors to efficient use of transistors. Thus, to truly meet the power and performance requirements, we must specialize the hardware.

At the same time, the current technology trends are shifting how we develop applications and where we run these applications. The software stack is evolving, becoming more abstract, enabling higher programmer productivity, but sacrificing hardware efficiency.

High-level programming languages and work flows enable domain experts and scientist to construct their own HPC applications. They will need to co-design the full stack, all layers of hardware and software, in order to meet their performance and power (FLOPs/W) targets for exascale, zettascale and beyond. This level of integration is not possible in a closed or even partially open ecosystem. For this fusion, the platform must be open.

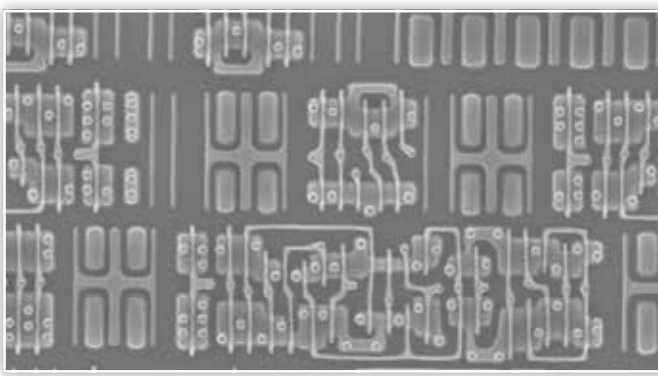


Many components in the software stack are already part of the open-source ecosystem and amendable to research and development targeting co-design and the resulting specialization. However, up until now, hardware has been a closed ecosystem that inhibits true hardware/software co-design.



The Laboratory for Open Computer Architecture

The Laboratory for Open Computer Architecture (LOCA) is an initiative to facilitate the development of an open HPC ecosystem based on open-source software and new open-source hardware. LOCA is a mechanism to drive global academic and industrial collaboration, training and education that will enable this revolution.



BSC merges the unique combination of expertise in various application domains with the hardware design capabilities required for software/hardware co-design and the MareNostrum facilities for HPC system deployment. We have all the ingredients to create this future with much of the work already underway, gaining momentum and garnering global recognition.

BSC open-source hardware path

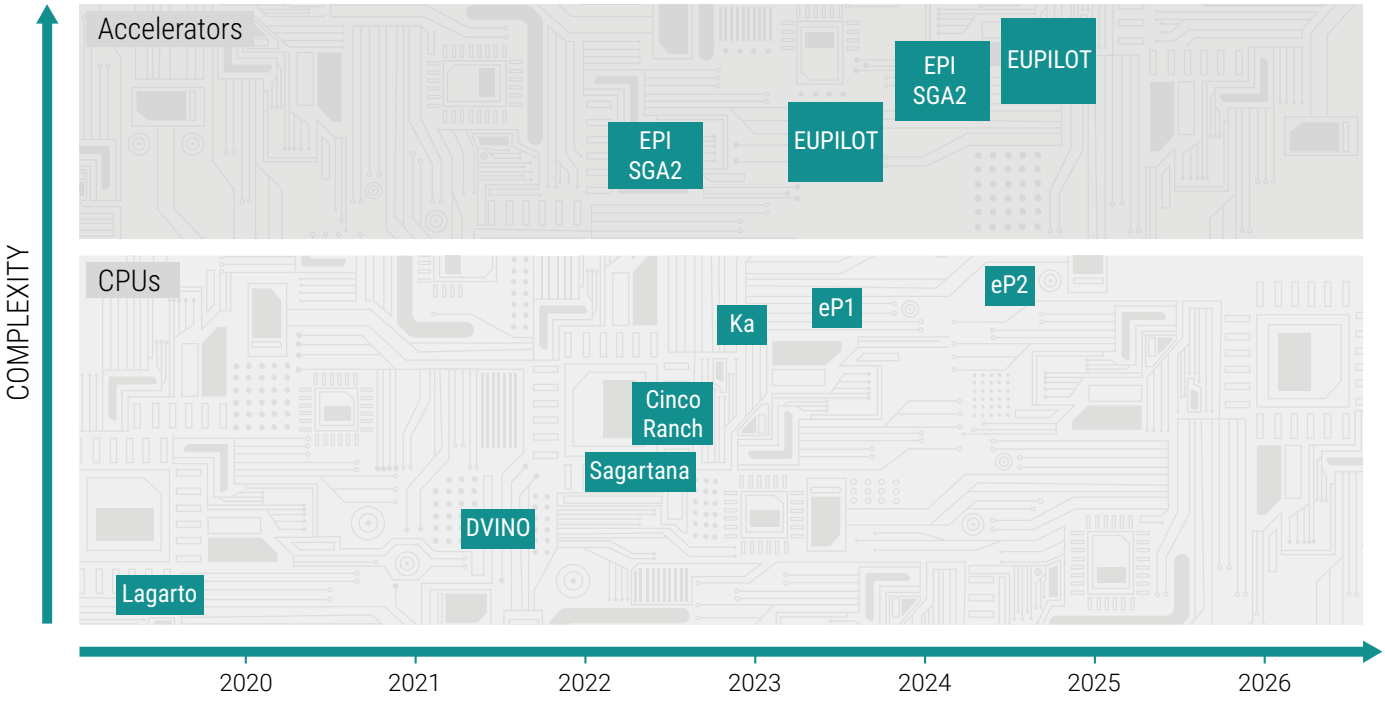
Recently, a viable open-source hardware option has been made available with the RISC-V open (ISA), which can be coupled with the strong and vibrant open-source software community, creating an open HPC ecosystem.

There are two main thrusts in hardware development: CPUs (Central Processor Units) and accelerators. Both can benefit from research based on an open ISA, enabling the freedom to add extensions to both CPU and accelerators, while maintaining a base-level compatibility with existing software.

In research, developing research prototypes provides higher quality results, easier technology transfer and overall technology know-how that is critical to solving our future HPC, artificial intelligence, machine learning, and deep learning challenges.

We have started down this open-source hardware path with the development of several CPU cores and accelerators. We are taking a pragmatic approach, developing simple cores and improving the CPU capabilities over time, both in terms of capabilities and smaller silicon technology nodes.

As the figure shows below, we started the Lagarto family of cores, with a simple process that can issue one instruction per clock cycle in program order, fabricated in May of 2019. Concurrently, we developed a vector processor, in particular the vector processing unit (VPU), with several partners participating in the European Processor Initiative (EPI SGA1), fabricated in March of 2021. We combined the capabilities of our first Lagarto Processor with the VPU to create DVINO, fabricated in July of 2021. The third generation processor is called Sargantana, fabricated in 2022. We have many more processors and accelerators to come from projects like DRAC, eProcessor, The European PILOT and EPI SGA2.



Featured **publications**

The multidisciplinary nature of BSC can be seen in the wide range of fields in which researchers publish scientific articles.

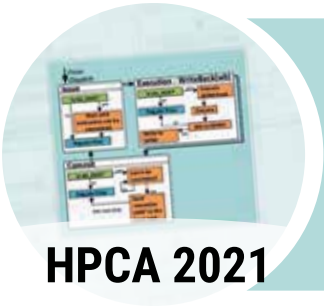
Below is a selection of the most notable publications in 2021.

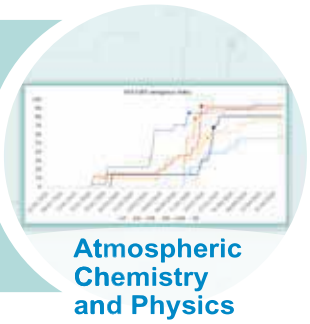
Morrigan: A Composite Instruction TLB Prefetcher

This paper is the first to demonstrate that data centre and server workloads suffer severe performance degradation due to the cost of instruction address translation. It proposes a new TLB prefetcher targeting instruction addresses, which provides an average performance improvement of 7.6%. G. Vavouliotis, L. Alvarez, B. Grot, D. Jiménez and M. Casas. Proceedings of the 54th Annual IEEE/ACM International Symposium on Microarchitecture (MICRO). Association for Computing Machinery, New York, NY, USA, 1138-1153.

VIA: A Smart Scratchpad for Vector Units with Application to Sparse Matrix Computations

Presentation of the new Vector Indexed Architecture (VIA), which accelerates applications with memory access patterns, such as sparse matrix computations. Acceleration is achieved with a smart notepad closely coupled to the vector functional units in the core. J. Pavon, I. Vargas-Valdivieso, A. Barredo, J. Marimon, M. Moretó, F. Moll, O.S. Unsal, M. Valero and A. Cristal. International Symposium on High-Performance Computer Architecture (HPCA), pp. 921-934. February 2021.





Time-resolved emission reductions for atmospheric chemistry modelling in Europe during the COVID-19 lockdowns

The study quantifies the reductions in primary emissions due to COVID-19 lockdowns in Europe, considering activity reduction factors that vary by source, country, day and meteorological data. M. Guevara, O. Jorba, A. Soret, H. Petetin, D. Bowdalo, K. Serradell, C. Tena, H. Denier van der Gon, J. Kuenen, V.-H. Peuch and C. Pérez García-Pando. Atmospheric Chemistry and Physics, 21, 773-797.

Engagement, involvement and empowerment: three realms of the coproduction framework for climate services

This article presents a cross-disciplinary co-production framework to help establish a smooth and effective interface between scientists and stakeholders in climate services. D. Bojovic, A.L. St. Clair, I. Christel, M. Terrado, P. Stanzel, P. Gonzalez and E.J. Palin. Global Environmental Change, 64, 10227.

One qubit as a universal approximant

In this paper we demonstrate for the first time how to train a single qubit to perform arbitrary mathematical operations. The training process is performed with real data in a simulator and transferred to and verified in an operational quantum device based on superconducting technology. A. Pérez-Salinas, D. López-Núñez, A. García-Sáez, P. Forn-Díaz, and J. I. Latorre. Physical Review A. June 2021.

Large eddy simulation of aircraft at affordable cost: a milestone in CFD Konrad

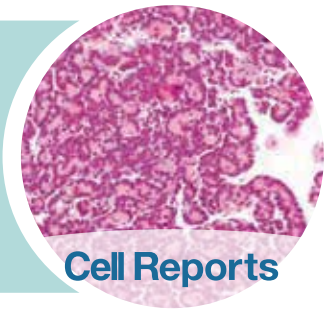
This research arises from one of the Grand Challenge problems in computational aerosciences identified by NASA concerning the use of Computational Fluid Dynamics as a key tool for aircraft design. The paper proves that it is feasible to meet the precision and affordability requirements using large eddy simulation in modern computer architectures. Konrad A. Goc, Oriol Lehmkuhl, George I. Park, George I. Park, Sanjeeb T. Bose, Parviz Moin. Flow 2021.

The impact of non-additive genetic associations on age-related complex diseases

The paper demonstrates how GUIDANCE, a genome analysis strategy proposed by BSC that includes multiple reference panels and X-chromosome analysis, increases the identification of genetic variants and provides insight into the genetic architecture of complex diseases. M. Guindo-Martínez, R. Amela, S. Bonàs-Guarch, M. Puiggròs, C. Salvoro, I. Miguel-Escalada, C.E. Carey, J.B. Cole, S. Rüeger, E. Atkinson, A. Leong, F. Sanchez, C. Ramon-Cortes, J. Ejarque, D. S. Palmer, M. Kurki; FinnGen Consortium, K. Aragam, J. C. Florez, R. M. Badia, J. M. Mercader, D. Torrents. Nature Communications. April, 2021.

Simulating SARS-CoV-2 epidemics by region-specific variables and modeling contact tracing app containment

Through an extended COVID-19 SIR epidemiological model, we show the extent to which contact tracing mediated by mobile applications can mitigate the epidemic, in different scenarios of population density, mobility and user fractions. A. Ferrari, E. Santus, D. Cirillo, M. Ponce-de-Leon, N. Marino, M. T. Ferretti, A. Santuccione Chadha, N. Mavridis, A. Valencia. NPJ Digital Medicine. January, 2021.



TIGER: The gene expression regulatory variation landscape of human pancreatic islets

The paper presents TIGER, a comprehensive resource of pancreatic islet genomic data, which enables an integrating exploration of how genetic variation affects islet function and enables therapeutic advances and precision medicine for type 2 diabetes. L. Alonso, A. Piron, I. Morán, M. Guindo-Martínez, S. Bonàs-Guarch, G. Atla, I. Miguel-Escalada, R. Royo, M. Puiggròs, X. Garcia-Hurtado, M. Suleiman, L. Marselli, J. L. S. Esguerra, J. V. Turatsinze, J. M. Torres, V. Nylander, J. Chen, L. Eliasson, M. Defrance, R. Amela; MAGIC, H. Mulder, A. L. Gloyn, L. Groop, P. Marchetti, D. L. Eizirik, J. Ferrer, J. M. Mercader, M. Cnop, D. Torrents. Cell Reports. October, 2021.

BSC is actively participating in studies for the climate summit and the debate about the measures to be taken

BSC has played a very active role in the preparations for the world summit on climate change and in publicizing the measures to be taken to mitigate the crisis. The director of the Department of Earth Sciences, Francisco J. Doblas-Reyes, coordinated one of the reports of the Intergovernmental Panel on Climate Change (IPCC), the United Nations body that provides world leaders with scientific reports to support their decision-making, and played an important role in outreach in our country concerning the state of the climate emergency and the actions needed to mitigate it.

In 2021 researchers at this department published several papers on how to improve the models used to predict the effects of climate change and those to be expected from global warming. Researcher Asun Lera St. Clair has been appointed as a member of the Citizens' Climate Assembly, one of the priority lines of action in the Declaration on the Climate and Environmental Emergency in Spain, enshrined in the Climate Change and Energy Transition Act.

Climate change may result in increased precipitation in Europe

Precipitation in Europe during the winter season could increase by about 20% over the next 30 years if the current level of greenhouse gas emissions is maintained.

This is the conclusion of a new study conducted by BSC in collaboration with the UK Met Office. The research was based on new very high-resolution climate models with a greater degree of realism than traditional ones. The results of the new study have major implications for assessing climate change risks in many socioeconomic activities, including water management, settlements, shipping, trade and wind energy production.

Simulations show that traffic restrictions in Barcelona are insufficient to meet European air quality legislation

A BSC study carried out with various simulation models developed at the centre shows that the traffic restriction measures currently in place in Barcelona are insufficient to comply with the air quality standards imposed by the European Union to preserve citizens' health.

According to the study, it is necessary to reduce private vehicle journeys by at least 25%, as the impact of the Low Emissions Zone is insufficient and measures to restrict the space allocated to vehicles, such as superblocks and tactical urban planning, have a knock-on effect on air quality in neighboring areas.

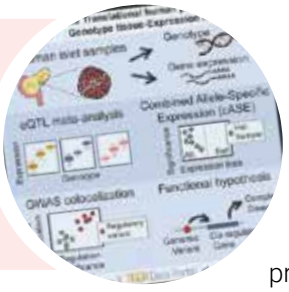
BSC is coordinating the definition of the European health data strategy

BSC is one of the two coordinators of HealthyCloud, the project responsible for defining the strategy for the future European Health Research and Innovation Cloud. Its objective is to create guidelines, recommendations and specifications to create distributed data repositories throughout Europe.

The research community considers these repositories to be essential to support both health research and health care at all levels: from public health to personalized medicine.

HEALTHYCLOUD
Health Research & Innovation Cloud

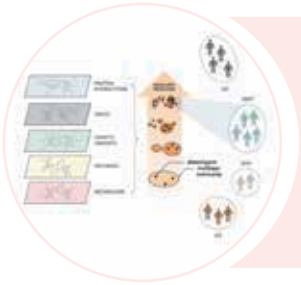
The strategic agenda must take into account the inclusion of ethical, legal and social aspects as well as technological solutions to aid the analysis of distributed health data at the European level. The project involves 21 organizations from 11 countries and is open to the participation of health bodies, academia, public administrations, companies and patient organizations, the general public and professionals.



Creation of the largest database of pancreatic islets, the key to type 2 diabetes

BSC, the Broad Institute in Boston and Université Libre de Bruxelles have developed and provided the scientific community with TIGER, a repository of genomic, transcriptomic and epigenetic data about pancreatic islets, a group of cells suspected of contributing to type 2 diabetes.

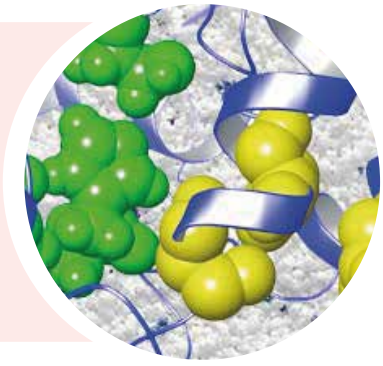
To create this repository, a large amount of data had to be harmonized and new statistical methods had to be developed to analyze differences in gene expression between individuals.



A new artificial intelligence method to characterize rare diseases

BSC researchers have created a new methodology, based on multilayer networks, to characterize rare diseases.

The majority of rare diseases are genetic but, since they are rare, studying them is complex as only small samples are available, which prevents statistically firm conclusions from being drawn. This new technology makes it possible to interpret the molecular basis of diseases, starting with very few cases, and opens up new doors to research.



Enzymes to drive the manufacture of less polluting fabrics, cosmetics and cleaning products

BSC is developing new computational tools to promote the development of enzymes that contribute to the manufacture of less polluting everyday products. These tools combine molecular modeling and artificial intelligence techniques to select the most suitable proteins for the production of fabrics, cosmetics and cleaning products. Recent studies assert that using enzymes to manufacture these products would reduce CO2 emissions by 42 million tons per year.

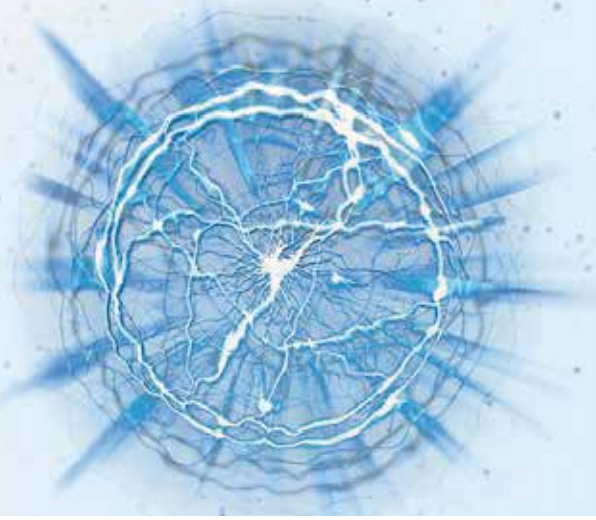
Applied Research & Innovation

EUROfusion entrusts BSC with the creation of an Advanced Computing Hub to accelerate fusion energy

EUROfusion, the consortium formed by 28 countries to make fusion energy a reality, has entrusted BSC with the creation and management of one of the five Advanced Computing Hubs that will support experimental scientists working on the development of this new source of energy to generate electricity.

Fusion energy, which is clean and risk-free, is based on the processes that drive energy production in stars and is one of the scientific community's main focuses to drastically reduce the CO2 emissions associated with electricity generation.

More than 150 research centres and companies are working on EUROfusion research, which combines experiments with simulations to reproduce the reactions between hydrogen isotopes that take place in the Sun's core inside reactors. The complexity and detail of these simulations require highly sophisticated hardware and software, which has highlighted the need for the support of advanced computing centres.



Supercomputing for the transport, oil, gas and wind energy industries

BSC researchers have collaborated on the development of advanced tools to study the use of renewable fuels in future sustainable transport systems. To achieve this, automotive technologies have been combined with current and future fuel requirements, within the framework of both exascale simulations of combustion engines and controlled experiments. This research has been carried out through the ENERXICO project, which focuses on the development of advanced simulation software solutions for the oil and gas, wind energy and transport combustion industries.

Daily forecasts to help the authorities manage the volcano emergency in La Palma

BSC has collaborated with the managers of the emergency caused by the eruption of the La Palma volcano, using the capacity of the MareNostrum 4 supercomputer to make daily forecasts of the movements of the volcano's emissions.

These daily forecasts are the result of collaboration between the Spanish National Research Council (CSIC) and BSC. Its aim has been to assist the authorities in making decisions aimed at limiting the damage caused by the eruption.

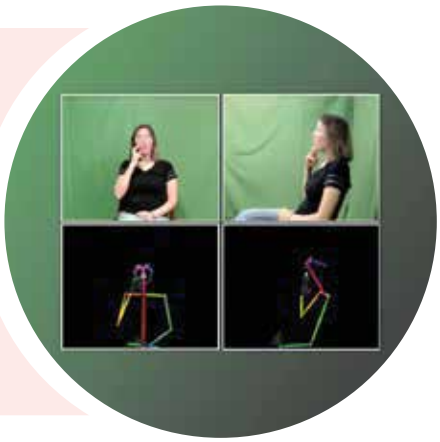
MarIA, the first open-access, Spanish-language massive artificial intelligence model, is born

BSC has created MarIA, a family of open-access, Spanish-language models, so that application developers, companies, research groups and society in general can use it in countless ways.

MarIA has been built using the digital documentary heritage of the National Library of Spain. It crawls and archives websites in Spanish, and its largest and most powerful model, GPT-2 large, has put the Spanish language in third place among the languages with the largest open-access massive models available, after English and Mandarin.

MarIA can be used to develop applications with a very wide range of capabilities, such as classifying documents or creating spellcheckers or translation tools. It can also be used to make automatic summaries, simplify complicated texts by tailoring them to different user profiles, generate questions and answers, maintain complex dialogues with users and even write complete texts (which may appear to have been written by humans) based on a headline or a small number of words.

The MarIA project is still ongoing with the development of new versions specialized in different application areas, including biomedicine and legal, and has been funded by the Secretariat of State for Digitalization and Artificial Intelligence.



BSC develops a database for machine translation of sign language through AI

Amanda Duarte, a PhD student and researcher at BSC, has developed How2Sign, an extensive database for machine translation of sign language with AI. How2Sign contains more than 80 hours of videos of American Sign Language (ASL) interpreters and three recorded in a studio with 510 cameras to reconstruct the interpreters' 3D posture. How2Sign is an open resource for researchers in the fields of both natural language processing and computer vision to make further progress in the area of sign language.

BSC researchers apply supercomputing techniques to reduce blockchain energy consumption

BSC is collaborating with the Ethereum Foundation to launch a new blockchain system in 2022. The plan is to multiply transaction capacity per second by up to a thousand times, while reducing current energy consumption by up to 500 times. To achieve this, Kumo, a spider crawler has been created, which collects information about the most diverse aspects related to the creation of blockchains and analyzes information to ensure the availability, reliability and efficiency of the data stored in the blockchain.

Meet us in person

Barcelona Deep Collage Festival: open day with activities to celebrate the new building

BSC wanted to share its joy at having a new corporate building by organizing an open day with activities for people of all ages. The public had the opportunity to visit the BSC-REPSOL Building and tour the spaces that will house MareNostrum 5 and the chapel where MareNostrum 4 is located.

The event included the Barcelona Deep Collage Festival, a meeting of scientists, artists and the public to recount their experiences during the COVID-19 pandemic and the interactions between science, technology and everyday life that this brought to light. The festival included collage workshops for children and adults, musical and theatrical performances, talks about science and technology, and an exhibition of collages by artists and art students with the special collaboration of ED: an artificial intelligence program developed at BSC that made its own collages, inspired by the artists' work. Around 700 people enjoyed these activities, organized in collaboration with the Barcelona Collage Society and with the support of Barcelona City Council, the Spanish Ministry of Science and Innovation, and the Barcelona Joint Cultural and Scientific Capital Program.

The first BSCTech Hackathon event

BSC has launched BSCTech Hackathons, aimed at experimenting with tools developed at BSC and investigating how they can be useful in meeting the computing challenges of the future. In 2021 the BSCTech Hackathons were held from October 25 to November 4 and consisted of three events: the "BSC-NVIDIA GPU Hackathon for HPC and AI", "MNHACK21: 3rd MareNostrum Hackathon" and the "Arm-BSC Hackathon". The participants used the MareNostrum 4 supercomputer in all three events.

Online visits for high schools all around Spain

In 2020, due to the lockdown, BSC began offering online tours to high schools. In 2021 these tours became an established feature, as they are a great alternative for young people, especially those from outside Barcelona, to learn about the MareNostrum supercomputer and the research being conducted at BSC. High schools from all around Spain are becoming interested in this activity and, month by month, demand is growing.

BSC gratefully acknowledges the support of:

BSC is a public consortium made up of:

Generalitat de Catalunya
Departament de Recerca i Universitats

EUROPEAN UNION
European Regional Development Fund

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