
BSC
Barcelona
Supercomputing
Center
Centro Nacional de Supercomputación

Barcelona Supercomputing Center
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EXCELENCIA SEVERO OCHOA

Supercomputació i Indústria 4.0

Josep M. Martorell, PhD
Associate Director

Trobada anual de la Comissió Indústria 4.0

10/2019

Instruments accelerate knowledge

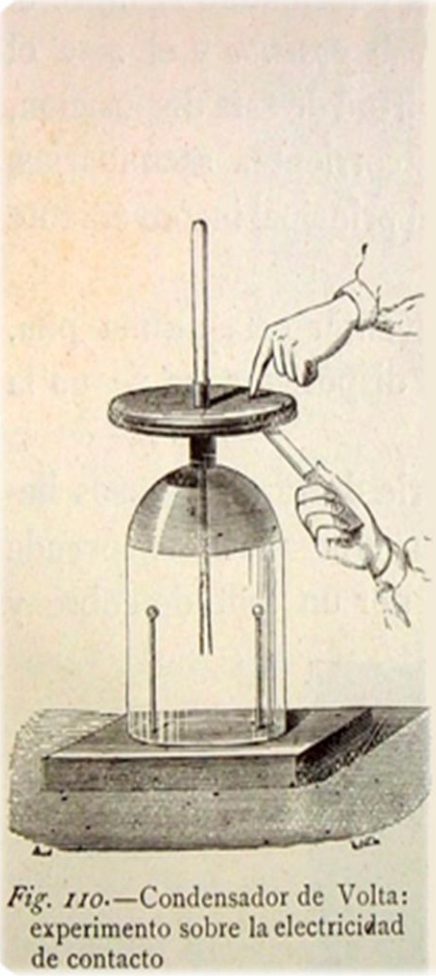


Fig. 110.—Condensador de Volta: experimento sobre la electricidad de contacto

"Nothing tends so much to the advancement of knowledge as the application of a new instrument.

The native intellectual powers of people in different times are not so much the causes of the different success of their labors, as the peculiar nature of the means and artificial resources in their possession."

Humphrey Davy (1778-1829)

Inventor of electrochemistry

Discoverer of K, Na, Mg, Ca, Sr, Ba, B, Cl

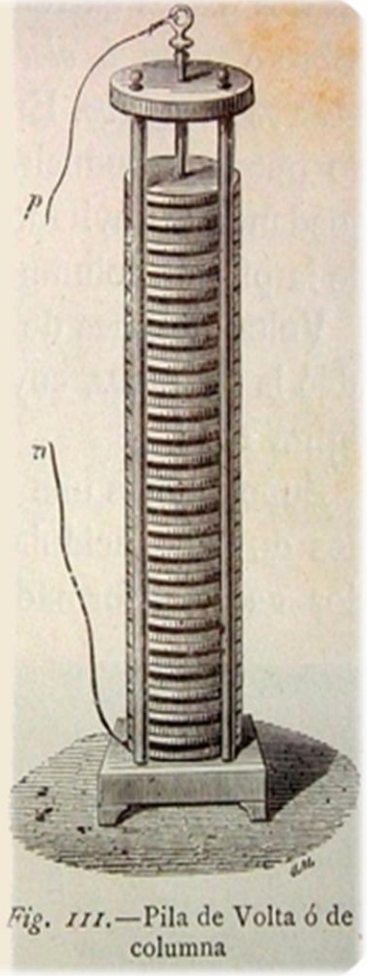


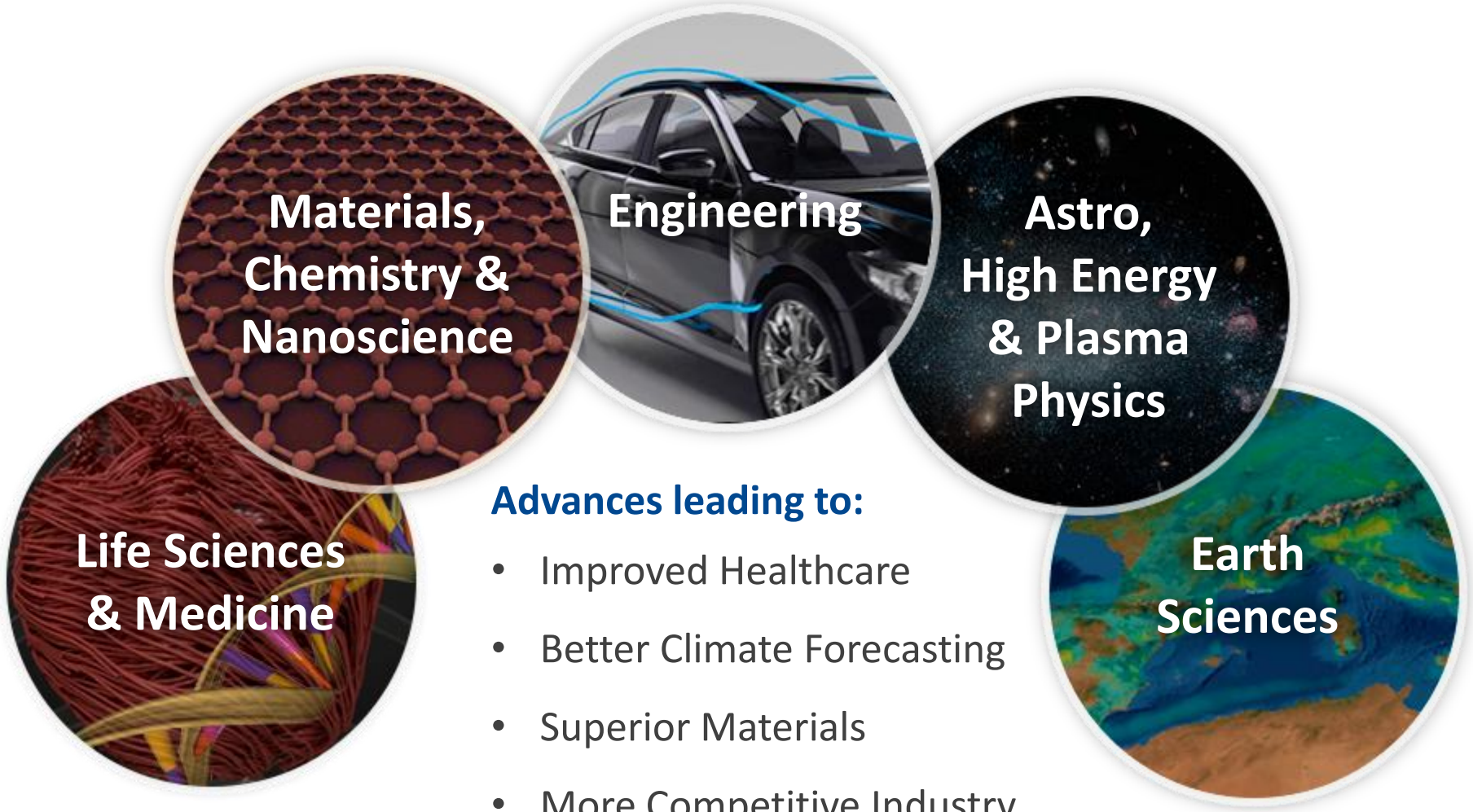
Fig. 111.—Pila de Volta ó de columna

The Evolution of the Research Paradigm

Numerical Simulation and Big Data Analysis

- Reduce expense
- Avoid suffering
- Help to build knowledge where experiments are impossible or not affordable

HPC: An enabler for all scientific fields

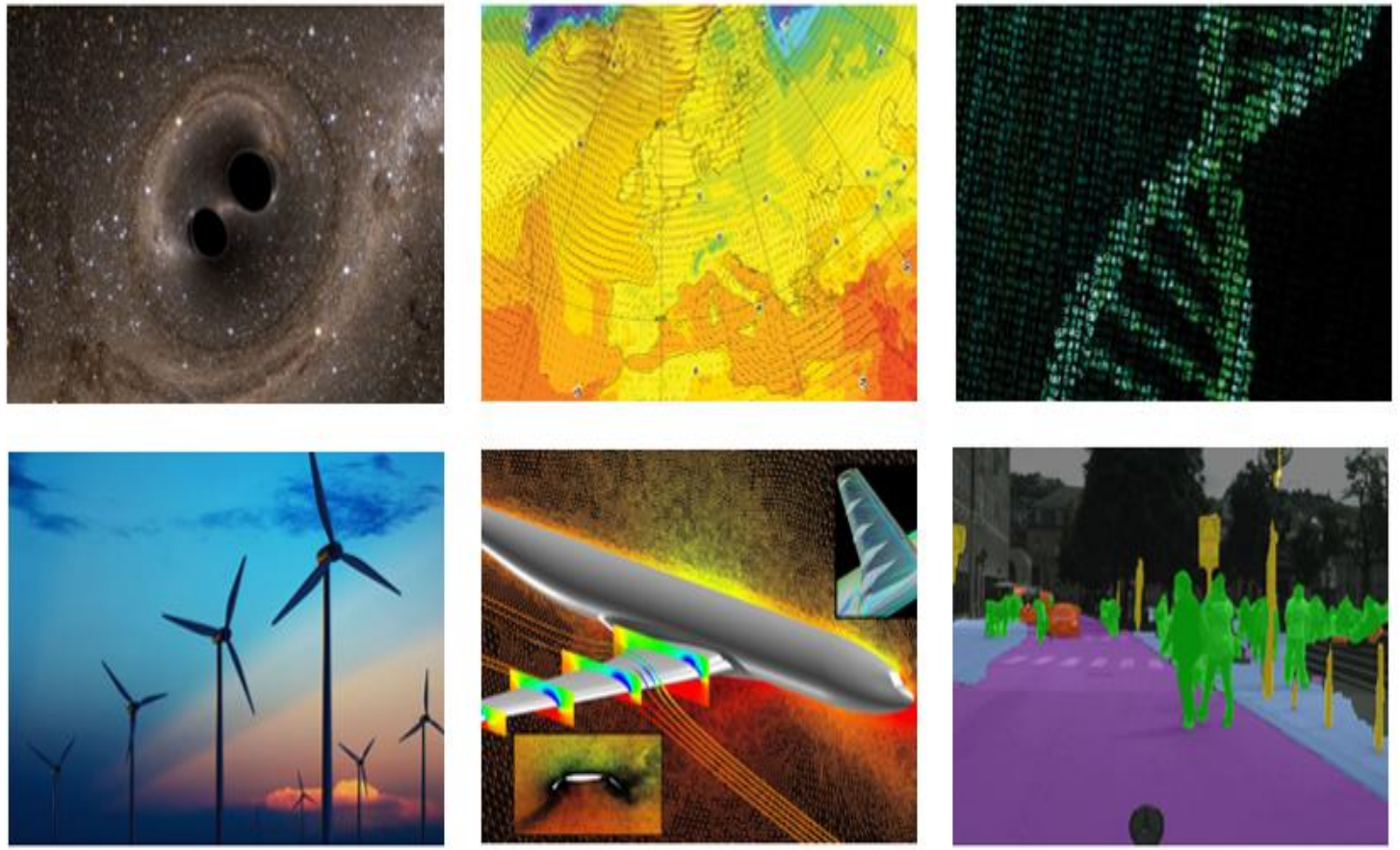


Advances leading to:

- Improved Healthcare
- Better Climate Forecasting
- Superior Materials
- More Competitive Industry

HPC & societat challenges

- Aging population
- Climate change
- Cybersecurity
- Increasing energy needs
- Intensifying global competition



Images courtesy of The PRACE Scientific Steering Committee, “The Scientific Case for Computing in Europe 2018-2026”

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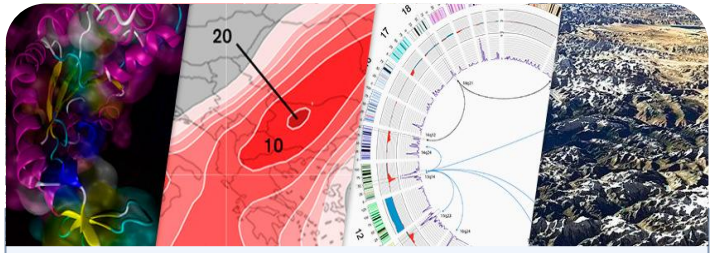
BSC-CNS objectives

Supercomputing services
to Spanish and EU researchers



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

PhD programme, technology
transfer, public engagement

BSC-CNS is a consortium that includes

- **Spanish Government**
- **Catalan Government** — Generalitat de Catalunya, Departament d'Empresa i Coneixement
- **Univ. Politècnica de Catalunya (UPC)** — Universitat Politècnica de Catalunya, BarcelonaTech

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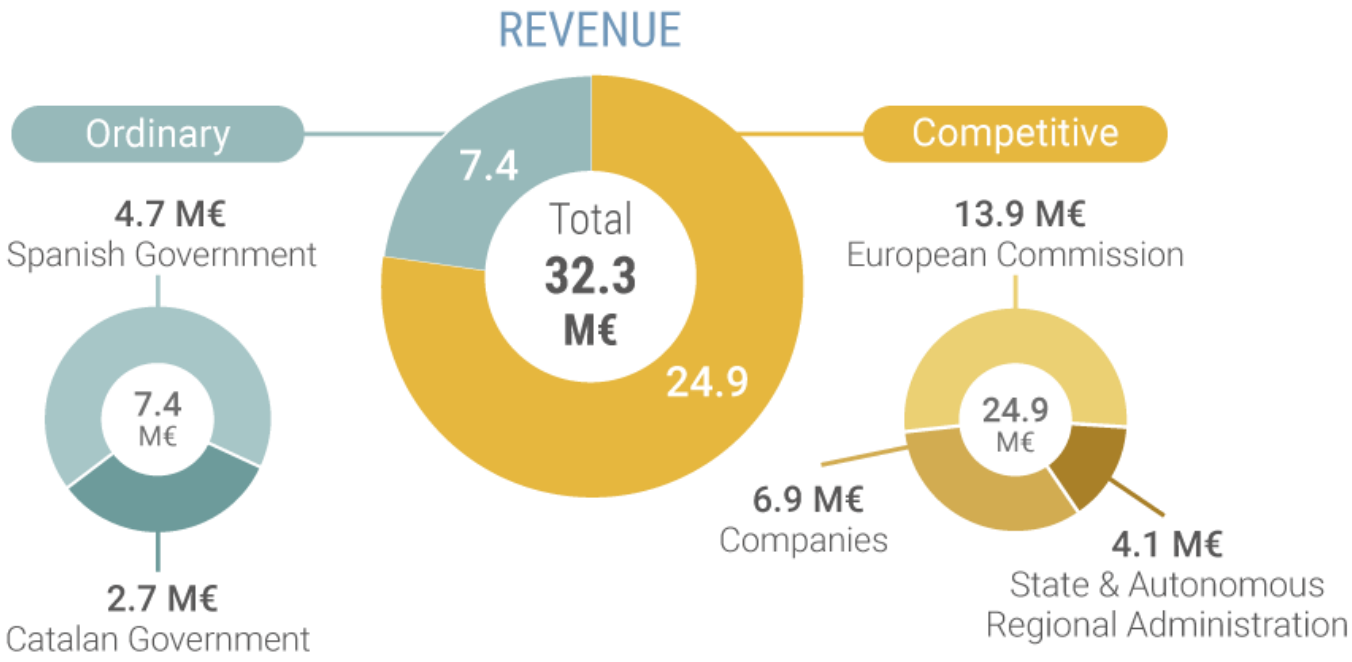
BSC Resources



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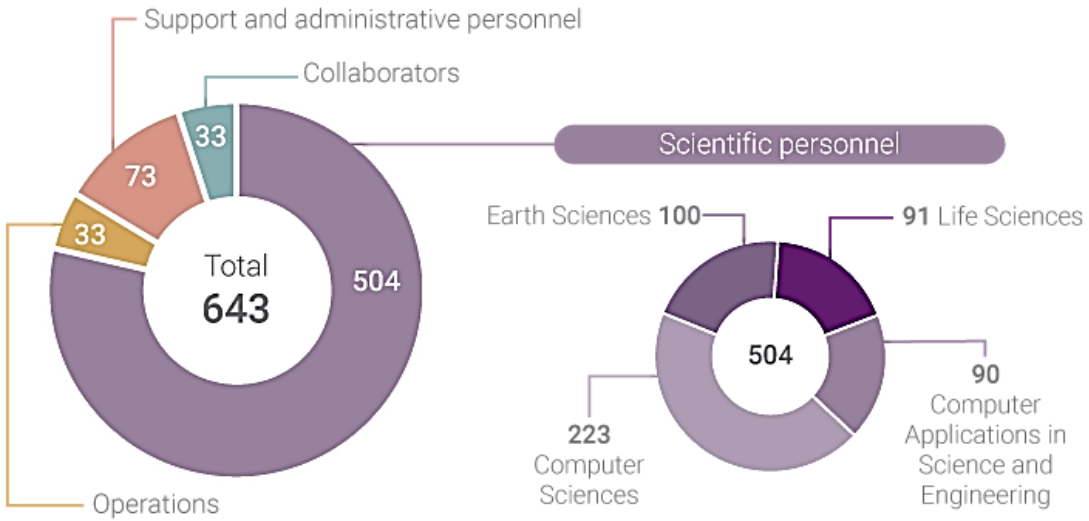
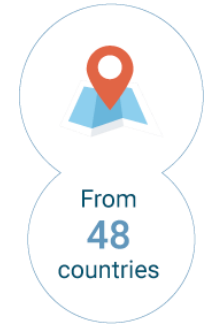
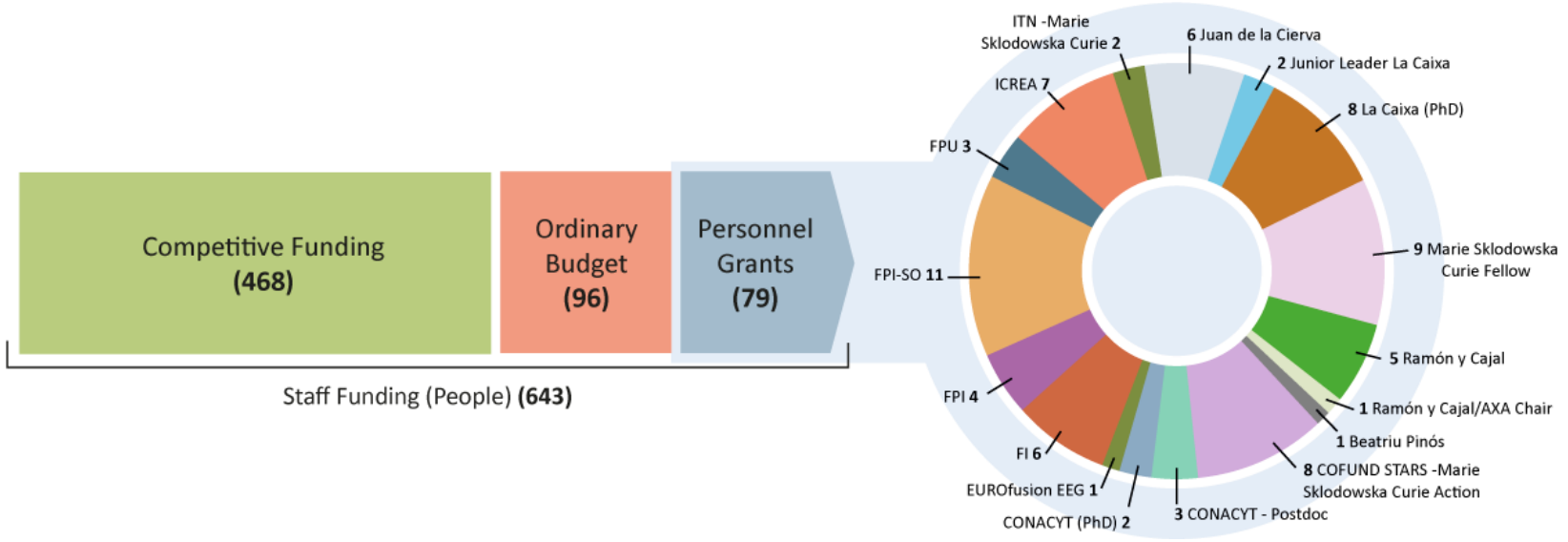
UPC contributes, in terms of assigned staff and room space, the equivalent of 10% of regular income

2018 executed budget

People


Support and administrative personnel
Collaborators
Scientific personnel
73
33
33
504
Total
643
Operations
Earth Sciences 100
91 Life Sciences
504
90
Computer Applications in Science and Engineering
223
Computer Sciences


From
48
countries


Competitive Funding (468)
Ordinary Budget (96)
Personnel Grants (79)
Staff Funding (People) (643)
ITN -Marie Sklodowska Curie 2
6 Juan de la Cierva
2 Junior Leader La Caixa
ICREA 7
8 La Caixa (PhD)
FPU 3
9 Marie Sklodowska Curie Fellow
FPI-SO 11
5 Ramón y Cajal
1 Ramón y Cajal/AXA Chair
FPI 4
1 Beatriu Pinós
FI 6
8 COFUND STARS -Marie Sklodowska Curie Action
EUROfusion EEG 1
3 CONACYT - Postdoc
CONACYT (PhD) 2

MareNostrum 4

Total peak performance: **13,7** Pflops		
General Purpose Cluster:	11.15 Pflops	(1.07.2017)
CTE1-P9+Volta:	1.57 Pflops	(1.03.2018)
CTE2-Arm V8:	0.5 Pflops	(????)
CTE3-KNH?:	0.5 Pflops	(????)

MareNostrum 1
2004 – 42,3 Tflops
1st Europe / 4th World
New technologies

MareNostrum 2
2006 – 94,2 Tflops
1st Europe / 5th World
New technologies

MareNostrum 3
2012 – 1,1 Pflops
12th Europe / 36th World

MareNostrum 4
2017 – 11,1 Pflops
2nd Europe / 13th World
New technologies

Distributed supercomputing infraestructure

24 members, including **5 Hosting Members**
(Switzerland, France, Germany, Italy and Spain)

110 PFlops/s of peak performance on **7 world-class systems**

>21.000 core hours for research awarded

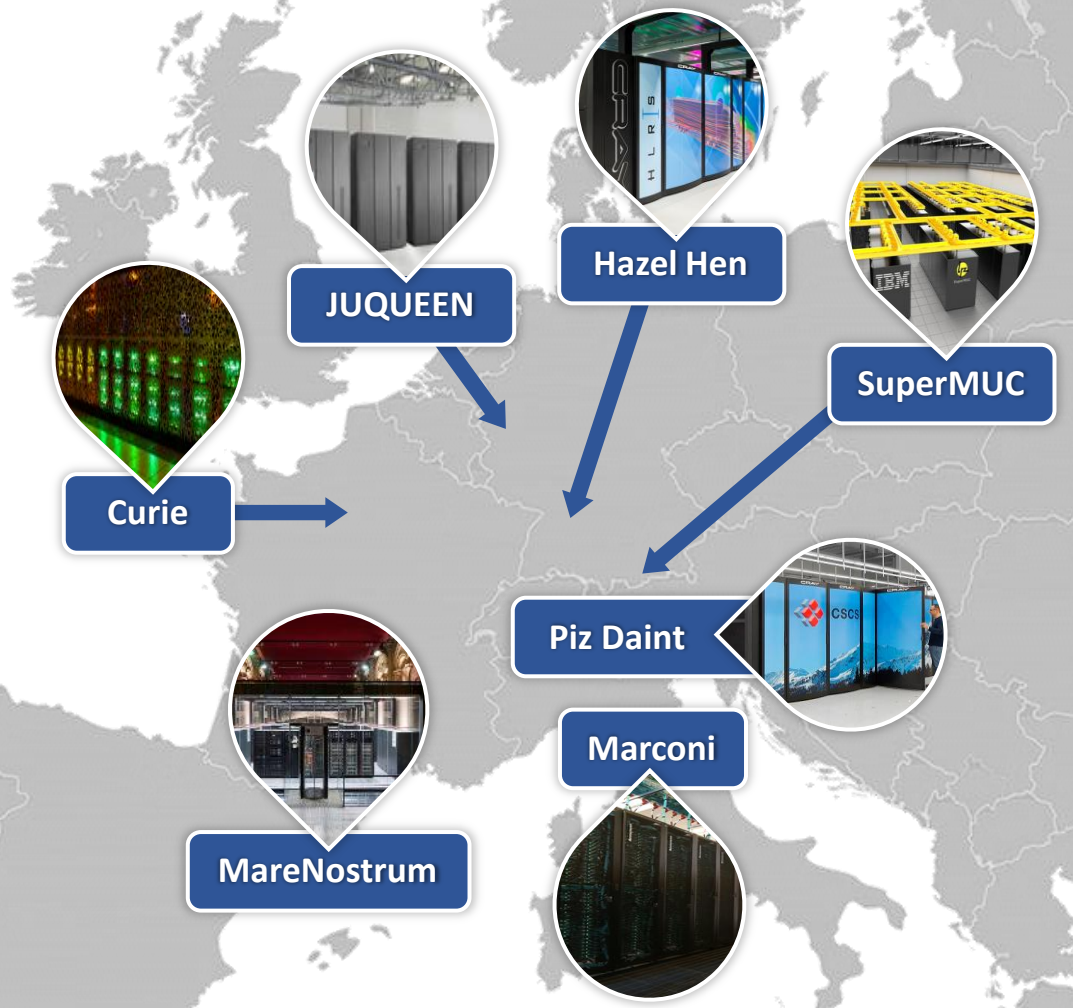
688 scientific projects **enabled**

>12.000 people trained

>50 companies supported

PRACE

Access prace-ri.eu/hpc-access



Data as August 2019

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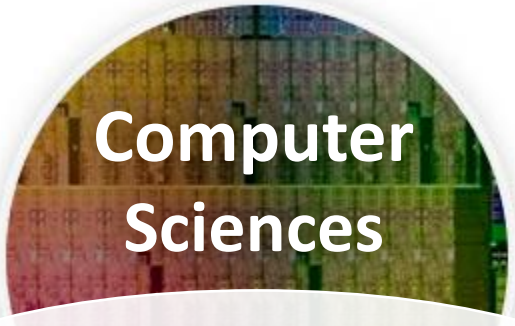
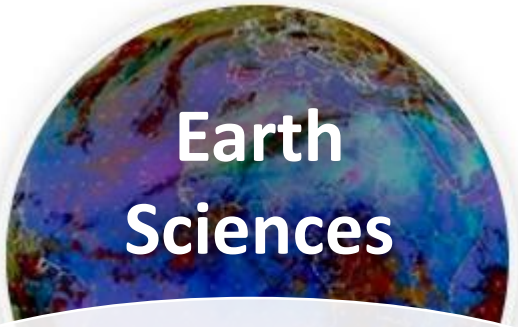
Mission of BSC Scientific Departments



To influence the way machines are built, programmed and used: programming models, performance tools, Big Data, Artificial Intelligence , computer architecture, energy efficiency

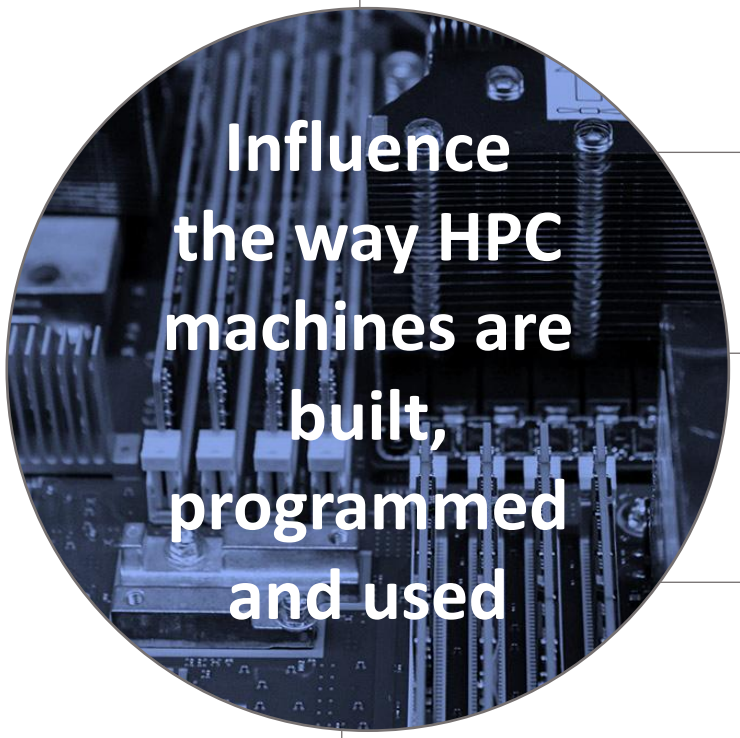


To develop and implement global and regional state-of-the-art models for short-term air quality forecast and long-term climate applications

To understand living organisms by means of theoretical and computational methods (molecular modeling, genomics, proteomics)

To develop scientific and engineering software to efficiently exploit super-computing capabilities (biomedical, geophysics, atmospheric, energy, social and economic simulations)

Computer Sciences



Leadership in architectural proposals for HPC
Runtime-aware architecture innovations
Multicore and accelerator architectures in real-time environments

Key player in the design of cores and accelerators
European Processor Initiative, gathering architecture innovations
Building solid knowledge on low-level system design

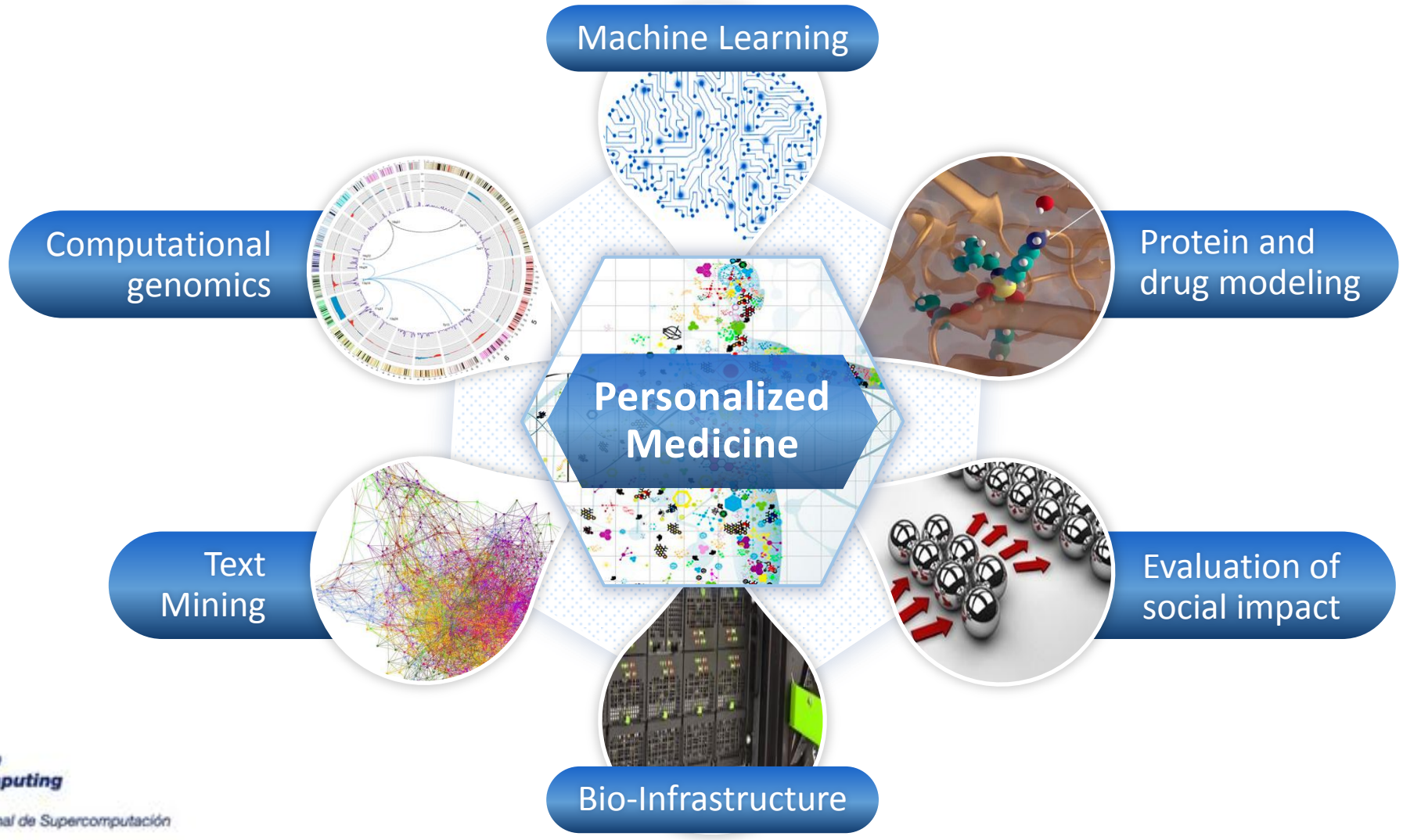
Leadership in the evolution and standardization of parallel programming
Influencing OpenMP evolution, Workflows towards Exascale Inter-operability and resource malleability across different runtime layers

Leadership in methodologies and tools for application/system behaviour understanding
Proof-of-concept and best practices towards improving applications scalability and performance

Key player in the HPC/AI convergence
Novel algorithms, system software and architectural support Adoption of AI technologies in future simulation frameworks

Life Sciences

Understanding living organisms by theoretical and computational methods



Earth Sciences

Environmental modelling and forecasting, with a particular focus on weather, climate and air quality

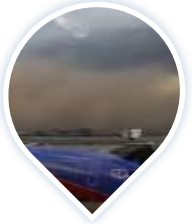
Research and Forecasts

Service Users Sectors


Infrastructures


Solar Energy

Urban development


Transport


Wind Energy


Agriculture


Insurance

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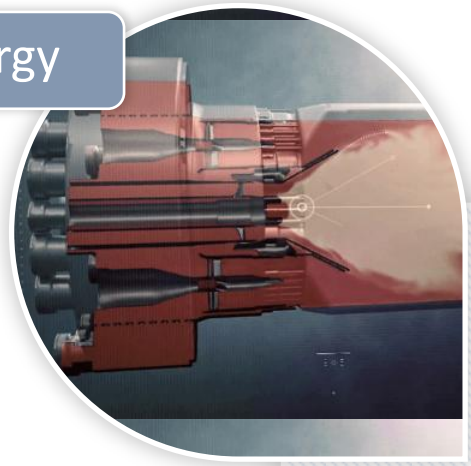
Computational Applications for Science and Engineering

Energy



Biomechanics

INDUSTRY ORIENTED DEPARTMENT

Smart & resilient cities

Data analytics & visualization

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TOP-10 Catalan Organizations in Horizon 2020

Legal name	EU Contribution (€)	Project Participations
Barcelona Supercomputing Center	76,524.698 €	132
Universitat Politècnica de Catalunya	59,475,312 €	158
Universitat Pompeu Fabra	56,816,732 €	109
ICFO	56,517,896 €	78
Universitat Autònoma de Barcelona	56,322,646 €	117
Universitat de Barcelona	46,638,492 €	131
CRG	42,807,120 €	69
EURECAT	32,515,822 €	75
LEITAT	29,039,901 €	68
IRIS	20,120,356	38

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Source:
European Commission Participant Portal
H2020 Projects

European Commission

August 2019

Technology Transfer

BSC IPR PORTFOLIO

28 patents approved or pending approval

93 software

↓

58 Open source

SPIN-OFFS AND LICENCING

4 Spin-offs created

13 Technologies transfered

37 Jobs created

2.3 M€ raised

13 licensed or transfered technologies

↓

4 patents
9 software

RESEARCH CONTRACTS

53,5 M€

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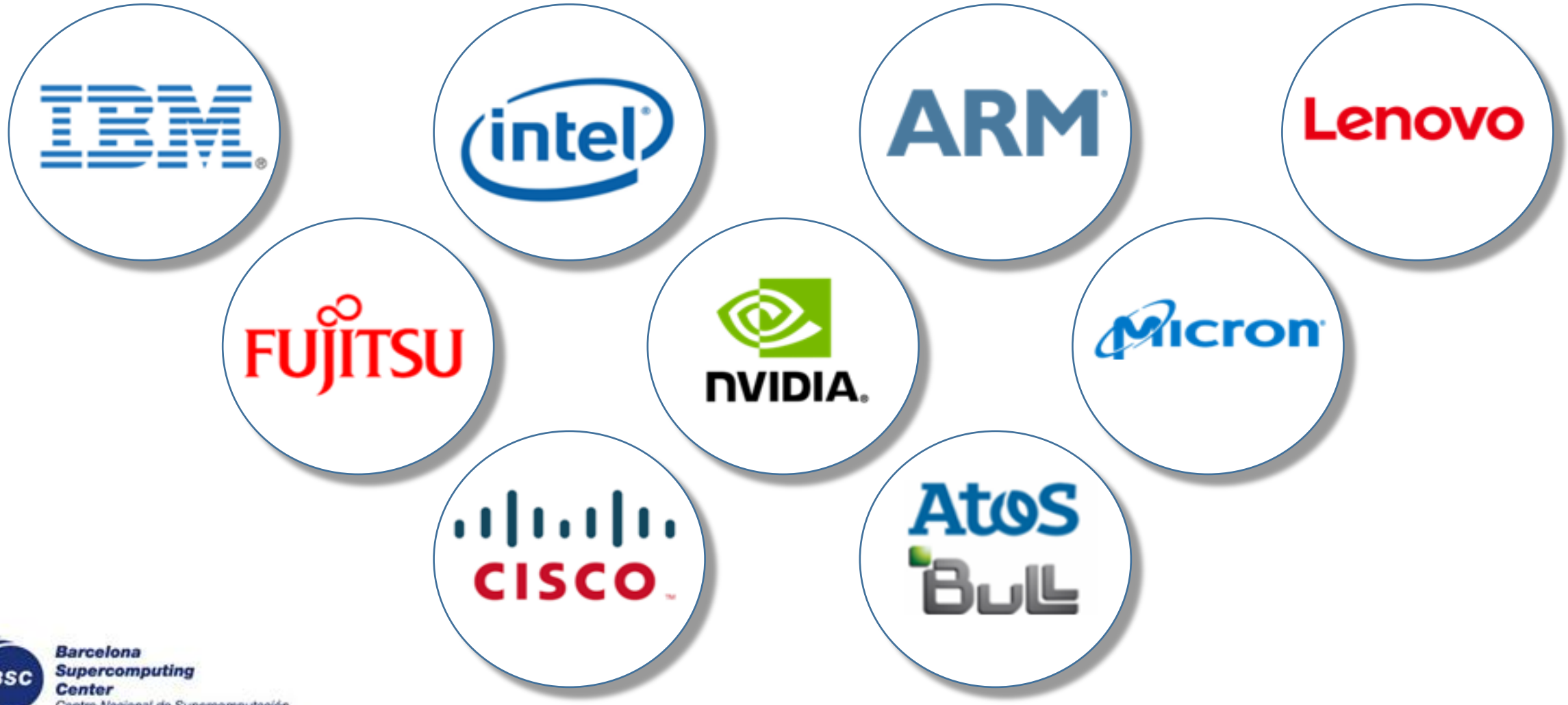
Collaborations with Global IT industry 2019



Collaborations with Industry

REPSOL

Research into advanced technologies for the exploration of hydrocarbons, subterranean and subsea reserve modelling and fluid flows

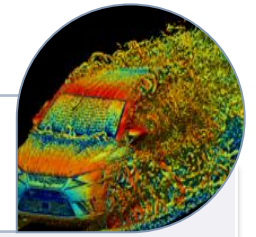
IBERDROLA

Research on wind farms optimization and wing energy production forecasts

CaixaBank

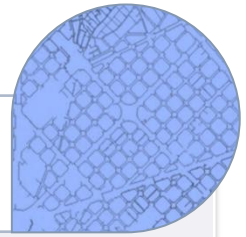
Collaboration agreement for the development of advanced systems of deep learning with applications to banking services

SEAT



Simulations to improve the understanding of the rotating wheels flow physics and its impact over the aerodynamic performance

Agbar



Advanced statistical methods to the optimization of maintenance, energy usage, and control of the city's water treatment and supply processes.

ikergune ETXETARgroup

Research on efficient data sensing, algorithms for analysis of industrial processes and visualization of large datasets of industrial data

ASEPEYO

Artificial Intelligence and Big Data techniques to improve the quality of care and personalized diagnosis

Rockwell Collins

BSC's dust storm forecast system licensed to be used to improve the safety of business flights.

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Collaboration with local companies

BSC's spin-offs

NOSTRUM BIODISCOVERY, S.L.

Applies supercomputing **TO SPEED UP DRUG DISCOVERY**

For the:

- **PHARMA INDUSTRY**
- **BIOTECH COMPANIES**

MITIGA SOLUTIONS, S.L.

Provides operational solutions **TO MINIMIZE THE IMPACT OF VOLCANIC ASH HAZARDS**

For the:

- **AVIATION INDUSTRY**
- **ENGINE MANUFACTURES**
- **CONSULTING SECTORS**

ELEM BIO, S.L.

Provides **BIOMECHANICS SIMULATIONS,** offering software-as-a-service simulation tool focused on cardiovascular and respiratory systems

For the:

- **PHARMA INDUSTRY**
- **MEDTECH COMPANIES**
- **PUBLIC HEALTH**
- **EDUCATION**

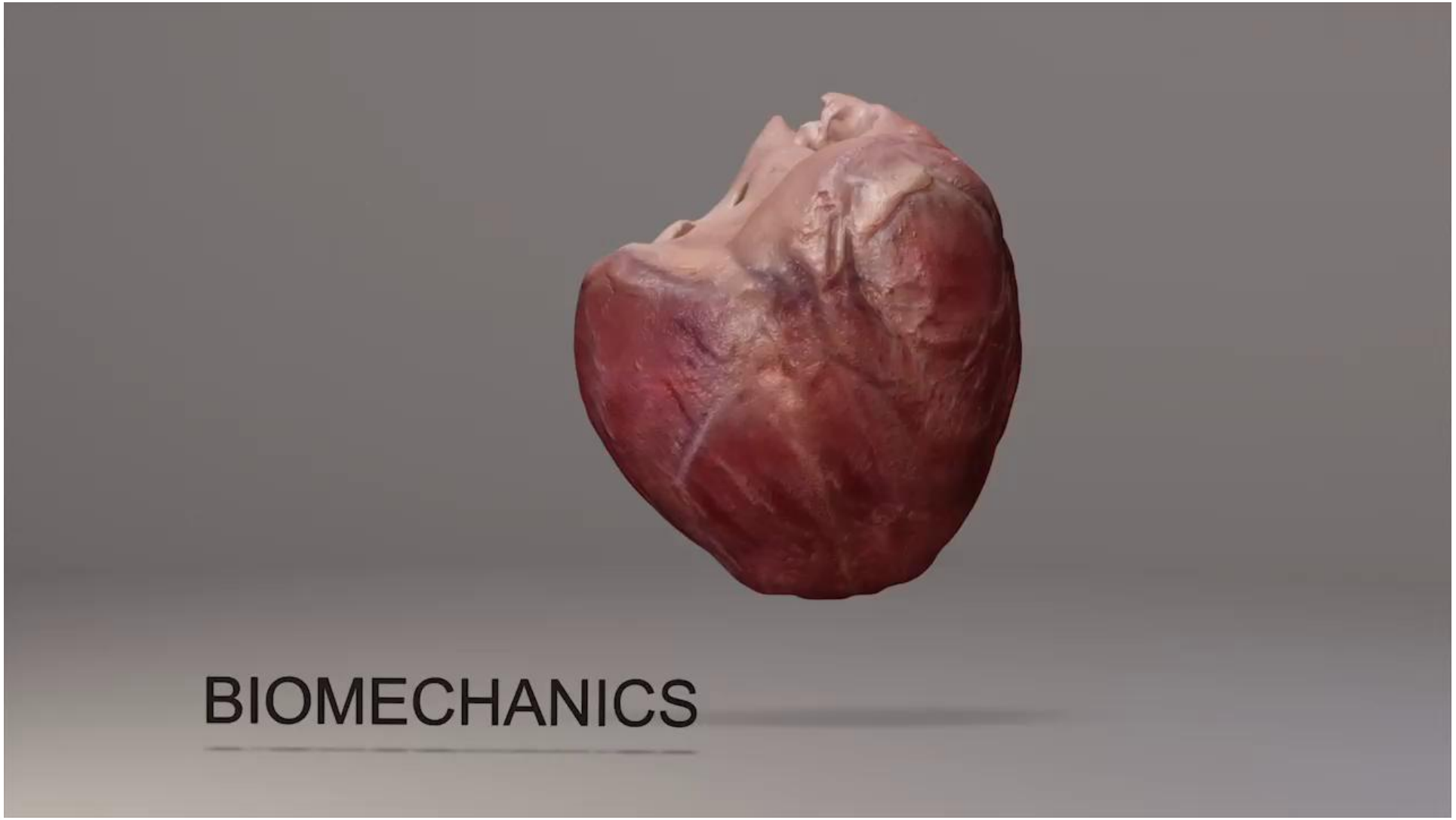
NEARBYCOMP, S.L.

Provides **FOG COMPUTING FOR IOT,** delivering customization services for different scenarios of FOG computing

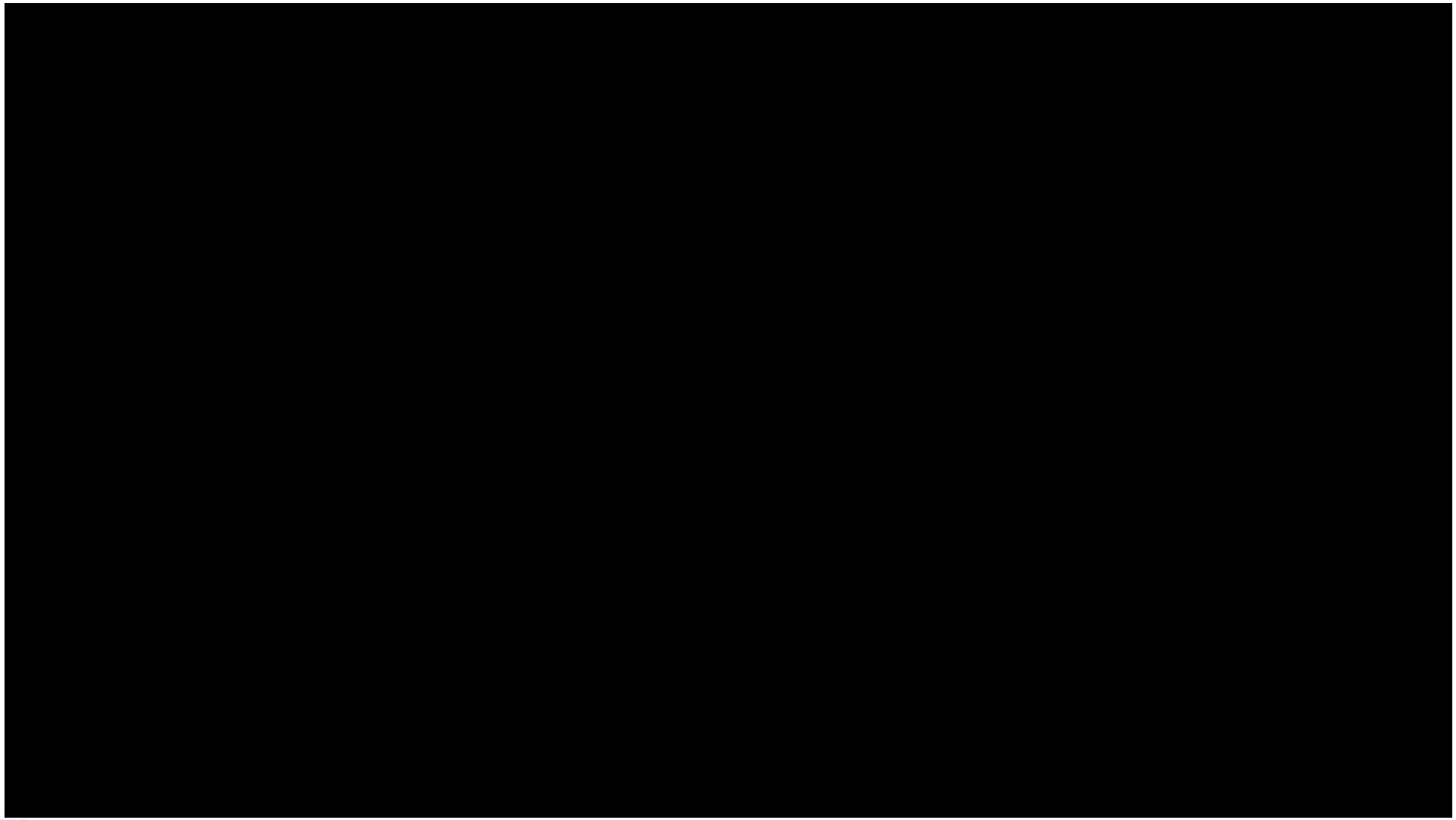
For the:

- **5G**
- **IOT**
- **SMART CITIES**

ALYA RED



Biomechanics: Respiratory System



Analysis of genomes in oncology

From the study of the genomic basis of cancer, to its clinical application for diagnosis and treatment

Nature 2011, 2015; ***Nature Biotechnology*** 2014; ***Nature Genetics*** 2012, 2017

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Wind farms simulation

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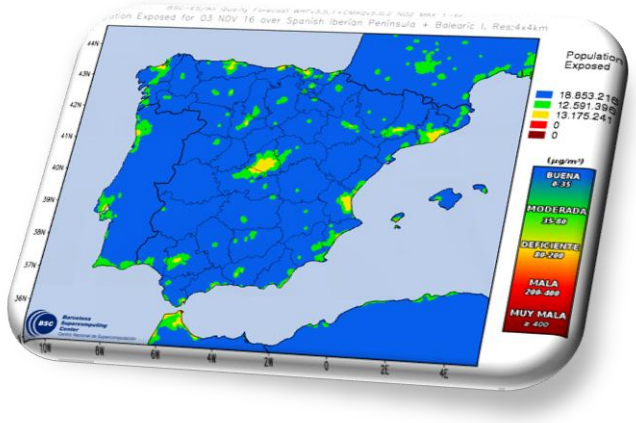
IBERDROLA

CALIOPE Real-time Air Quality forecasts

Provides air quality related information for the coming days and for the application of short term action plans for air quality managers

Information is delivered using both online or custom applications

www.bsc.es/caliope



Smart city platform

vodafone IBM

Air quality index & population exposed

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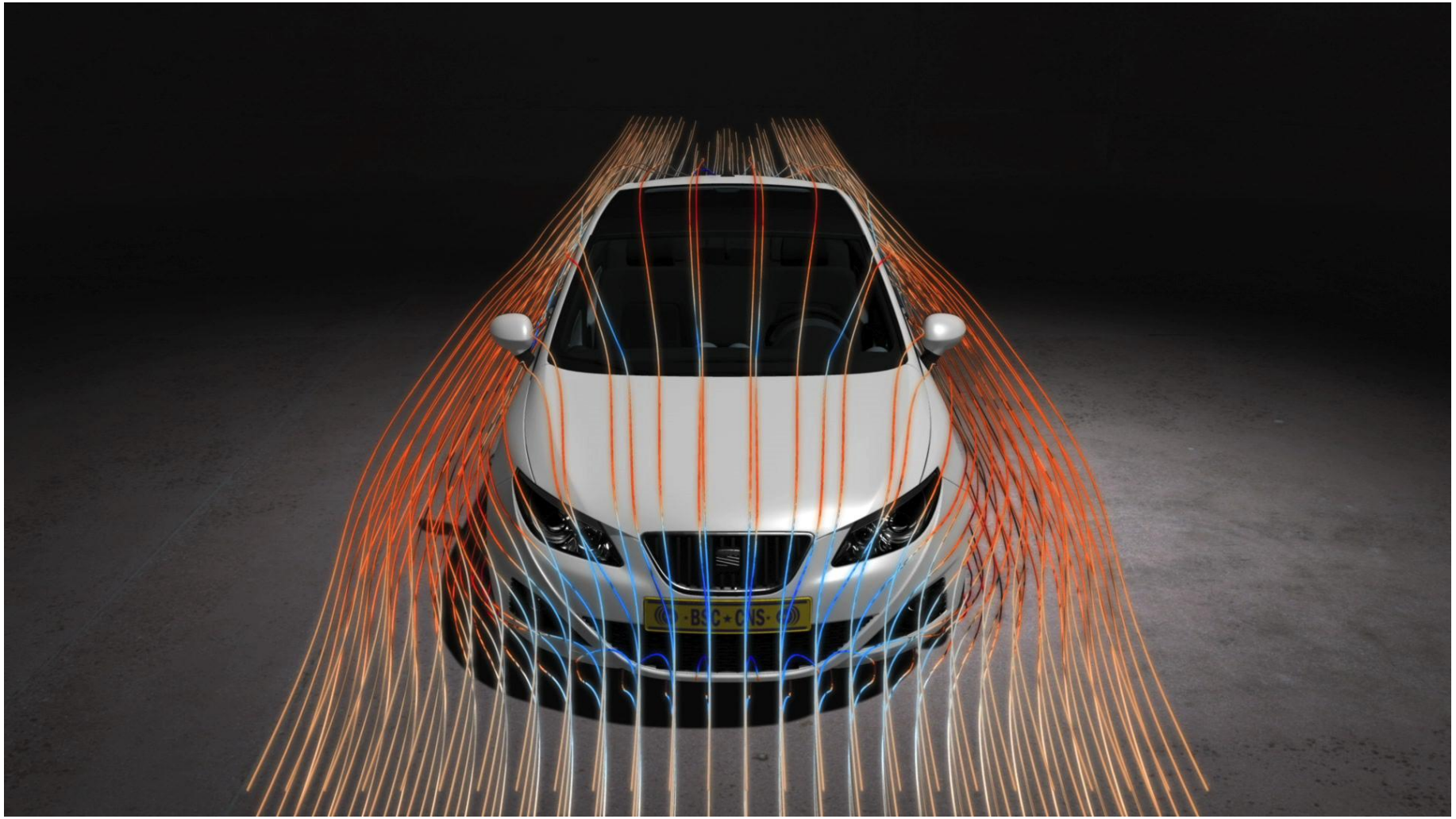
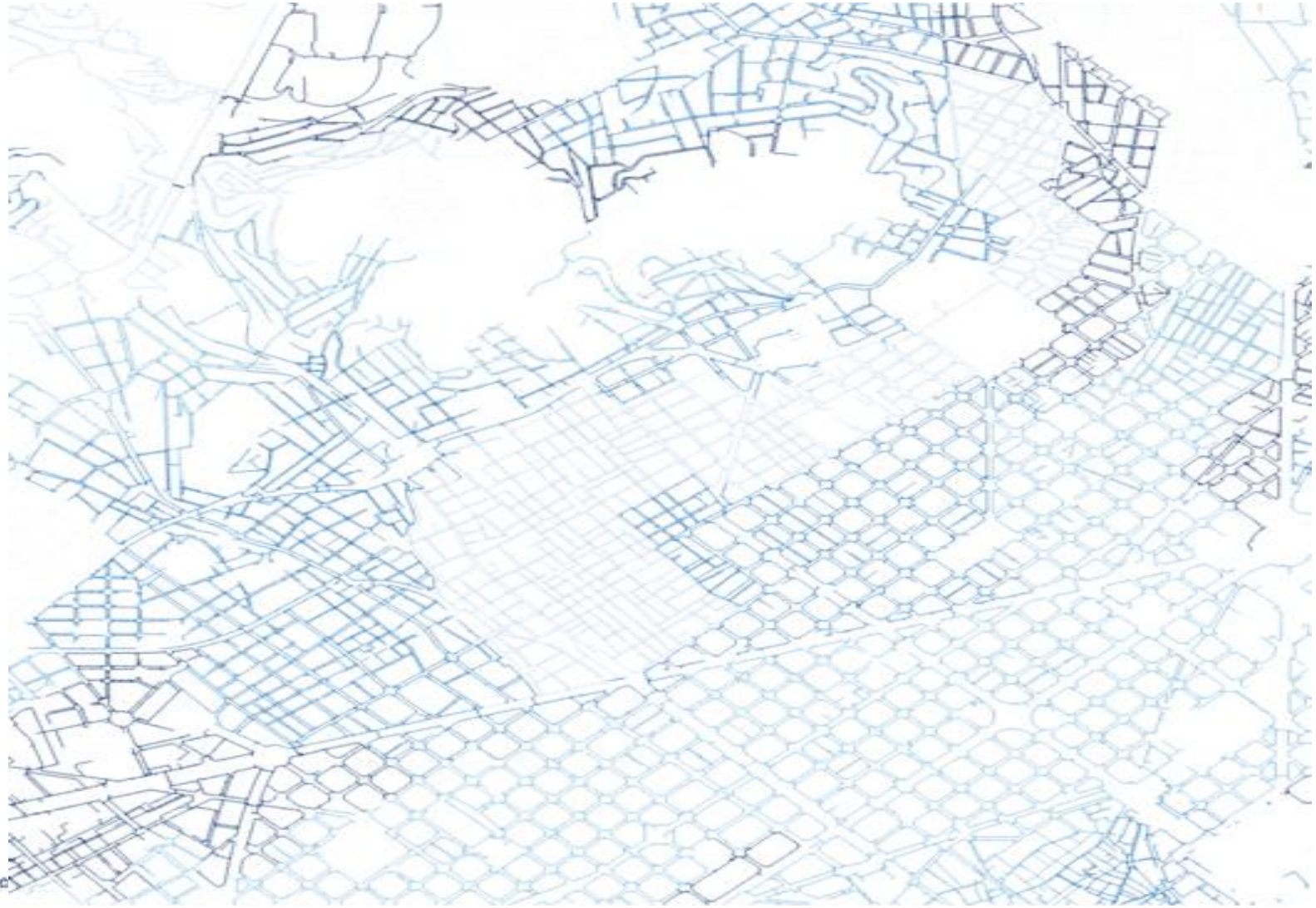
External Aerodynamics



Predictive Maintenance: Water distribution network

Agbar



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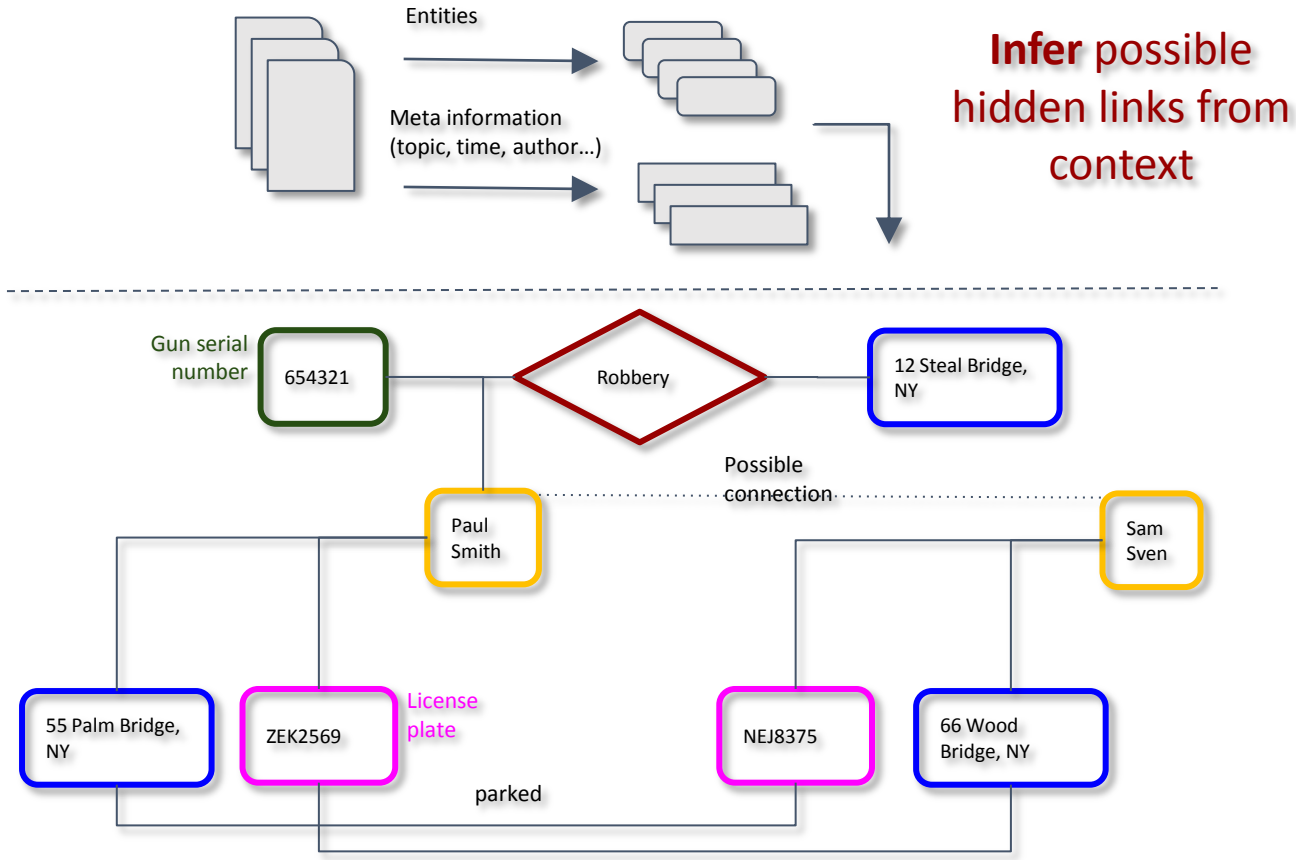
ASGARD: Looking for hidden links

Our specific task is part of the Knowledge Extraction stage, and aims at finding **links** among given entities in **text**

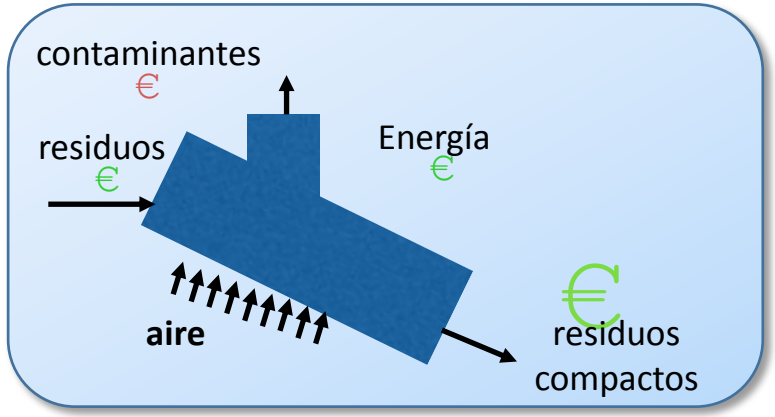


Urban waste incineration plant

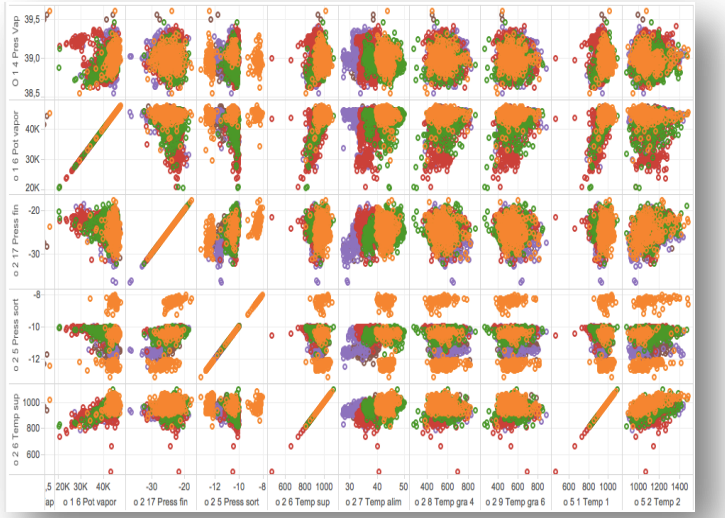
Incineradora del Besos

Machine learning

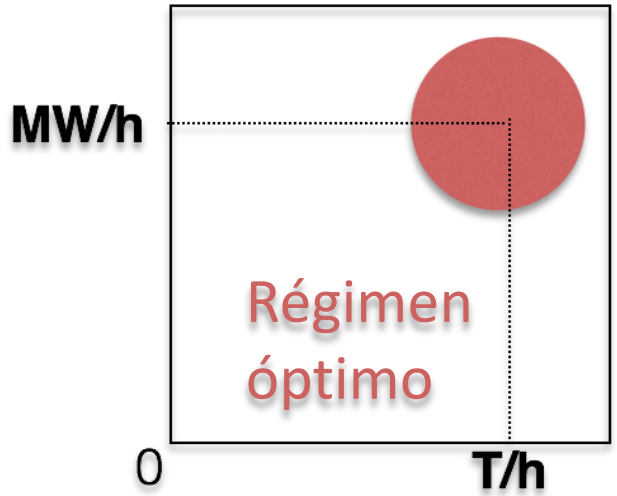
Data gathering/modelling



Information retrieval/display



Automatic machine control



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OPTRETINA

Deep Learning for Retina Early Disease Detection with high Resolution Images

The fundus retina image is the gold standard technique to do the screening of several diseases related with eye early illness

We use a Convolutional Neural Network (CNN and full-network embedding) to detect early disease features related 5 different illnesses related with Retinopathy. We use more than 200,000 high resolution images (3000 by 4000 pixels)

Image Processing → Data Mining → Training → Analyze and Test

Methods

- Deep Learning
- Convolutional Neural Networks
- Reinforcement Learning
- Data aumentation

Opretina Collaboration

- **E. Ulises Moya** (PostDoc) (CS/AI)
- Dario Garcia-Gasulla (Post Doc CS/AI)
- Ulises Cortés (Full Profesor)

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Deep Learning for CaixaBank documental activities

Processing 7M pages monthly with deep neural networks

Document classification with hybrid features (text + visual)

Optimizing production performance for quick response times

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CaixaBank

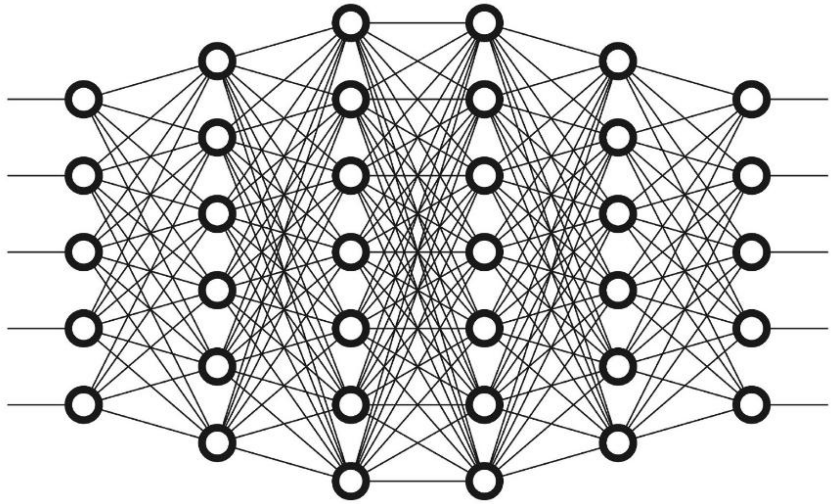
Proyecto: **Previsión de días de baja**

Objetivo

El objetivo principal del proyecto es poder detectar aquellos casos más propensos a estar de baja durante más tiempo, en otras palabras, aquellos en los que sea más probable que la baja dure más que lo que se correspondería con un valor estándar o normal, dependiendo de cada diagnóstico.

Modelo predictivo con técnicas de *Machine Learning*

Idealmente, el sistema podría proporcionar una previsión de los días de baja de desviación respecto a lo estimado como normal, o en su defecto, algún índice que permita ordenar los casos por la magnitud de la desviación para poder priorizar su tratamiento



Datos del paciente
Datos de la empresa
Datos de actividad asistencial
Datos del histórico de siniestralidad o expedientes
Datos de diagnósticos
Imágenes complementarias en algunos casos

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Proyecto: Asistente

Objetivo

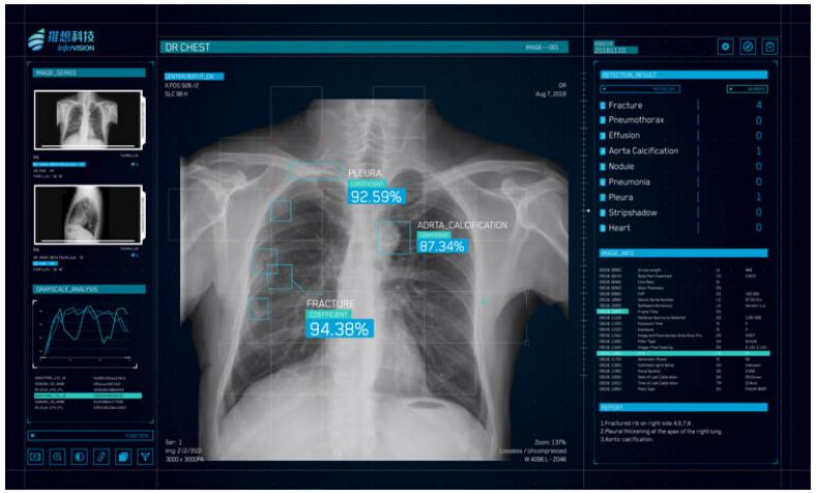
El objetivo de este proyecto consiste en desarrollar un sistema capaz de asistir a los médicos en la valoración de las imágenes de RX. Este sistema debe ser capaz de incorporar módulos de análisis que permitan aplicar diferentes metodologías de diagnóstico a las imágenes en estudio.

Asistente en el diagnóstico de fracturas

En este módulo el sistema debe proporcionar un visor de imagen radiológica, mediante el cual el médico pueda visualizar las imágenes de RX capturadas con las herramientas habituales de estos visores, señalando en la imagen los hallazgos encontrados por el sistema experto. Estos hallazgos pueden ser valorados por el médico de forma que el sistema continúe entrenando con esta valoración.

Asistente en el diagnóstico neumoconiosis (categorización ILO)

En este módulo el sistema experto se aplicará a las placas de tórax tomando como referencia la categorización ILO para la lectura de posibles neumoconiosis.



HPC is a global competition

"The country with the strongest computing capability will host the world's next scientific breakthroughs".

US House Science, Space and Technology Committee Chairman
Lamar Smith (R-TX)

"Our goal is for Europe to become one of the top 3 world leaders in high-performance computing by 2020".

European Commission President
Jean-Claude Juncker (27 October 2015)

"Europe can develop an exascale machine with ARM technology. Maybe we need an AIRBUS consortium for HPC and Big Data".

Seymour Cray Award Ceremony Nov. 2015
Mateo Valero

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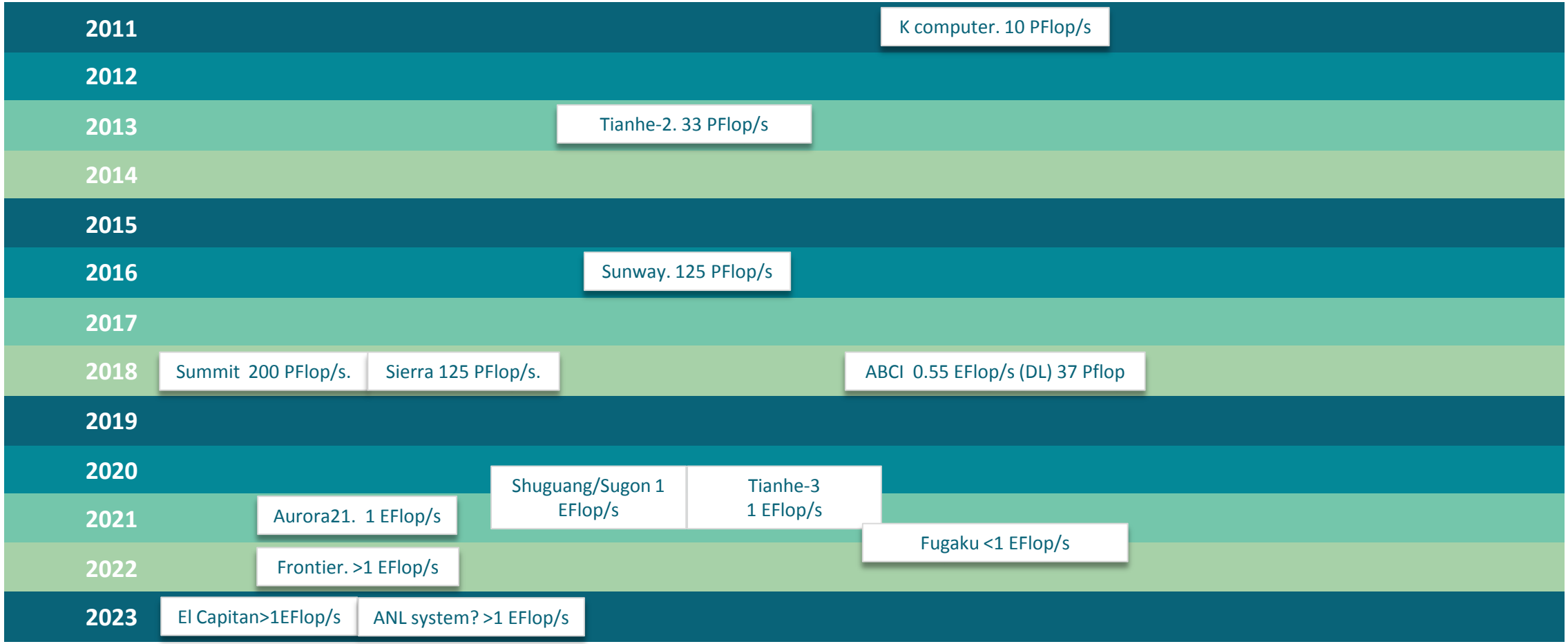
The race towards exascale



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EuroHPC: to European HPC technologies

EuroHPC-Ju members:

Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and Turkey

"A new legal and funding structure – the EuroHPC Joint Undertaking – shall acquire, build and deploy across Europe a world-class High-Performance Computing (HPC) infrastructure.

It will also support a research and innovation programme to develop the technologies and machines (hardware) as well as the applications (software) that would run on these supercomputers."

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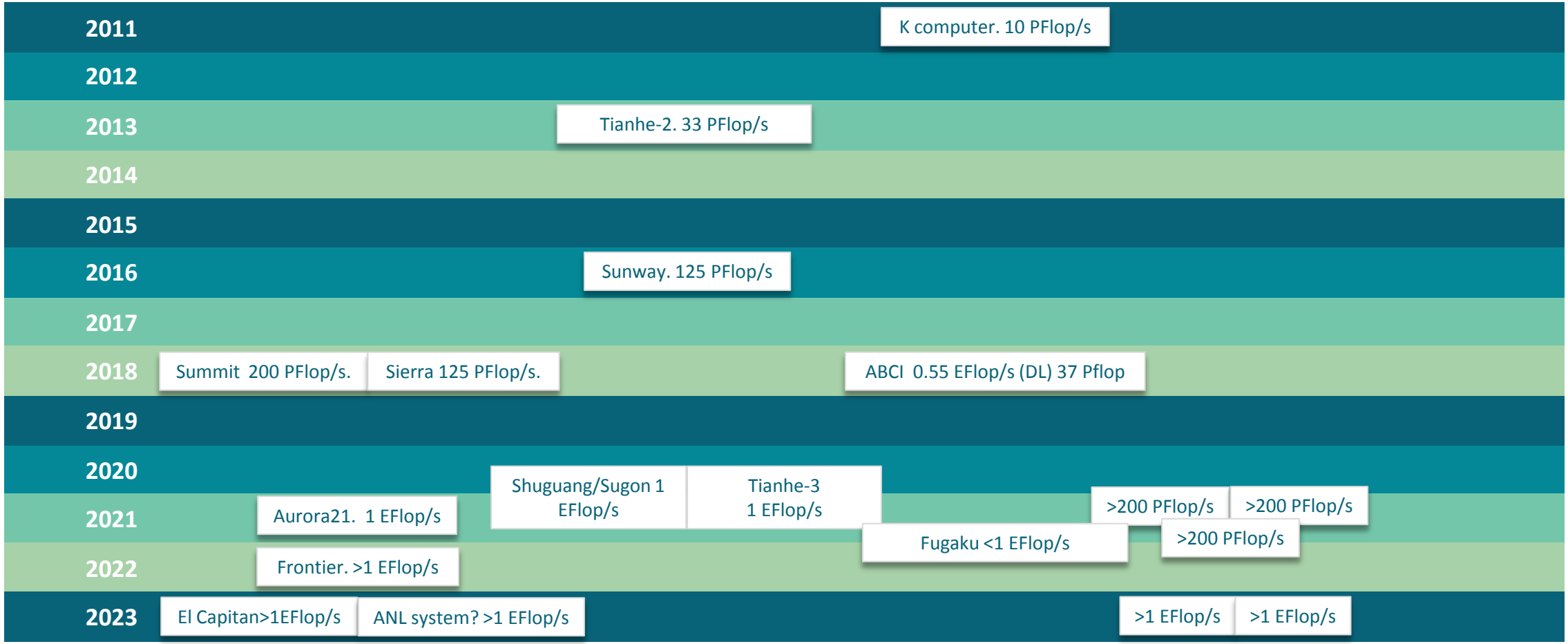
August 2019

The race towards exascale



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August 2019

The new MareNostrum5

La UE instalará en Barcelona uno de los tres superordenadores más veloces del continente

Apuesta por la ciencia

Llega una nueva generación de superordenadores a BCN

El Barcelona Supercomputing Center albergará esta joya de la tecnología a partir del 2020

La Unión Europea aportará 100 millones de euros para el proyecto del MareNostrum 5

Europa confía en España para «supercompetir» con EE.UU. y Asia

▸La Comisión Europea elige Barcelona para instalar uno de los nuevos superordenadores, que contará con una inversión de 200 millones de euros

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MareNostrum 5. A European pre-exascale supercomputer

- **200 Petaflops** peak performance (200 x 10^{15})
- **Experimental platform** to create supercomputing technologies “made in Europe”
- **223 M€** of investiment

Hosting Consortium:

Spain **Portugal** **Turkey** **Croatia**

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EuroHPC Joint Undertaking

Where Europe needs to be stronger

- Only 1 of the 10 most powerful HPC systems is in the EU
- HPC codes must be upgraded
- Vital HPC hardware elements are missing: general purpose processor and accelerators
- EU needs its own source of as many of the system elements as possible

Why Europe needs its own processor

- Processors now control almost every aspect of our lives
- **Security** (back doors, etc.)
- Possible **future restrictions on exports to EU** due to increasing protectionism
- **A competitive EU supply chain** for HPC technologies will create jobs and growth in Europe

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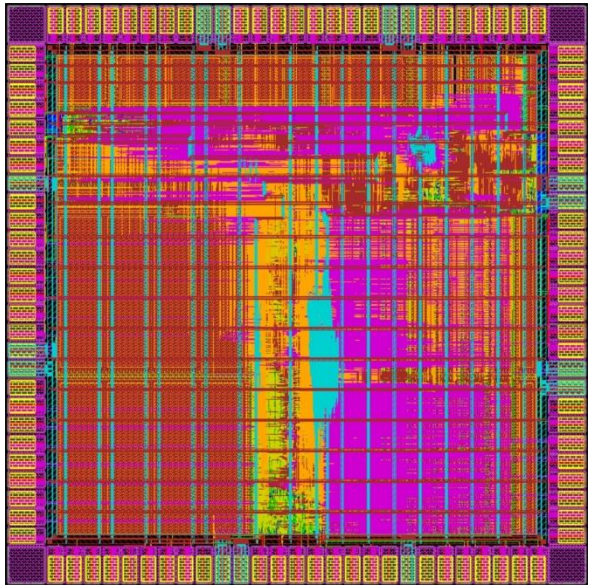
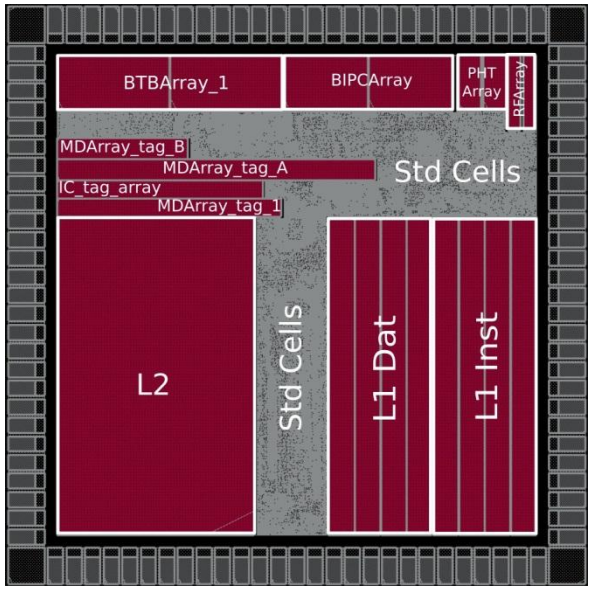
EPI, 26 partners from research to industry

First Lagarto Tapeout

- Target design:
  - Simple in-order core with 5 stages, single issue
  - 16KB L1 caches, 64KB L2 cache, TLB
  - Memory controller on the FPGA side
    - FPGA – ASIC communication via packetizer
  - Debug ring via JTAG
  - Target technology: TSMC 65nm
    - Design fits in the total area budget of 2.5mm2
    - Submitted for fabrication in May 2019
- Collaborative project with different teams:
  - RTL Design: Lagarto (BSC + CIC-IPN)
  - Verification (BSC)
  - Logic Synthesis (UPC + BSC)
  - Physicial design (IMB-CNM + BSC)
  - Tapeout and bringup (IMB-CNM + BSC)





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UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

Centro Nacional de Microelectrónica IMB

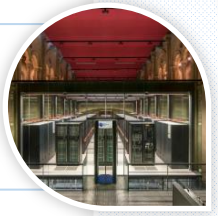
Thank you

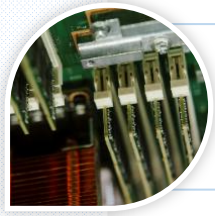
martorell@bsc.es

An European HPC visionary

First Computer Professor in Spain (UPC, 1984)

Barcelona Supercomputing Center founder and director





The first of a family of more than 700 PhD in Computer Sciences

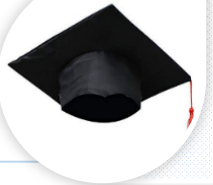
The only European with the highest ACM and IEEE awards

IEEE

Association for Computing Machinery

>700 Coauthored publications

Honorary Doctorate by 9 Universities



Mateo Valero

Member of 9 Scientific Academies

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