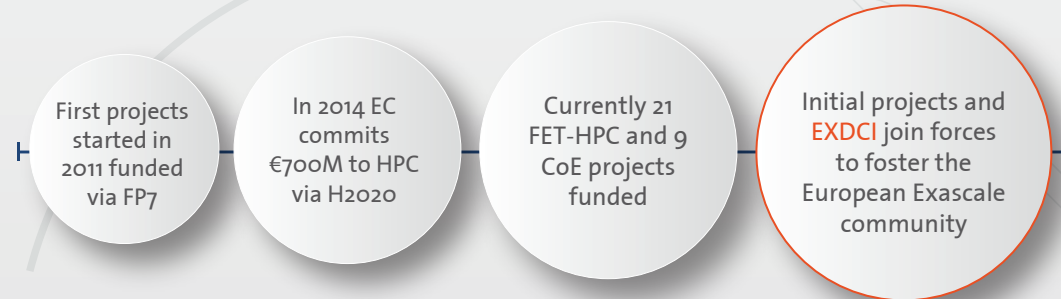


# EUROPEAN EXASCALE PROJECTS



Exascale research is considered as one of the grand challenges for the European Union. Since 2011 substantial funding has been devoted to key research areas: hardware design, programming models, algorithms & tools, and applications.



## The three main strategic objectives are:

- For HPC to tackle major scientific, societal and competitiveness challenges
- To develop innovative world-class industrial products and services in a cost effective way
- To underpin scientific discovery through modeling and simulation



[www.exascale-projects.eu](http://www.exascale-projects.eu)

The CRESTA, DEEP/DEEP-ER, Mont-Blanc, EPIGRAM, EXA2CT, EXDCI and NUMEXAS projects receive funding from the EU's Seventh Framework Programme (FP7/2007-2013) under the grant agreements no. 287703, 287530, 610476, 288777, 610402, 610598, 610741, 611636 and 671558



## INNOVATIVE COMPUTER ARCHITECTURES

The **DEEP/-ER** architecture provides the flexibility needed by complex scientific applications, which often present various scalability levels. It consists of a Cluster for low/medium scalability components and a Booster to run the highly scalable code parts.



The **Mont-Blanc** prototype is built on embedded commodity System on Chips (SoCs) used in mobile technology. ARM processors and embedded GPU accelerators used in a high-density packaging and commodity interconnects for a complete functional HW/SW stack.



## ENERGY EFFICIENCY

Energy efficient algorithms, tools for measuring energy efficiency and techniques for reducing energy consumption are all areas of investigation within the projects. Intelligent new technologies such as warm water-cooling or low energy consumption chips are evaluated in the **DEEP/-ER** and **Mont-Blanc** projects.

## PROGRAMMING PARADIGMS

> **CRESTA** investigated directive based models to programme accelerators, PGAS models such as CAF and hybrid models to exploit overlapping communication and computation.

> **DEEP/-ER** and **Mont-Blanc** are developing the European OmpSs, a task based programming model extending OpenMP with new directives to support asynchronous parallelism and heterogeneity.

> **EpiGRAM** is investigating the Message Passing and PGAS programming models. The focus is on the scalability of MPI and GPI-2 in terms of execution time and memory consumption.



> **EXA2CT** is looking at enhanced programming models that take into account the communication architecture, the platform heterogeneity, and that can deal with hardware failure.

> **NUMEXAS** is investigating hybrid approaches and will evaluate in their solvers the recently developed programming paradigms.

## NOVEL ALGORITHMS

> **CRESTA** investigated novel linear solvers, FFT implementations and alternatives and asynchronous algorithms.

> **EpiGRAM** is investigating innovative collective communication algorithms in Message Passing and PGAS programming models.

> **EXA2CT** is making pipelined, robust numerical solvers that scale up to Exascale performance and that survive hardware failures.

> **NUMEXAS** will develop new FEM and optimization solution algorithms and investigate on suitable linear solvers and pre-conditioners.

## PERFORMANCE ANALYSIS TOOLS

> Performance analysis tools: Vampir, Scalasca, Allinea's MAP and Extrae/Paraver.

> Debugging tools: Allinea's DDT and Temanejo.

> Pre- and Post- processing tools: PPStee and VIRACHOCHA.

> Simulators of parallel collectives and applications: LogGOPSim and DIMEMAS.



## SCIENTIFIC APPLICATIONS

### CRESTA

Co-design approach to enable six large-scale applications

### MONT-BLANC

Porting a pool of scientific applications, used by academia and industry to ARM based heterogeneous architecture

### EpiGRAM

Redesigning the communication kernels of two large-scale applications

### NUMEXAS

Will improve the scalability of several industrial solvers and scientific applications

### DEEP/-ER

Applications are optimized to take best advantage of the innovative Cluster-Booster architecture

### EXA2CT

Open source proto-applications to help boot-strap the creation of genuine Exascale codes

Weather modelling

IFS: exploring new communication models, task graph parallelism and acceleration