European Exascale Software Initiative EESI2

Towards exascale roadmap implementation

Very Quick Overview

http://www.eesi-project.eu/

Philippe RICOUX (TOTAL) , EESI2 Coordinator
Jean Yves BERTHOU, Thierry BIDOT, all WP leaders

Build and consolidate a **vision and roadmap** at the European level, **including applications**, both from *academia and industry* to address the challenge of *performing scientific computing* on the new generation of super-computers, **hundreds of Petaflop/PBytes** in 2017 and **Exaflop/ExaBytes** in 2020/2022
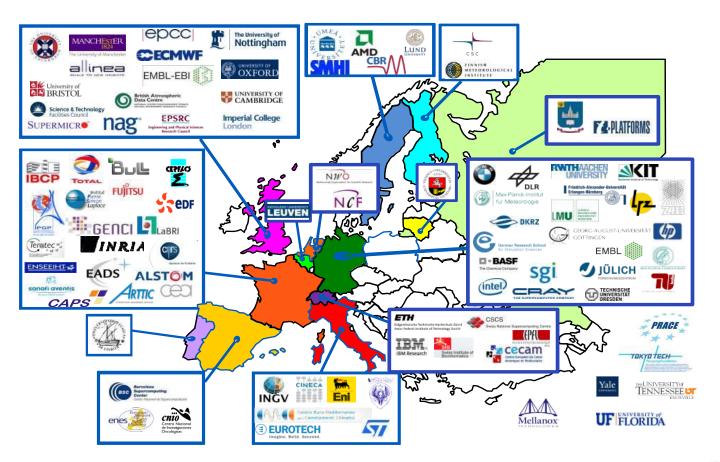
Propose & Initiate International collaborations
In order to tackle the key issues

Toward EFFICIENT EXASCALE APPLICATIONS

EESI: 150 experts, 100 entities

14 countries covering Europe including Russia , International Links, Participation of US, Israel, Lithuany, ...

Towards Exascale: Main issues to be addressed (EESI1)

At the level of simulation environment:

- **Unified Simulation Framework** and associated services: CAD, mesh generation, data setting tools, computational scheme editing aids, visualization, etc.

- **Multi-physics simulation**: establishment of standard coupling interfaces and software tools, mixing legacy and new generation codes

- common (jointly developed) **mesh-generation tool, automatic and adaptive** meshing, highly parallel

- Standardized **efficient parallel IO and data management** (sorting memory for fast access, allocating new memory as needed in smaller chunks, treat parts of memory that are rarely/never needed based on heuristic algorithms, …)

50% Computer Power for Data movement Synchronization and Communication reducing algorithms

At the level of codes/applications:

- **New numerical methods**, algorithms, solvers/libraries, improved efficiency

- coupling between stochastic and deterministic methods : Numerical scheme involving Stochastic HPC computing **for uncertainty** and risk quantification

- meshless methods and **particle simulation**

- **Scalable program, strong and weak scalability**, load balancing, fault-tolerance techniques, multi-level parallelism (issues identified with multi-core with reduced memory bandwidth per core , Collective communications, Efficient parallel IO)

- *Development of standards programming models* (MPI, OpenMP, C++, Fortran, …) handling multi-level parallelism and heterogeneous architecture

- **Human resources, training (what level?)**

From EESI to EESI2

EESI roadmaps, vision and recommendations *need to be monitored, updated, on a dynamical way*

Key issues to be addressed are pointed out in EESI1 … Now EESI2 must recommend R&D actions **how to tackle them**

- **Extend, refine, and update** Exascale cartography (**directly in the dedicated WG for better analysis of each WG)** and **roadmaps** from HPC community, on software, tools, methods, R&D and industrial applications**, ...**

With a Gap Analysis.

Including WG on *disruptive technologies*

Address "Cross Cutting issues": Data management and exploration, **Uncertainties - UQ&VQ**, Power & Performance, Resilience, Disruptive technologies

Investigation on funding scheme and opportunities, education, co-design centres, international coordination
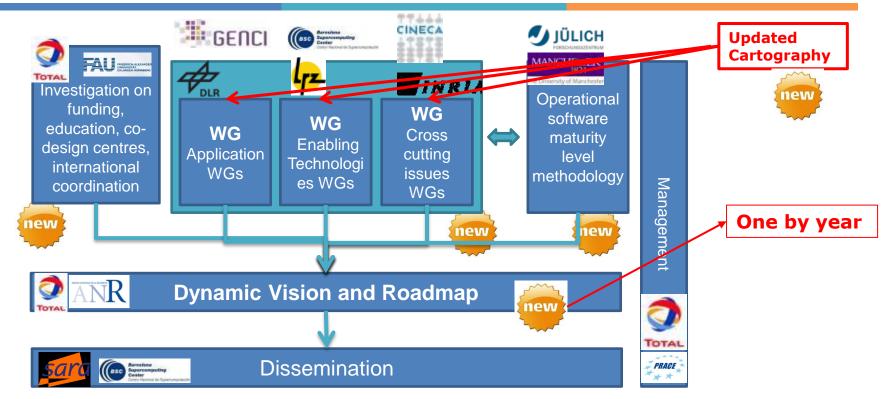
Operational **Software maturity** level methodology, evaluation

EESI2 general picture

Updated Cartography

One by year

Investigation on funding, education, co-design centres, international coordination

WG Application WGs

WG Enabling Technologies WGs

WG Cross cutting issues WGs

Operational software maturity level methodology

Management

Dynamic Vision and Roadmap

Dissemination

Contractual partners: TOTAL (coordinator), PRACE AISBL (acting for third parties LZR, GENCI, BSC, CINECA, EPCC, SARA…)

Contributing partners, involved in the management of EESI2 tasks but not associated to PRACE AISBL: INTEL, DLR, EDF, ANR, CERFACS, …

Supporting partners : more than 50 letters of Support

EESI2 proposal submitted in November to INFRA-2012-3.3: *Coordination actions, conferences and studies supporting policy development, including international cooperation, for e-Infrastructures.*
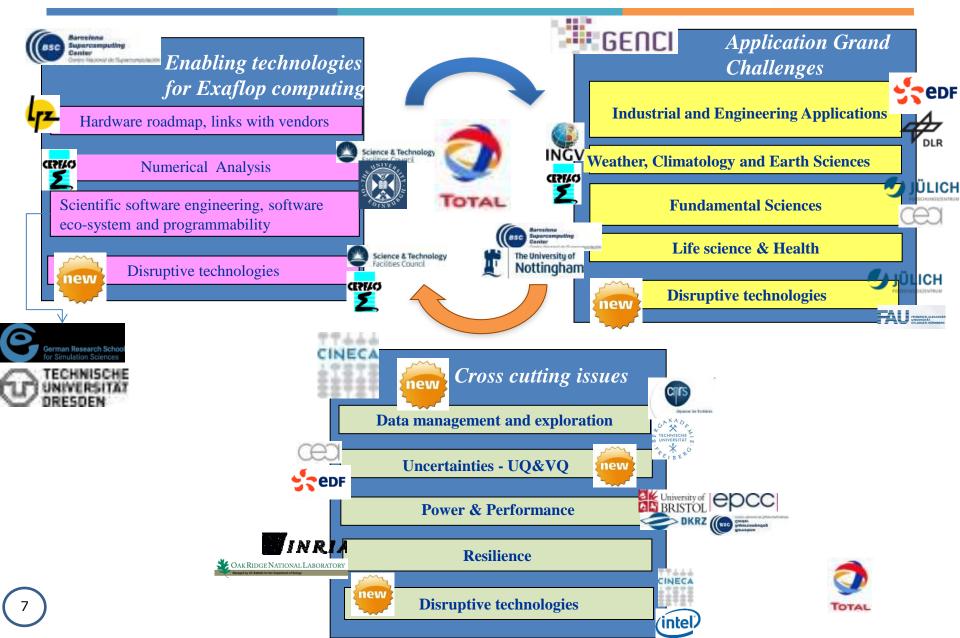
Requested funding: 1.5 M€   → 1.36 M€ accepted by EC

Duration: 30 months, Start 1st September 2012 - kick off 18th September 2012 (extended to 34 months)

EESI2 Working Groups

Enabling technologies for Exaflop computing

- Hardware roadmap, links with vendors
- Numerical Analysis
- Scientific software engineering, software eco-system and programmability
- Disruptive technologies

Application Grand Challenges

- Industrial and Engineering Applications
- Weather, Climatology and Earth Sciences
- Fundamental Sciences
- Life science & Health
- Disruptive technologies

Cross cutting issues

- Data management and exploration
- Uncertainties - UQ&VQ
- Power & Performance
- Resilience
- Disruptive technologies

❑ **The EESI2 Vision**

The vision which is presented here is also inspired by some worldwide recent installations in Europe, Asia and in USA of 10 (and more) Petaflops computers and by the feedback of several applications and tests running on full configurations of these systems. These tests have shown the *extreme difficulty to get some acceptable results* in term of performance on these computers. In particular the following points appear to be critical:

  ❑ **Resilience**
  ❑ **Error propagation**
  ❑ **Reproductibility**
  ❑ **Data transfert, communication**
  ❑ **Task synchronization**

❑ **As a consequence, Exascale applicative software appear to be a very difficult challenge and most worldwide experts consider that this challenge will not be solved with existing algorithms.**

EESI2 VISION Summary (1st Year)

- **What appears presently, shared by US, Japanese and European experts, is that:**
  - *Exascale technology will **trickle down to every scale** (architecture system as well physics and time)*
  - *Exascale **cannot be justified only if we are just planning to do the usual thing but bigger***
  - *Exascale machines will be useless without algorithms that use their specific features*
  - ***Exascale imposes to do something different and differently***

- **The following points are on the critical path to Exascale Computing::**
  - *The use of **hierarchical algorithms** which reduce communications and tasks synchronizations*
  - *The use of **multi-physics methods** which do not need or **minimize data transfers** and include **multi scaling and parallel space-time** methods*
  - *The **reshaping of operating systems** and management tools such as MPI and OpenMP and **mesh generation tools** to the new developed algorithms*
  - *The use **of in situ data processing***

EESI2 VISION Summary (1st Year)

□ ***In term of organization,*** the EESI experts agree that ***multi disciplinary research* teams** approach enable the emergence of significant progress toward the implementation of Exascale applications. **The best coupling of Architecture, Algorithm and Application (AAA)** is the challenge of efficient Exascale software. **That leads *to increase international collaboration*, international working teams**.

□ But, even if all agree on these points, there is an **on going debate on co-design centre structure**. EESI2 will go on deeper on this item. The related EESI2 working group just begins its works and **will give recommendation within the next deliverable in 2014.** As a first recommendation, EESI claims that co-design centers/centers of excellence **should conciliates scientific multi-disciplinarity, international dimension, critical mass of researchers working at the same place, the balance of vertical (specialty) and horizontal (transverse) scientific domain and the need to do things differently.**

EESI Conclusions

- Europe need for a **sustainable, long term and coordinated** effort

- Europe is still well positioned to be part of the few player worldwide deploying and exploiting Exascale technology but action is needed now

- A 2,5 to 3,5 billions euros total budget over 10 years, supported by EC, National European funding agencies, industry, … **a several decades** engagement

- Scientific Computing at Exascale, from a computing and data intensive point of view are **strategic** for maintaining and developing both **European Scientific Excellence and Industry Competitiveness**

- **International** collaboration is required

- Beside legacy codes, Europe should encourage the development of **Open Source solutions** to foster international collaborations and the emergence of international *de facto* standards, enabling commercial exploitation