FP7 Support Action - European Exascale Software Initiative

DG Information Society and the unit e-Infrastructures

Addressing the Challenge of Exascale

Towards Exascale roadmap implementation

European Exascale Software Initiative

EESI

EESI2 - 2014 Recommendations

Philippe RICOUX (TOTAL) , EESI2 Coordinator

EESI Motivations and Organization

Origins of EESI: **IESP** (Jack Dongarra)
www.exascale.org

Build an international plan for developing the next generation open source software for scientific high-performance computing

*www.**eesi-project.eu***

IESP meetings

Nov 2008

Nov 2009 — **EESI proposal**

Apr 2010 — **EESI start**

Oct 2011 — **EESI proposal**

Sept 2012 — **EESI2 start**

May 2013 — **BDEC**
Charlestone
Fukuoka
Barcelona

EESI objectives

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 2015 and **Exaflop/ExaBytes** in 2020

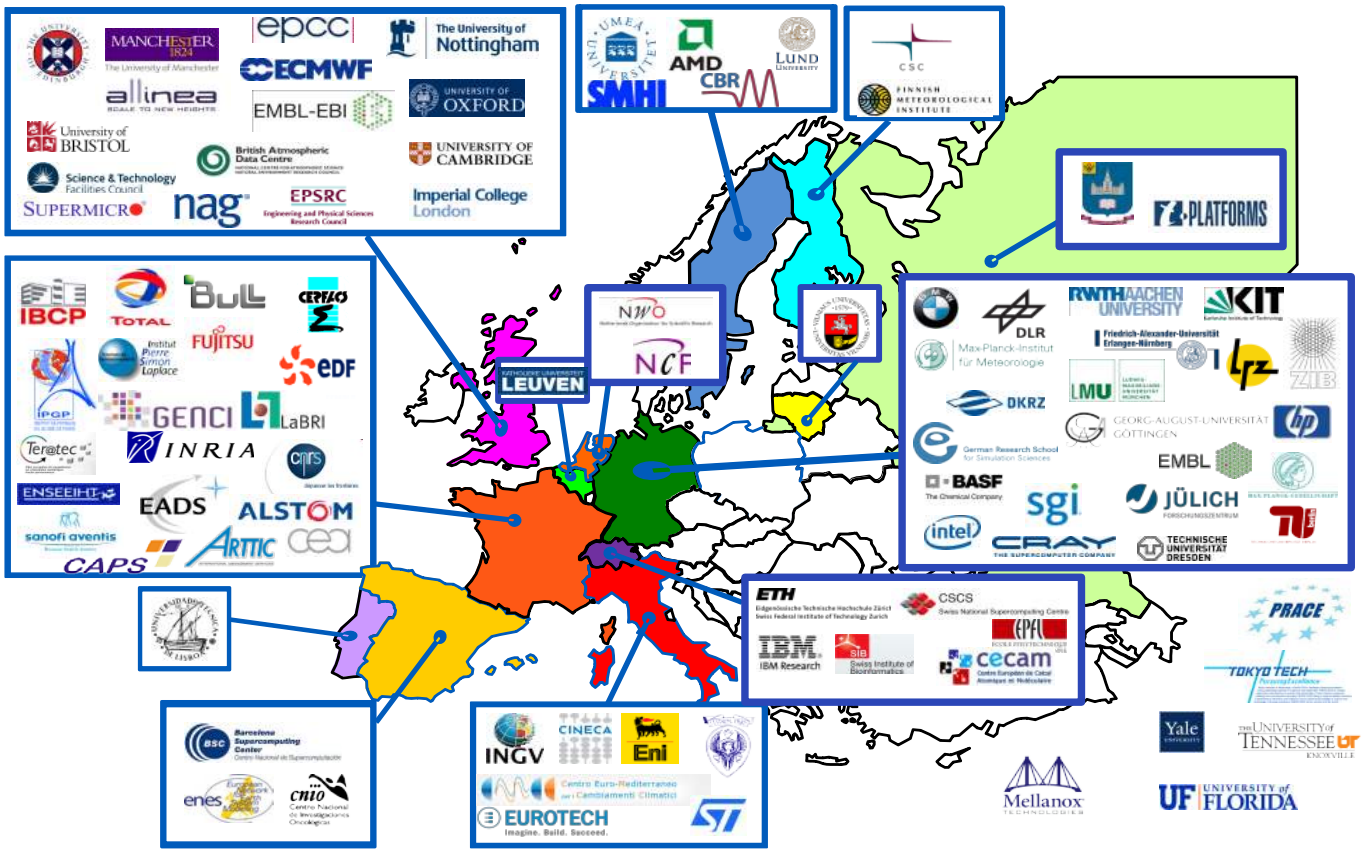
Toward EXASCALE EFFICIENT APPLICATIONS

What is at stake?

EESI: 150 experts, 100 entities

14 countries covering Europe including Russia , International Links,

Participation of US, Israel, Lithuany, ...



EESI vision and recommendations (Oct. 2011)

European Strengths

- HPC intensively used in academy thanks to PRACE and in industry: Energy (TOTAL, EDF, Schlumberger), Aeronautic (AIRBUS), Finance, Defense&Security, …
- Applications: astrophysics/cosmology, fusion research, materials sciences, life sciences, Engineering
- Hardware: Europe has all the competences to build an Exascale computer
- Applied math.: Europe has one of the best scientists in applied mathematics …
- Software: Europe has leading position in some software areas: system design (mobile, network, energy efficiency), simulation frameworks/coupling tools, meshing tools

European weaknesses

- Not clear how European ISV are preparing the coming of Exascale
- Simulation not as strongly supported as observations and experiments (ITER)

From a technical point of view:

- Lack of coordination in the development of HPC software,i.e often few isolated centres
- Not enough participation in the definition of new standards for programming (MPI, OpenMP, C++, Fortran, …)
- Lack of critical mass on critical software domains: Fault tolerance, OS, compilers, File system, hybrid core design

EESI vision and recommendations (Oct. 2011)

EESI recommendations – general statement

- **Fund** strategic projects where Europe is strong and able to federate significant critical mass
- Insure the coordination of European efforts with the rest of the world, in particular:
- Reinforce Multi-disciplinary HPC Centers providing support in terms of code development, porting and optimization as well as algorithm development.
- co-design centers/centers of excellence should conciliates scientific multi-disciplinarity, international dimension,
- Europe need for a **sustainable, long term and coordinated** effort: A 2,5 to 3,5 billions euros total budget over 10 years, supported by EC, National European funding agencies, industry,
- 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

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?)**

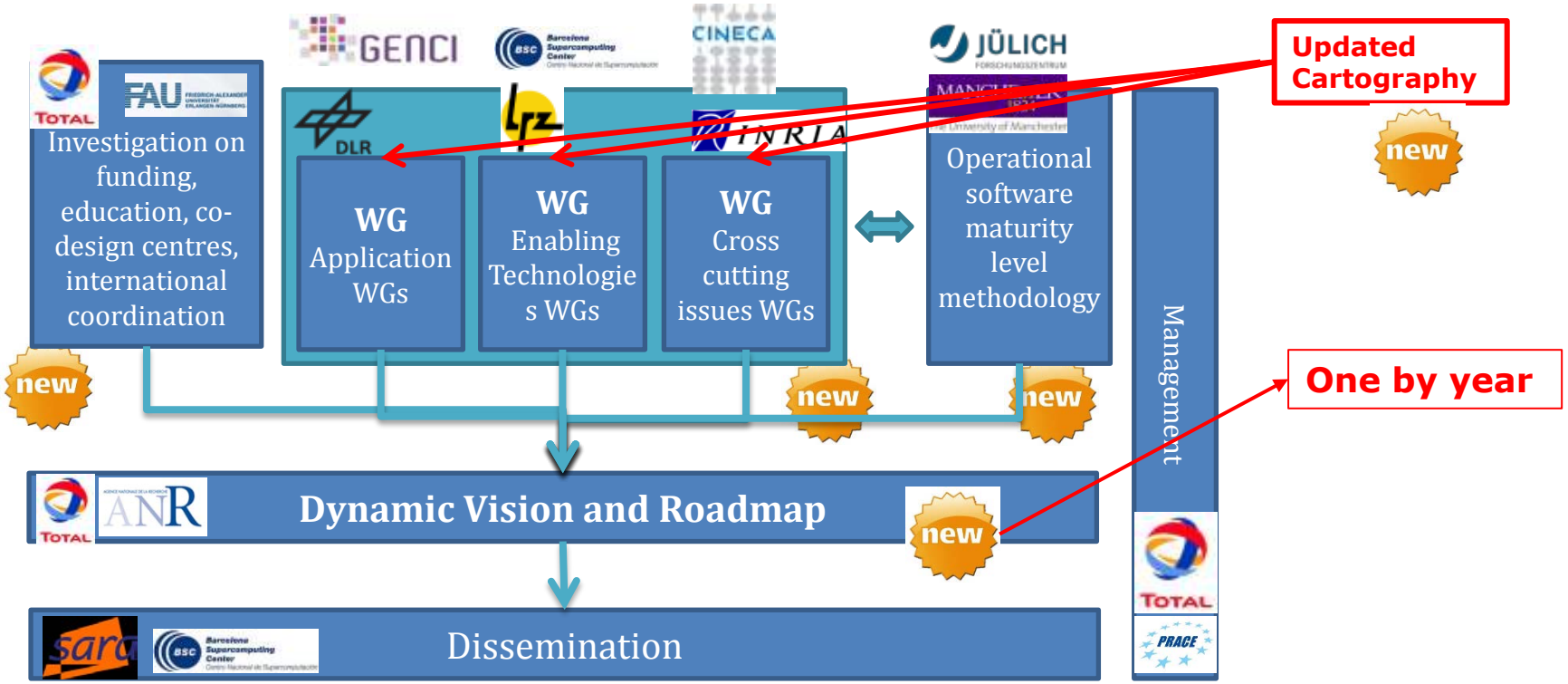
From EESI to EESI2

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, **…**
- new *With a Gap Analysis.*
  - new Including WG on ***disruptive technologies***
- new **Address "Cross Cutting issues":** Data management and exploration, **Uncertainties - UQ&VQ**, Power & Performance, Resilience, Disruptive technologies
- new **Investigation on** funding scheme and opportunities, education, co-design centres, international coordination
- new Operational **Software maturity** level methodology, evaluation

EESI2 general picture



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, …

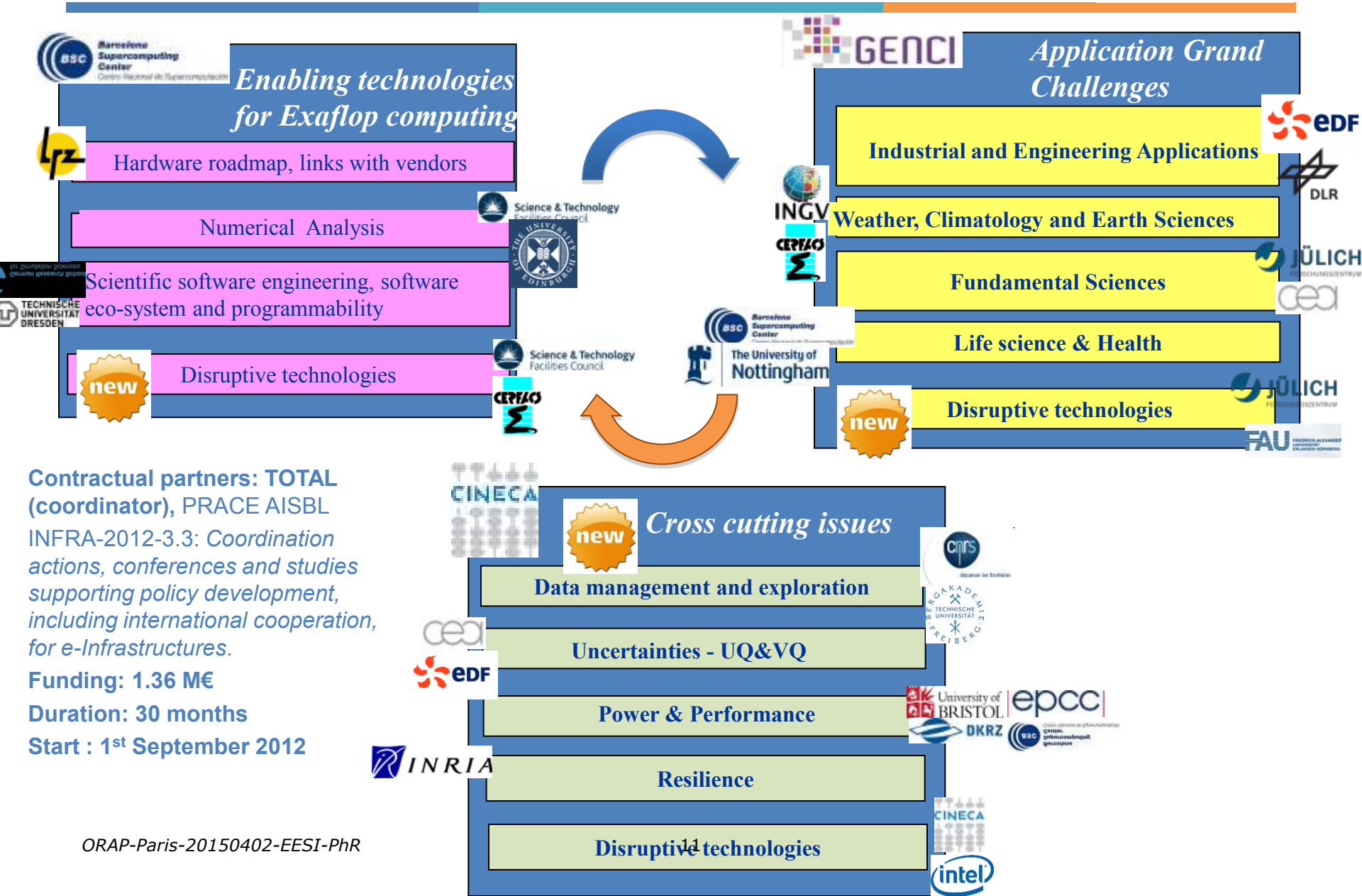
Supporting partners : more than 50 letters of Support

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)

2013/2014 EESI2 recommendations



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INFRA-2012-3.3: *Coordination actions, conferences and studies supporting policy development, including international cooperation, for e-Infrastructures.*

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2014 EESI2 recommendations

D7.2
2014 Update
Vision & Recommendations

CONTRACT NO	EESI2 312478
INSTRUMENT	CSA (Support and Collaborative Action)
THEMATIC	INFRASTRUCTURE

Due date of deliverable:

Actual submission date: 30th July 2014

Publication date:

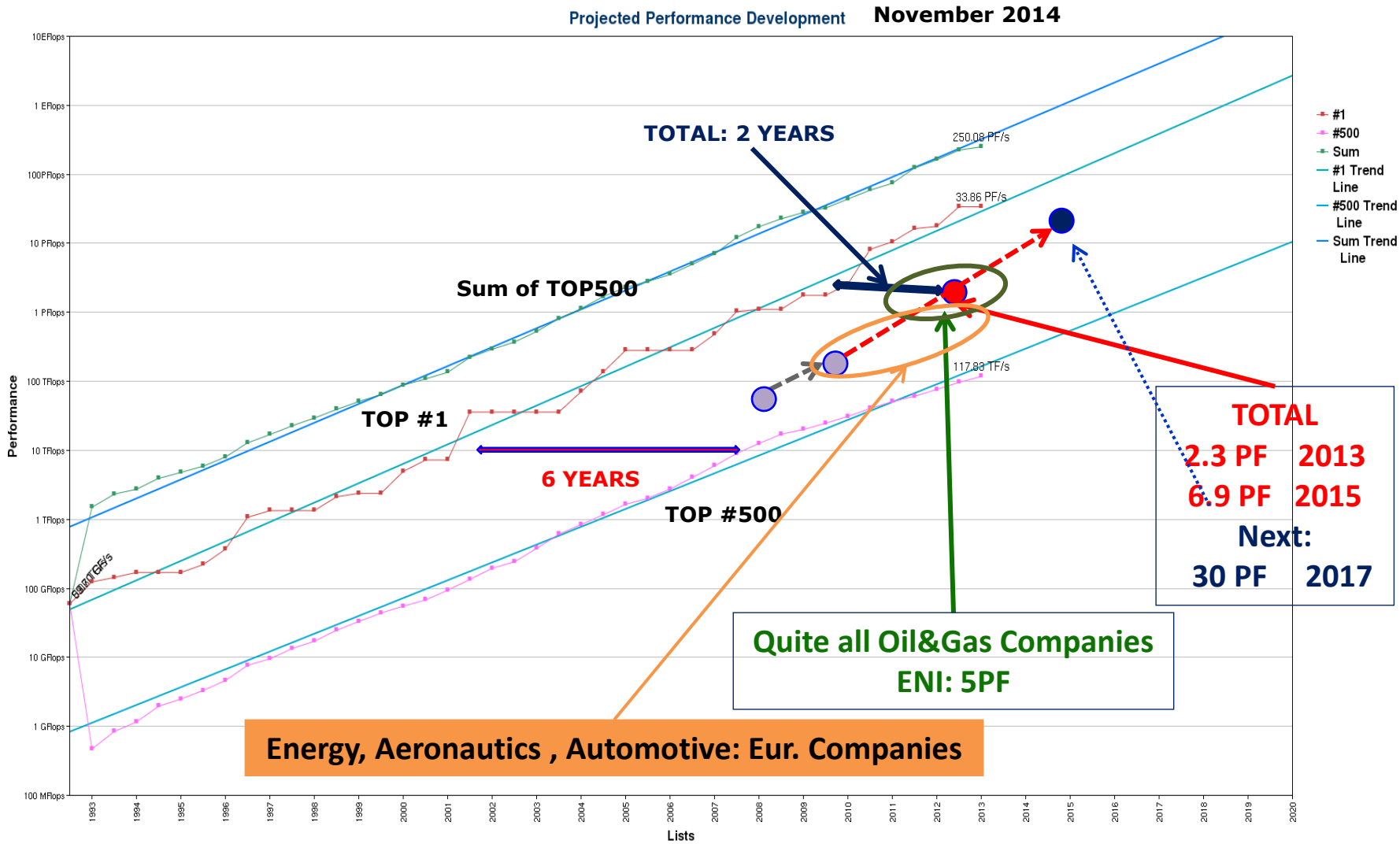
Start date of project: 1 September 2012 Duration: 34 months

Name of lead contractor for this deliverable: TOTAL SA, Philippe RICOUX

All documents on EESI: WP, WG Reports, All Final Reports, Roadmap, Vision & Recommendations, ...

http://www.eesi-project.eu

Industries in Top500: Insight into HPC Performance



Exascale, a breakthrough

System attributes	2010	"2015"		"2018"		Difference Today & 2018
System peak	2 Pflop/s	200 Pflop/s		1 Eflop/sec		O(1000)
Power	6 MW	15 MW		~20 MW		
System memory	0.3 PB	5 PB		32-64 PB		O(10
Node performance	125 GF	0.5 TF	7 TF	1 TF	10 TF	
Node memory BW	25 GB/s	0.1 TB/sec	1 TB/sec	0.4 TB/sec		
Node concurrency	12	O(100)	O(1,000)	O(		
Total Concurrency	225,000	O(10^8)				
Total Node Interconnect BW	1.5 GB/s					
MTTI						

Techn issues:

alancing

Best Coupling Between Architecture , Algorithms, Applications (A A A)

EXASCALE, a methodological, technological and scientific breakthrough

these new h xisting software stack

H ch is needed

From har software to applications

EESI: 150 experts, 100 entities

14 countries covering Europe including Russia , International Links,

Participation of US, Israel, Lithuany, ...

Exascale, a technological breakthrough, imposes

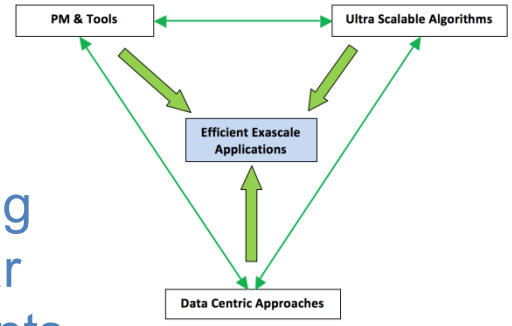
To think different and differently

Exascale cannot be justified only if we are just planning to do the usual thing but bigger

Exascale needs breakthroughs in several domains

(Algorithms, Algebra, Uncertainties, Couplers, Meshing ...)

2014 EESI2 recommendations

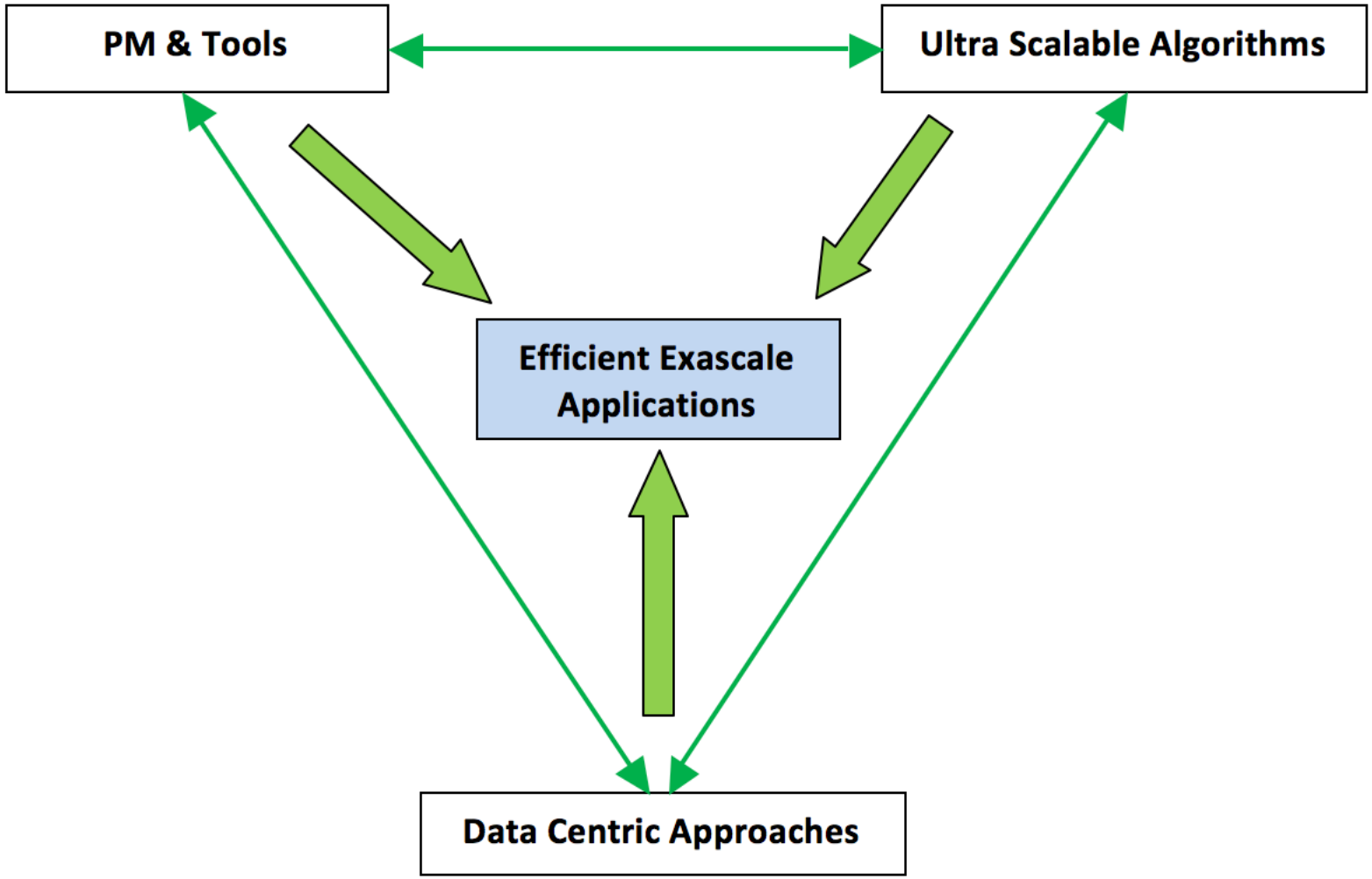


New thinking is required to develop new programming models, new algorithms, new tools, new data processing methods ... not only bigger than the present ones but far beyond the required innovation, **disruptive** improvements are needed

Extreme computing and **Extreme Data** should be tackled simultaneously

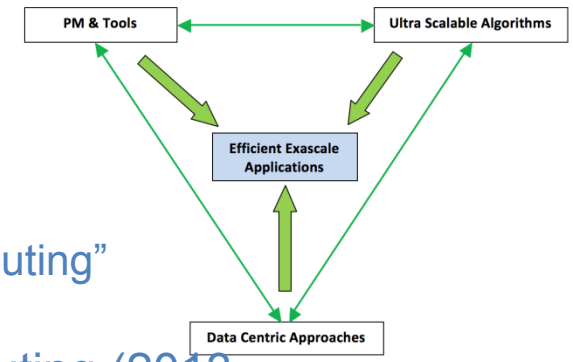
Assuring the **efficiency and productivity** of tools and applications at Exascale

2014 EESI2 recommendations



2014 EESI2 recommendations

Data Centric Approaches



Data Centric Approaches pillar

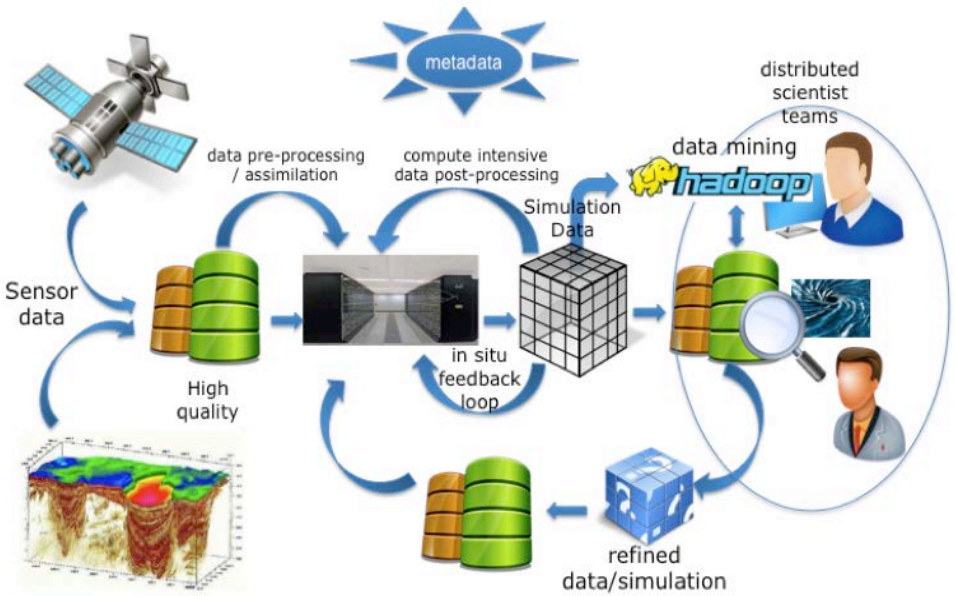
A vision "Software for Data Centric Approaches to Extreme Computing"

- Software for Data Centric Approaches to Extreme Computing (2013 update)
    - Toward real time Extreme Data Processing and better science through I/O avoidance in High-Performance Computing systems
        - Identification of turbulent flow features from massively parallel Exaflops and Exabytes simulations
    - Towards flexible and efficient Exascale software couplers (direct or not, exchange of big data) (2013 update)
    - Declarative processing frameworks for big data analytics, extreme data fusion

Software for **Data Centric Approaches** to Extreme Computing (2013 update)

Data Centric Approaches

Motivations : foster synergies between data-intensive science and extreme-scale computing, understanding the full cycle of data



Proposal :

- Data/compute research topics:
  - data transformational algorithms (extreme concurrency, asynchronous parallel data movement and access patterns, …),
  - disruptive I/O and scalable multi-tiered data storage and parallel data management system
  - data analytics algorithms and techniques

- End-to-end simulation cycle:
  - simplify human-in-the-loop workflows,
  - libraries of scalable data analytics and data mining algorithms,
  - full-service data lifecycle management systems, in-situ vs.ex-situ data processing
- Task force: for the creation of a set of multi-disciplinary proxy applications (or mini applications) and scientific use cases
- Bridge the gap between scientists trained in both extreme-scale and data-intensive computing

Toward real time Extreme Data Processing and better science through I/O avoidance in High-Performance Computing systems

new

Data Centric Approaches

Motivations

- Exascale challenges related to extreme data, energy and I/O constraints will make impossible for scientists to save a sufficient amount of raw simulation data to persistent storage for subsequent processing
- Post-process centric approaches -> real time in situ/in transit processing (reduction, topological features extraction, quality assessment) for benefiting from data locality, save energy and perform visualisation and computational steering :
  - In situ = use of the primary compute resources
  - In transit = data processing is offloaded to a set of secondary resources using asynchronous data transfers

Proposal : Fund R&D programs in order to explore

- Real Time (In situ) data-related energy/performance trade-offs for end-to-end simulation workflows running at scale on current high-end computing systems
- Take into account future multi tiered storage architectures and asynchronous data transfers
- Design and implement new analysis techniques typically performed on large-scale scientific simulations: topological analysis, descriptive statistics, surrogate data model, filtering, compression, active learning, pattern/feature discovery, error analysis …
- Explore disruptive approaches like sub-linear algorithms addressing the fundamental mathematical problem of understanding global features of a data set using limited resources.
- The use of in situ data analysis for tracking and checking fault or error propagation into the simulation, associating a resilience aspect with the execution of workflows on parallel systems.

Industrial support for Data Management

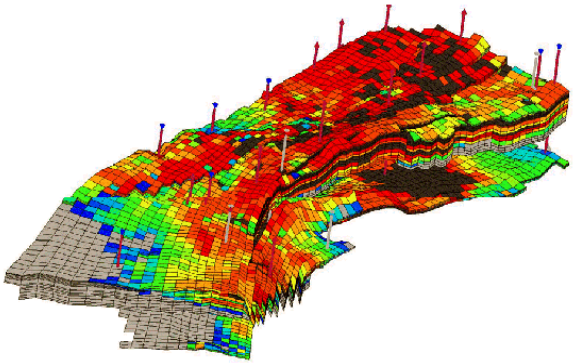
In Situ Extreme Data Processing in massively parallel numerical simulations: A necessary approach for Exascale (Cf Paper from EESI)

Large Scale Reservoir Modelling

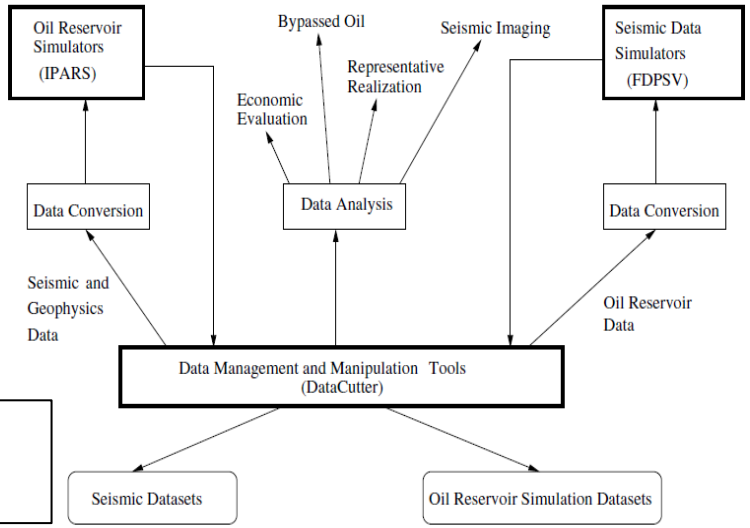
Finite Volume on 1 Billion Cells

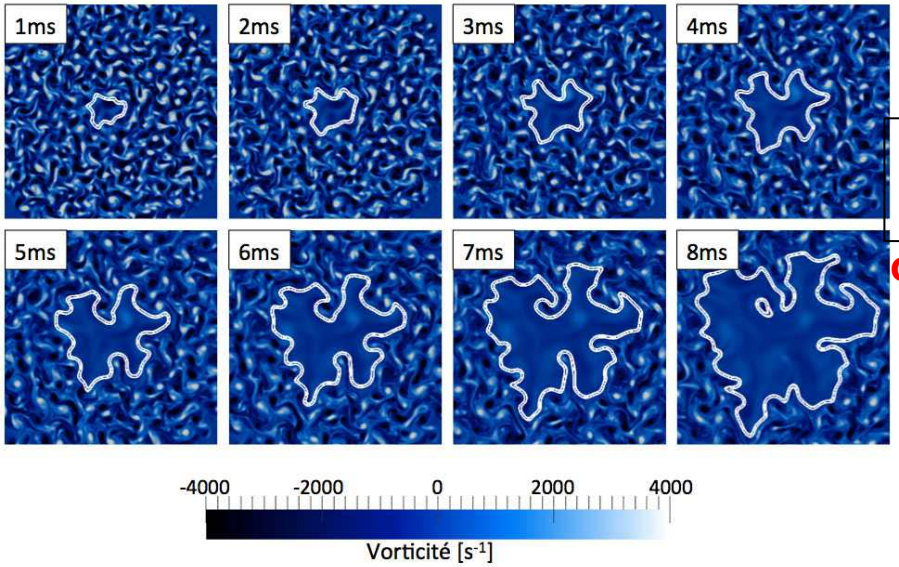
Generation of 350 TB by Run

Storage?? Post processing??



Even VISUALIZATION !

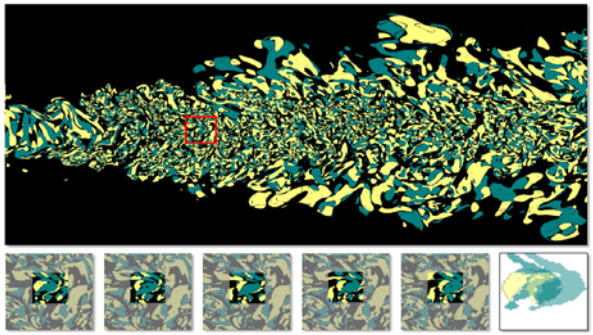




Turbulent combustion

Generation of 1PB

Every 30 minutes



Towards flexible and efficient Exascale software couplers (2013 update)

Data Centric Approaches

Motivations

- Multiscale and multiphysics simulations as one of the main driver for Exascale systems will require flexible and efficient couplers
- Current coupling technologies include direct coupling or coupling via top-level interfaces
- Both approaches need to be supported and redesigned in order to address same challenges : use more parallelism, less communications and less memory

Proposal

- Assess pro and cons of *direct coupling* vs. *top level API* approached in the context of Exascale
- design standard coupling API in order to enable interoperability, ease the integration of new models and cross disciplinary exchanges and sharing of performance analysis
- Implement asynchronism into localization process, geometrical or mesh changes process or communications between coupled models.
- Support of heterogeneous ressources and new programming models (component based model) at the level of the coupler and the coupled models
- Integrate coupling tools into an optimised pre/post processing stack including mesh connection between model, quick verifications of conformity, evaluation of physical quantities during computations, joint exploitation of massive results…

Europe very well positioned couplers with SALOME (EDF/CEA), OpenPALM (CERFACS) and mpCCI (Fraunhofer SCAI)

Declarative processing frameworks for big data analytics, extreme data fusion

new

Data Centric Approaches

Motivations:

- There is a convergence in data challenges between large scale instruments generating acquired data and (pre)Exascale systems delivering massive amount of synthetic data
- The Variety, Volume and Velocity, Value, Veracity of data imply a synergy and collaboration between different fields of science in order to extract full intelligence and knowledge from these data in close to real time.
- Current declarative langage concepts need to be expanded in order to support data locality and volume and complexity while keeping abstraction and portability

Proposal : develop novel methods in order to adress the challenges of :

- Declarative specification and automatic deployment of complex data analysis programs
- Develop declarative scalable data analysis libraries
- Continuous, workload-aware optimization and execution of data analysis programs over evolving data
- Adaptive, seamless deployment (automatically optimize for specific properties of the underlying hardware)
- Explore trading-off virtualization
- First results fast
- Better account of models
- Provide automatic mathematical based procedure to recognize in raw data features that will help in better interpreting and/or visualizing and/or interact with data

Europe is well positionned with the Stratosphere/Flink Eu funded project

Identification of turbulent flow features from massively parallel Exaflops and Exabytes simulations

Data Centric Approaches

Motivations

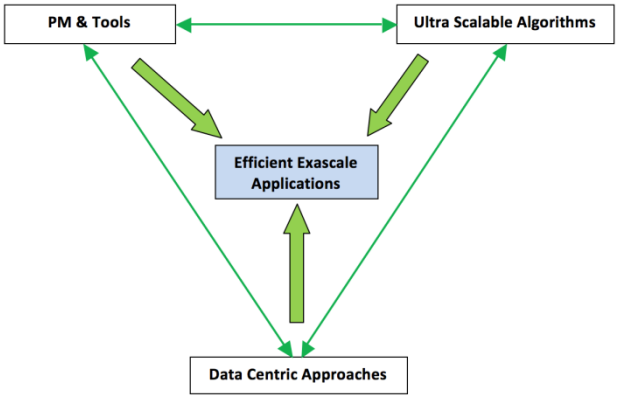
- The rise of multi Petascale and Exascale systems will allow turbulent simulations based on LES and DNS methods to address high fidelity complex problems in climate, combustion, astrophysics or fusion
- These billion-cells simulations will produce such deluge of data which is difficult and inefficient to post process asynchronously later after by a single researcher.
- It becomes mandatory to propose tools able to extract and follow automatically pertinent flow structures

Proposal : Develop a complete toolbox based on

- Massively parallel high-order low-pass and band-pass filters
- Conservative high-order interpolation kernels for the interpolation of fine grids to coarser grids
- Massively parallel Singular Value Decomposition algorithms for Dynamic Mode Decomposition of large sets of data
- Highly efficient linear solvers for symmetric matrices as those encountered in implicit filters
- Work in collaboration with scientific communities in order to make this toolbox an European standard used for addressing turbulent structures used in climate, combustion, traditional CFD, astrophysics, fusion , …

European researchers in France, Germany, Spain, UK or Sweden are worldwide leaders in LES and DNS methods

2014 EESI2 recommendations



Ultra Scalable Algorithms

Ultra Scalable Algorithms pillar

extremely efficient scalable solvers for a wide range of applications

- Algorithms for Communication and Data-Movement Avoidance new
- Parallel-in-Time: a fundamental step forward in Exascale Simulations (disruptive approach) new

Algorithms for Communication and Data-Movement Avoidance

Ultra Scalable Algorithms

Motivations:

- Data Movement as a key pitfall of Exascale systems for performance and energy reasons
- Tuning and communications overlap as a technique but will reach its limits with Exascale
- New techniques for communication and data movement avoidance far beyond the well-known communication hiding techniques, including the design of Hierarchical algorithms (based on compression techniques) have to be developed

Proposal:

- Explore the design of a new generation of algorithms, for both dense and sparse linear algebra and beyond, that are able to drastically reduce communication costs, and even provably minimize it in some cases;
- Focus on operations that are at the intersection with the data mining community, as for example computing the low rank approximation of a very large matrix, an important tool in different areas;
- Focus on a comprehensive treatment of data movement within & between computing nodes;
- Enable the development of sustainable software that implements this new generation of communication avoiding numerical algorithms;
- Enable leadership of European researchers in selected areas;
- Enable the coordination and federation of multiple efforts to reach a critical mass.

Target: Dense and sparse linear algebra operations, mesh generation algorithms, parallel in time methods,…

European researchers co-invented communication avoiding algorithms for dense and sparse linear algebra

Parallel-in-Time: a fundamental step forward in Exascale Simulations

Ultra Scalable Algorithms

Motivations:

- As Exascale systems will consist on millions of computing cores, their efficient use will rely on extracting sufficient parallelism from applications to support parallel execution across millions of threads of execution.
- Today most of the applications contain time-stepping in some form and present-day codes make little or no use of parallelism in the time domain ➔ time stepping is currently treated as a serial process
- Potential application areas include: climate research, computational fluid dynamics, life sciences, materials science, nuclear engineering, etc

Proposal: Fund R&D programs in order to

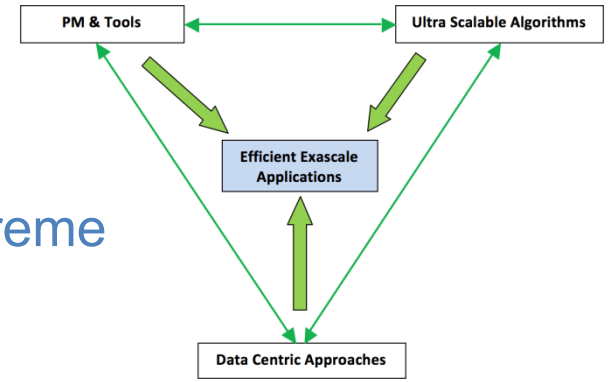
- Establish multi-disciplinary consortia to work on the deployment of Parallel-in-Time methods and applications to new fields, combining the expertise of applied mathematicians, application scientists, computational scientists and HPC technology specialists, following a co-design approach.
- Develop a series of benchmarks and test cases in order to have a clear view of the advantages, disadvantages and quality of the different Parallel-in-Time methods. The test cases should be at the same time close to the real applications and simple enough to allow both the integration and test of Parallel-in-Time methods.
- Parallel-in-Time software should be encapsulated in reusable scalable libraries

Disruptive approaches delivering 10 to 100x performance speedups

European researchers are leading Parallel-in-Time developments

2014 EESI2 recommendations

Tools & PM



Tools & Programming Models pillar

- High productivity programming models for Extreme Computing (2013 update)
- Holistic approach for extreme heterogeneity management of Exascale supercomputers
- Software Engineering Methods for High-Performance Computing (2013 update)
- Holistic approach to resilience for simulations and data analytics (2013 update)
- Verification Validation and Uncertainties Quantifications tools evolution for a for better exploitation of Exascale capacities (2013 update)

High productivity programming models (2013 update)

Tools & PM

Motivations:

- Ease the development of applications
- Decoupling the logic of the applications from the actual resources
- Enabling rapid prototyping, performance analysis, simulation
- Enable exploitation of heterogeneous and parallel platform from runtimes : exploit locality or load balancing, minimize global communications, promote asynchronous communication, minimize energy conception, support resilience, …

Proposal:

- High level of abstraction
- New approaches in task-based asynchronous execution model, hiding the details of the HW platform
- Automatic exploitation of parallelism enabling scalability at large number of nodes
- communication hiding programming in heterogeneous architectures
- Embedded Domain Specific Languages for high efficient implementations in heterogeneous environments (prototyping programming languages or scripting languages)
- tools for automatized detection of data- and task-dependencies for multi-threaded task based programming
- Smart & efficient runtime (efficient resource management, exploiting data locality, automatic load balancing, energy aware)
- tools for the development and analysis of the applications

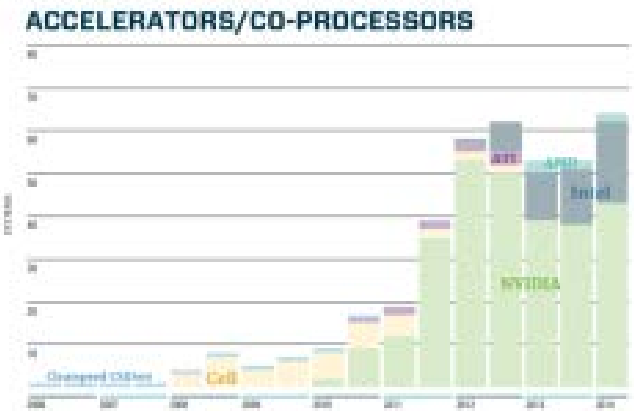
Europe very well positioned in programming models, right moment to fund initiatives which can unify good ideas from Europe, and get a strong European programming model

Holistic approach for extreme heterogeneity management of Exascale supercomputers

Tools & PM

Motivations:

- Exascale systems require a 50x gain in energy efficiency w.r.t. the today top500
- Disruptive technologies are needed to achieve at the same time a significant energy and performance gain
- The entire software stack is needed to evolve to hide the complexity of this wide design space supporting the programmer as well as the system administrator



Proposal: design and develop new efficient HW/SW APIs for the integrated management of heterogeneous systems, near-data technologies and energy-aware devices, to enable exascale-ready applications

- Design strategies for scalable and efficient heterogeneous-aware exascale applications;
- Scalable and efficient community scientific applications for exascale;
- System software to support efficient usage of exascale heterogeneous supercomputers in production.
- Coordinated design of the SW stack: programming models, run-time, OS and system support software
  - ⇒ Links with recommendations: “High Productivity Programming Models for Extreme Computing” and “Software Engineering Methods for High-Performance Computing”
- Development of novel management and control HW/SW APIs which can be exploited by the programmer and by the runtime to deploy at Exascale the potential energy-efficiency of novel architectures in the different application domains.

Software Engineering Methods for High-Performance Computing (2013 update)

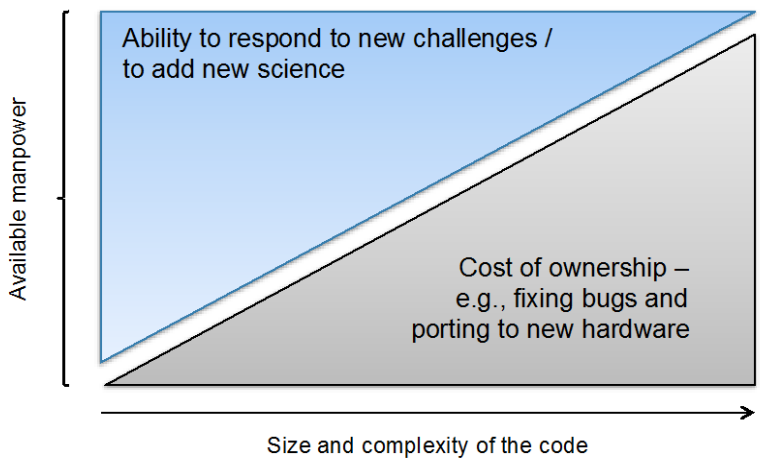
Tools & PM

Motivations:

- Need methods and tools: design, quality management, and reuse aspects of HPC software
- Because of the complexity and lifespan (x10 decades) of HPC applications

Proposal: productivity-enhancing methods and tools development and maintenance of Exascale software

- Develop predictive methods and tools to assist software re-design and co-design
- Support the transformation of codes into resilient software (see *resilient* recommendation)
- Carry out a survey of current software engineering practices and processes, define and validate optimal software new engineering processes for exascale applications
- Develop scalable debugging and performance analysis tools



Challenges at exascale:

- Performance
- Scalability
- Fault tolerance (hard and soft errors)
- Energy efficiency
- Change of algorithmic paradigms
- Pre- and post-processing

Holistic approach to resilience for simulations and data analytics (2013 update)

Tools & PM

Motivations:

- dealing the resilience challenge,
- HW not able to detect and correct all sources of errors&failures
- Checkpoint technique is becoming a serious bottleneck

Sources of faults

- fail stop errors (process, node, network, file system, OS, … failures)
- Silent Data Corruptions

- Multiples sparse techniques need to be coordinated: multi-level checkpointing, fault tolerant protocols, alternative to checkpointing, failure prediction, resilient algorithms, detection of silent data corruptions

Proposal:

- resilience API global solution from hardware/OS, algorithms, software
  - understanding and modeling of fault propagation,
  - error detection,
  - failure prediction,
  - roll-back and roll-forward recovery.
- An international effort: take a complementary position to USA and Japan

State of the art :

- fault model - No clear leader
- Resilience for tasks based programming models - Europe is leading (OMPSS)
- Fault notification/management back plane - No clear leader (CIFTS is no longer funded)
- Resilient OS (make sure that OS confine faults) - No leader for OS
- Resilient Algorithms - Avoid overlap with USA and Japan, focus on complementarities (may need to establish a forum/working group)

Verification Validation and Uncertainty Quantification tools (2013 update)

Tools & PM

Motivations: enhance the scientific recognition and societal acceptance of Exascale simulation

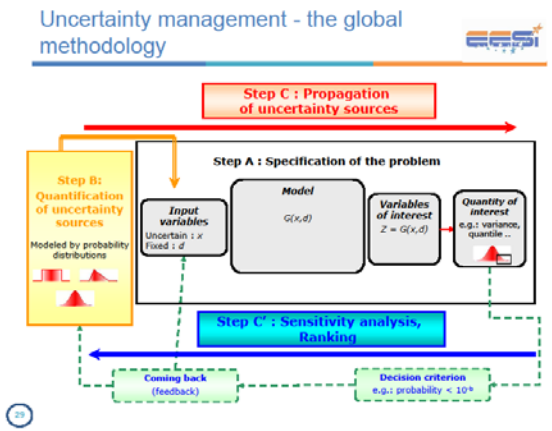
- Defining the domain of predictability of a Exascale simulation tool
- Enabling, improving decision making of the Exascale simulation process

Proposal: unified framework for usability VVUQ and Optimization on Exascale Systems

- Ultrascalable tools for VVUQ and optimisation
- Accessibility of the software: an unified European-wide package for VVUQ
- Methodological progresses *(model errors in the validation process, surrogate models and reduced basis models)*

Sources of uncertainties:

- Lack of knowledge on a physical parameter (epistemic uncertainty),
- Parameter with a random nature (aleatory uncertainty),
- Uncertainty related to the model (model error),
- Uncertainty related to the numerical errors (numerical errors)



State of the art :

Strong European expertise: OpenTurns (AIRBUS, EdF, CEA …), URANIE (CEA) platforms

US involvement: DAKOTA (Sandia Lab/DOE), PSUADE (Lawrence Livermore Lab/DOE)

EESI2 recommandation on UUVQ

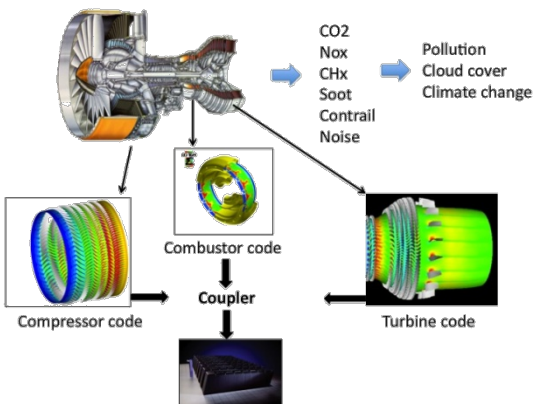
- **Multiscale/multiphysics + big data ➔ UUVQ**
  - Multiple sources of uncertainties due to
    - lack of knowledge on a physical parameter (epistemic uncertainty)
    - parameter with a random nature (aleatory uncertainty)
    - uncertainty related to the model (model error, too simplified model)
    - uncertainty related to the numerical errors (numerical errors of the model, to the input and output data, …).
- **Understanding uncertainties essential for acceptance of numerical simulation for decision making**
  - Strong impact in industry (automotive, oil & gas, aeronautics, nuclear,…) and academia (climate)
  - EU well positionned in UUVQ : Uranie and OpenTurns

➔Toward an unified UUVQ env. for Exascale

- Dev of ultrascalable UUVQ tools (scheduling, optimisation, …)
- Embeeding UQ loops at the lowest levels of the simulation code
- Use of surrogate models and reduced basis models

EESI2 recommandation on couplers

- **Coupler : a major software component**
  - Multiphysics simulations / legacy and new codes
  - Crucial for industry (aeronautics, automotive, …) and academia (climate, astrophysics, life sciences, …)
  - Coupling of 100k cores applications is a good driver for Exascale

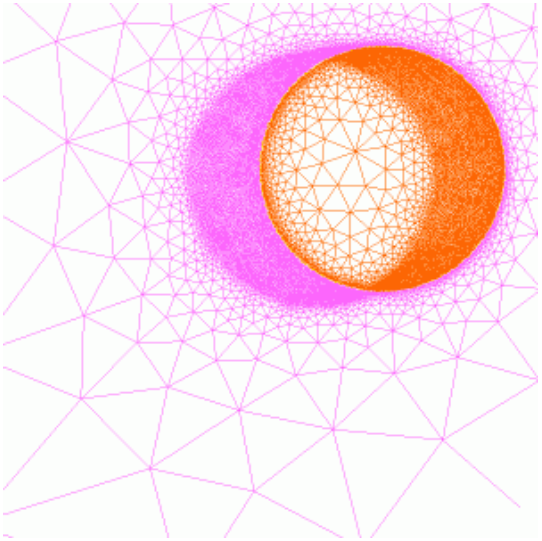


- **Europe owns multiple coupler tools**
  - OpenPALM, OASIS, MpCCI, …
- **2 approaches**
  - Direct coupling (multiple binaries) vs coupling via top-level interfaces (one unified binary)
- **But strong challenges to face for Exascale**
  - Standard coupling API
  - memory footprint, use of asynchronous (reduced) communications, …
  - Interpolation methods, smart search algorithms, ….

EESI2 recommandation on Mesh

Mesh Generation

- Automatic, Adaptive, Intelligent
- From billions « regular »meshs … to millions !



With numerical methods for solving differential equations such as

Disontinuous Galerkin: combining features of the finite element and the finite volume framework

DG methods have a huge interest for electrodynamics, fluid mechanics and plasma physics equations.

Conclusions

IDC 2014 Study for EESI: **HPC must produce ROI**

There is the only way for Exascale!

Industrial applications are the key factors of potential Exascale viability

-> Exascale applications must be efficient for ROI !
largely than they are today!

So, need of R&D programs, need of innovation, disruptive methods on all scientific domains …

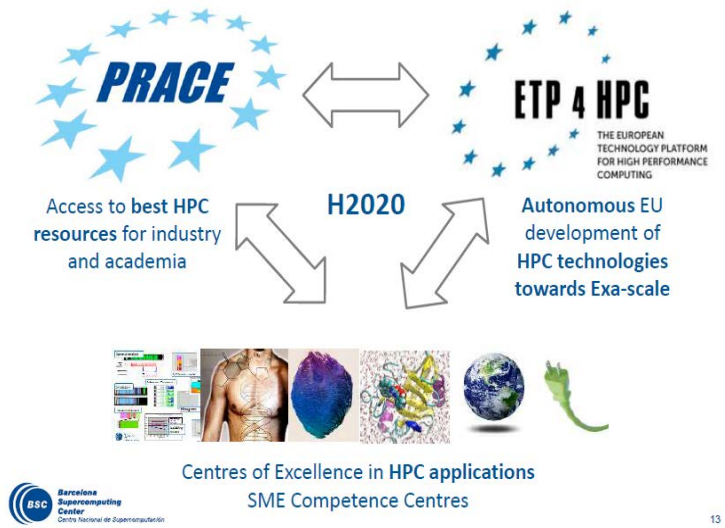
Please Submit EU Calls on concrete R&D for Exascale

Thank you for your future active contribution

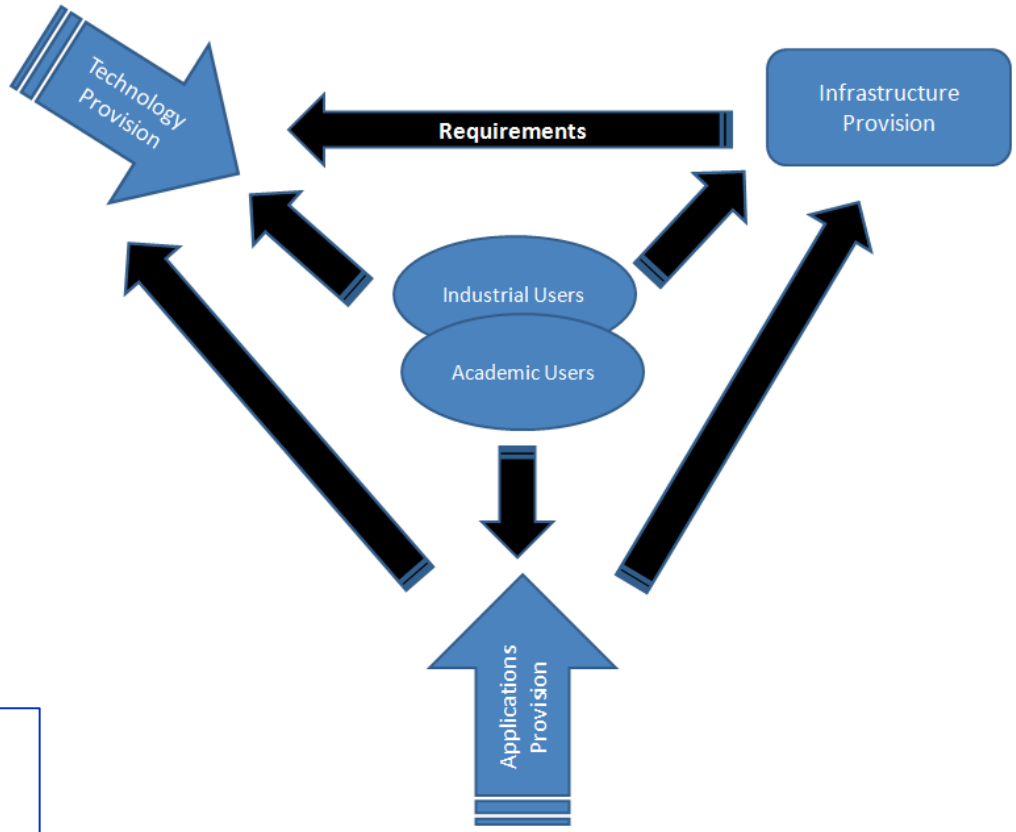
NEXT …. EXDCI

Extreme Data and Computing Initiative

Following EESI , and gathering the EC pillars of HPC



Accepted by EC On March 2015,
Start: Sept 2015 (?)
Leader: Sergi Girona (Prace)
Scientific Director: François Bodin (Irisa)



With an economic vision of HPC and Exascale
And Integration of the "fruits" of EESI recommendations

EESI is also friendly and largely open

Le Tremblay 2013

THANK YOU

Bologna 2014

Open to new disruptive

Ex: Non Linear Algebra (2^k, zero divisors, …) breaking Vectors & Matrices structure,