ETP 4 HPC

THE EUROPEAN TECHNOLOGY PLATFORM FOR HIGH PERFORMANCE COMPUTING

www.etp4hpc.eu

ETP4HPC
Strategic Research Agenda (SRA)
HiPEAC Conference, January 2016

THE EUROPEAN TECHNOLOGY PLATFORM
FOR HIGH PERFORMANCE COMPUTING

Introduction
HPC EC plan

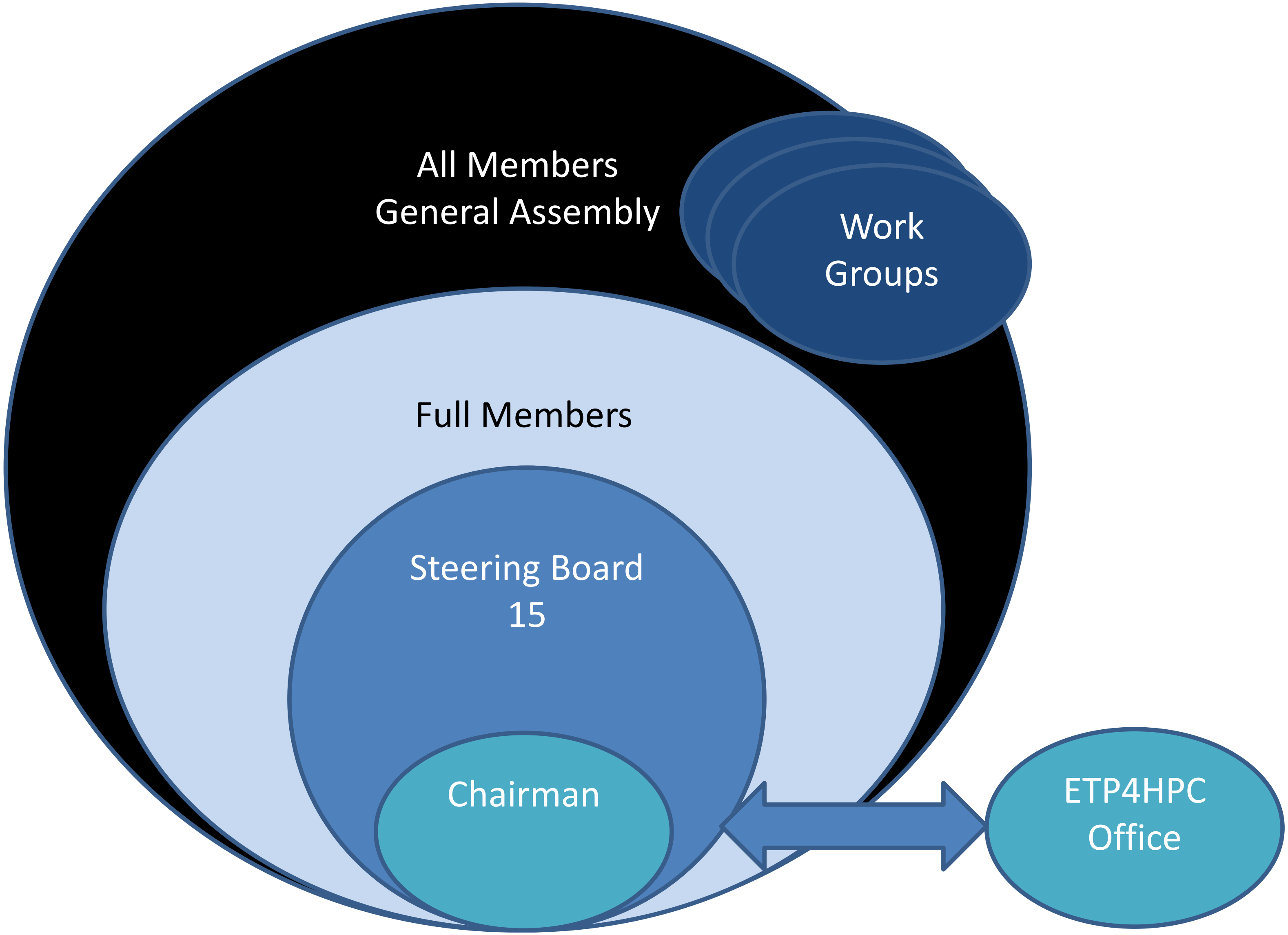
The Main **Objective** of ETP4HPC

"To build a globally competitive European world-class HPC technology value chain"

ETP4HPC members

- **71** organizations involved in HPC technology research based in Europe:
  – 36 companies (22 SMEs)
  – 31 RTOs + 2 others

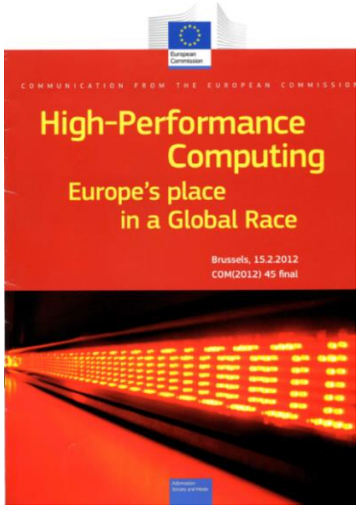
- Full members : 48


All Members
General Assembly
Work
Groups
Full Members
Steering Board
15
Chairman
ETP4HPC
Office

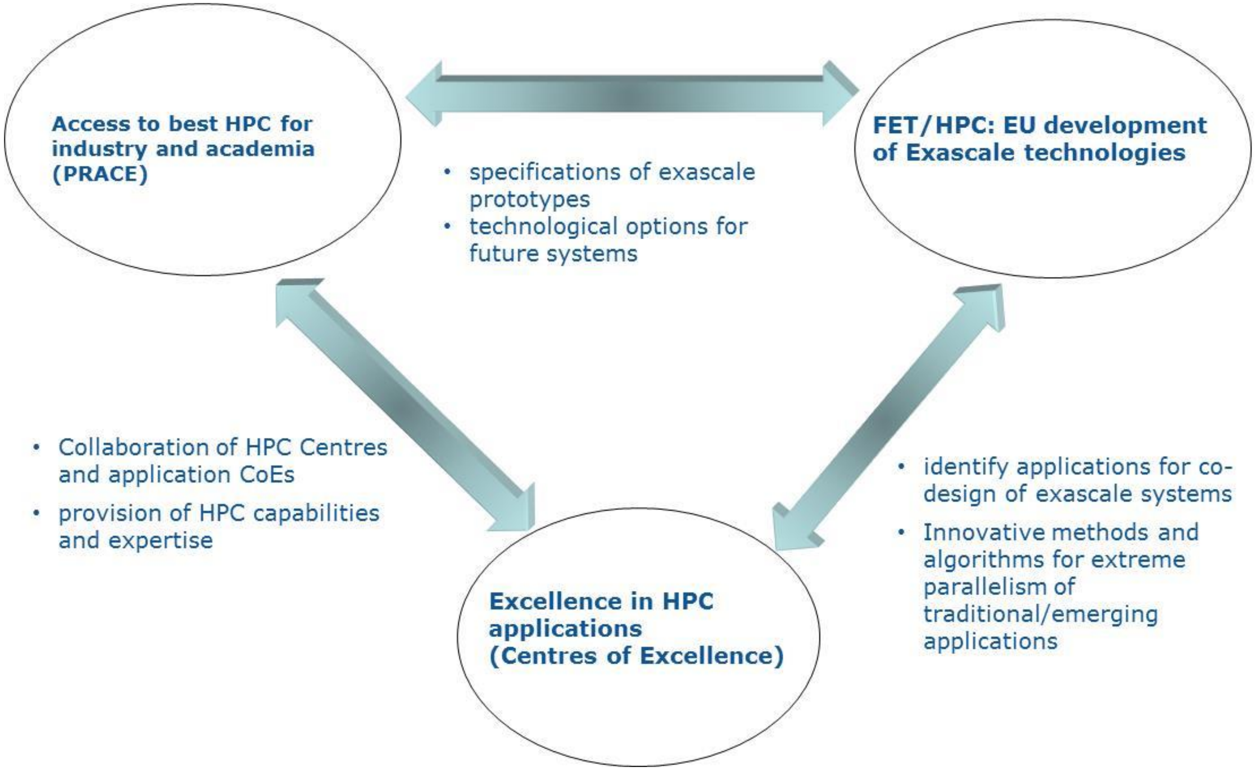
A bit of history

- 2004: first attempts at designing and building a **European HPC Research Infrastructure** (HPCEUR, HET), which resulted in the creation of PRACE in 2010
- 2010: meetings of experts representing EC and European stakeholders to define **a global policy**
- 2011: the creation of ETP4HPC
- Actions in FP7
  - PRACE Preparatory Phase and first Integrated Projects
  - Supports action : EESI and EESI2
  - Calls for Exascale computing in WP2011 and WP2013

The EC Communication



- High-Performance Computing: Europe's place in a Global Race issued in Feb 2012
- Policy based on 3 pillars



The HPC Public Private Partnership

- Mutual commitment
  - European Commission
    - HPC as a priority in Horizon2020
    - Funding of 700 M€
  - ETP4HPC
    - Investment to match EC funding in R&D
    - Effort to maximise impact on European industry
- Partnership board
  - strategy setting
  - impact monitoring

EUROPEAN COMMISSION

PRESS RELEASE

Brussels, 17 December 2013

EU industrial leadership gets boost through eight new research partnerships

The European Commission today launched eight contractual Public Private Partnerships (cPPPs) of strategic importance for European industry. The partnerships will leverage more than €6 billion of investments to be allocated through calls for proposals under Horizon 2020, the new EU programme for research and innovation. Each euro of public funding is expected to trigger additional investments of between three and 10 euro to develop new technologies, products and services which will give European industry a leading position on world markets (MEMO/13/1159).

European Commissioner for Research, Innovation and Science Máire Geoghegan-Quinn said: *"Europe needs industry to innovate to create income and jobs. New technologies and products, such as green cars, energy efficient buildings and cleaner manufacturing processes, are essential to address societal challenges such as climate change, energy and resource efficiency. We want these contractual PPPs to have a substantial impact on the competitiveness of the EU industry, on sustainable economic growth and the creation of new high-skilled jobs in Europe."*

Vice President Neelie Kroes, Commissioner responsible for the Digital Agenda, said: *"This is a great opportunity for Europe. These PPPs will maintain our global lead in robotics, photonics, high performance computing, telecoms and give us a head start in smart cities, intelligent transport, education, entertainment, media and other promising markets. Combined with a comprehensive industrial strategy, the PPPs will ensure vigorous European leadership and a better future for all."*

The eight contractual Public-Private Partnerships are:

- **Factories of the Future (FoF)**, to support the manufacturing industry through the development of sustainable production technologies and systems (Link to factsheet)
- **Energy-efficient Buildings (EeB)**, to increase the competitiveness and energy efficiency of the construction industry (Link to factsheet)
- **European Green Vehicles Initiative (EGVI)**, to develop a competitive and resource efficient transport system with significantly less CO2 emissions (Link to factsheet)
- **Sustainable Process Industry (SPIRE)**, to make the process industry more resource- and energy-efficient (Link to factsheet)
- **Photonics**, one of the key enabling technologies for our future prosperity and an essential element of many sectors, from energy and health, to everyday products like DVD players and mobile phones (Link to factsheet)
- **Robotics**, a key driver of industrial competitiveness and essential to address key societal challenges in areas such as demographic change, health and well-being, food production, transport and security (Link to factsheet)
- **High Performance Computing (HPC)**, which plays a pivotal role in stimulating Europe's economic growth and advancing European science (Link to factsheet)
- **Advanced 5G networks for the Future Internet (5G)**, to stimulate the development of network internet infrastructure to ensure advanced ICT services for all sectors and users (Link to factsheet)

The contracts setting up the PPPs were signed today by the Commission and chairpersons of specially-created industrial research and innovation associations, representing more than 1,000 large and small enterprises across Europe.

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Support actions

- EESI and EESI2
  - run by European experts from 2008 to 2015
  - important recommendations covering technology, applications, algorithms
  - http://www.eesi-project.eu/
- EXDCI
  - managed by PRACE and ETP4HPC
  - started in Sept 2015
  - supporting:
    - roadmap : technical (SRA), scientific cases
    - cross cutting topics : technical topics, training, SMEs
    - international cooperation
    - monitoring

European
Extreme Data
& Computing
Initiative

The Horizon 2020 HPC projects

- First call of Horizon2020
  - 19 research projects and 2 support actions
  - Most projects started in Sept-Oct 2015 for 3 years
  - Total effort : 94 M€ for R&D projects
- Summary:
  - 170 organisations involved in this effort
  - Project distribution
    - 9 HPC core technologies and architectures
    - 5 Programming methodologies, environments, languages and tools
    - 0 APIs and system software
    - 5 New mathematical and algorithmic approaches

15,7%	industry
0,2%	non EU
68,9%	research
15,3%	SME

More in progress

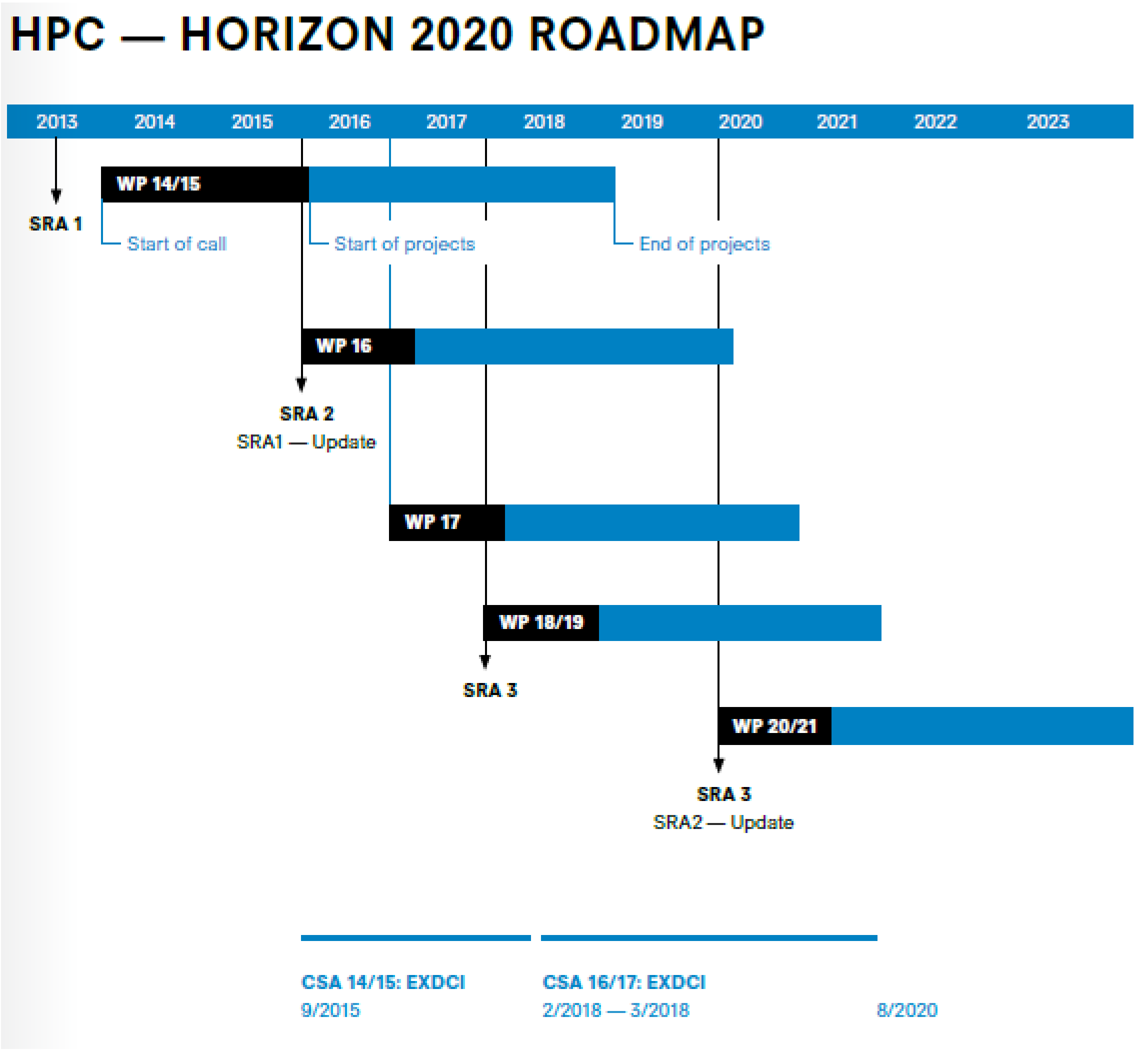
- 2 calls in Work Programme 2016-2017
  - FET HPC 1 2016 : Co-design of HPC systems and applications
    - budget : 41 M€ - deadline : 27 September 2016
  - FET HPC 2 2017 : Transition to Exascale Computing
    - 5 subtopics :
      - High productivity programming environments for exascale
      - Exascale system software and management
      - Exascale I/O and storage in the presence of multiple tiers of data storage
      - Supercomputing for Extreme Data and emerging HPC use modes
      - Mathematics and algorithms for extreme scale HPC systems and applications working with extreme data
    - budget : 40 M€ - deadline : 26 September 2017
- On-going discussion on additional Horizon2020 programme
- New HPC initiative by the European Commission

Strategic Research Agenda

SRA

a multi-annual roadmap towards
Exascale High-Performance Computing Capabilities

Horizon 2020 WP and SRA



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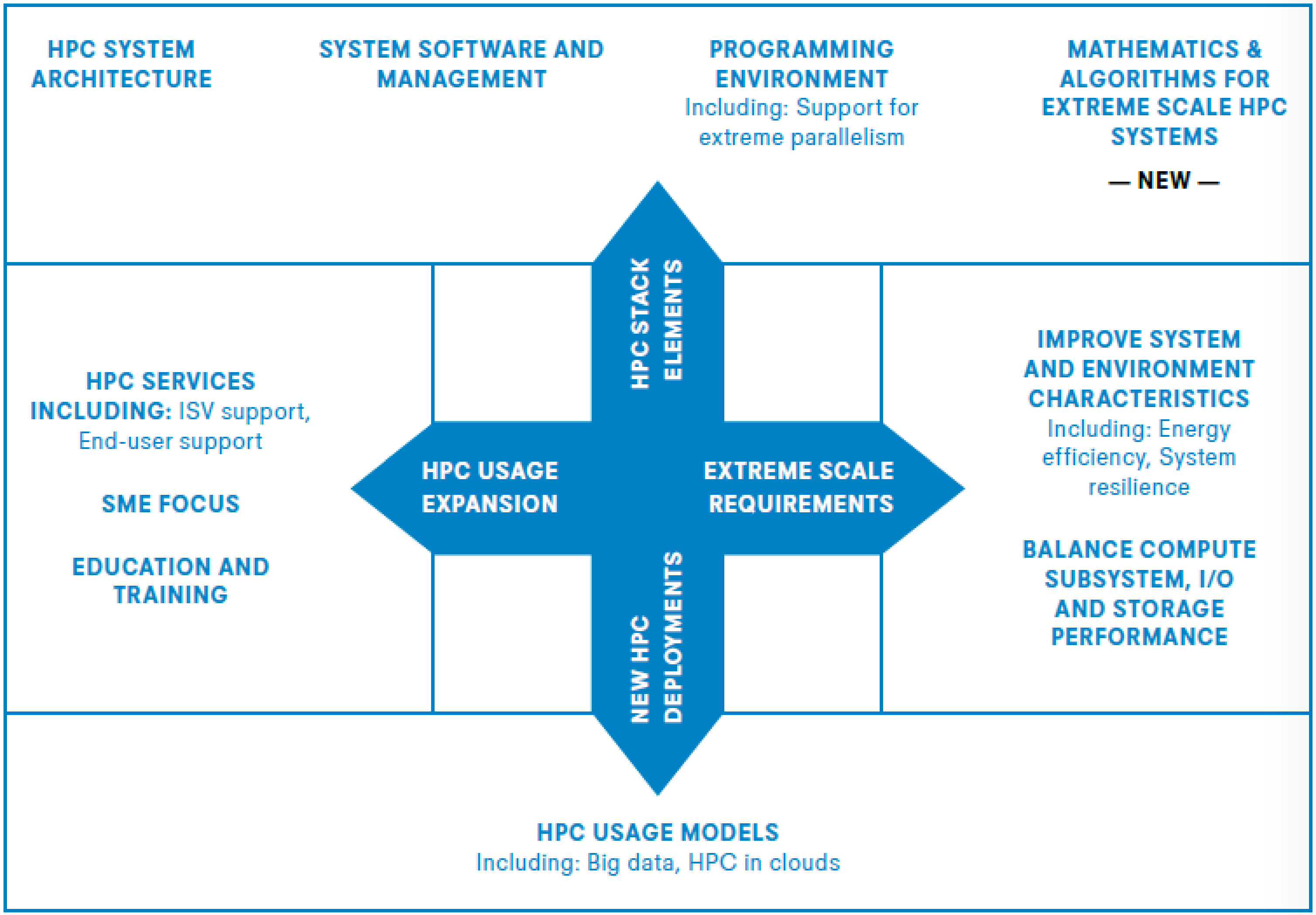
Priorities

- There is a demand for R&D and innovation in both extreme performance systems and mid-range HPC systems
  - Scientific domain and some industrial users want extreme scale
  - ISVs and part of the industry expect more usability and affordability of mid-range system
- The ETP4HPC HPC technology providers are also convinced that to build a sustainable ecosystem,
  - their R&D investments should target not only the exascale objective (too narrow a market)
  - an approach that aims at developing technologies capable of serving both the extreme-scale requirements and mid-market needs can be successful in strengthening Europe's position.

4 dimensions of the SRA



Transversal issues to be addressed

- Three technical topics:
  - Security in HPC infrastructures to support increasing deployment of HPDA
  - Resource virtualisation to increase flexibility and robustness
  - HPC in clouds to facilitate ease of access

- Two key element for HPC expansion
  - Usability at growing scale and complexity
  - Affordability (focus on TCO)

How was the SRA been built?

8 Workgroups covering the 8 technical focus areas:

SRA 2015 technical focus areas

- HPC System Architecture and Components
- Energy and Resiliency
- Programming Environment
- System Software and Management
- Big Data and HPC usage Models
- Balance Compute, I/O and Storage Performance
- Mathematics and algorithms for extreme scale HPC systems
- Extreme scale demonstrators

- 48 ETP4HPC member orgs/companies involved in these workgroups
- Members named 170 individual experts to contribute, 20-30 per working group

Other interactions

- Feedback sessions with end-users and ISVs at Teratec Forum
  - 20 end-users outline their deployment of HPC, future plans and technical recommendations
  - Very diverse set of priorities (performance &scale, robustness, ease of access, new workflows etc.)
  - No 'One size fits all' – approach possible
- Technical session with Big Data Value Association (BDVA) to understand architectural influences of HPDA
  - Technical dialogue started, much more to be done over next 1-2 years
  - BDVA will issue update to their SRIA in Jan 2016

The overall goals of the proposed research

- Exascale and extreme scale
- Ease-of-use
- Efficiency
  - energy
  - more globally TCO
- enabling both extreme data and extreme computing
- broadening of HPC use

The technical domains and the ESD proposal

Trends and recommended research topics – a few examples

HPC System Architecture, Storage and I/O, Energy and Resiliency

- ## Major trends - a subset:
  - Increased use of accelerators (e.g. GPUs, many core CPUs) in heterogeneous system architectures
  - Compute node architectures efficiently integrate accelerators, CPUs with high bandwidth memory
  - Non volatile memory types open up new interesting memory and caching hierarchy designs
  - System networks to significantly scale up and cut latencies, introducing virtualisation mechanisms
  - Storage subsystems to become more ‘intelligent’ to better balance compute and I/O
  - Increased activities in object storage technologies with major architectural revamp in the next years
  - Focus on architectural changes to improve energy efficiency and reduce data movement

- ## Research topics to be addressed (examples)
  - Compute node deep integration with embedded fast memory and memory coherent interfaces
  - Silicon photonics and photonic switching in HPC system networks
  - Global energy efficiency increases with targets of 60kW/PFlops in 2018 and 35 kW in 2020
  - Active storage technologies to enable ‘in situ’ and ‘on the fly’ data processing
  - Research in methods to manage ‘energy to solution’
  - Prediction of failures and fault prediction algorithms

HPC System Architecture, Storage and I/O: milestones

M-ARCH-1: New HPC processing units enable wide-range of HPC applications.	2018
M-ARCH-2: Faster memory integrated with HPC processors.	2018
M-ARCH-3: New compute nodes and storage architecture use NVRAM.	2017
M-ARCH-4: Faster network components with 2x signalling rate (rel. to 2015) and lower latency available.	2018
M-ARCH-5: HPC networks efficiency improved.	2018
M-ARCH-6: New programming languages support in place.	2018
M-ARCH-7: Exascale system energy efficiency goals (35kW/PFlops in 2020 or 20 kW/Pflops in 2023) reached.	2020-2023
M-ARCH-8: Virtualisation at all levels of HPC systems.	2018
M-ARCH-10: New components / disruptive architectures for HPC available.	2019

M-BIO-1: Tightly coupled Storage Class Memory IO systems demo.	2017
M-BIO-2: Common I/O system simulation framework established.	2017
M-BIO-3: Multi-tiered heterogeneous storage system demo.	2018
M-BIO-4: Advanced IO API released: optimised for multi-tier IO and object storage.	2018
M-BIO-5: Big Data analytics tools developed for HPC use.	2018
M-BIO-6: 'Active Storage' capability demonstrated.	2018
M-BIO-7: I/O quality-of-Service capability.	2019
M-BIO-8: Extreme scale multi-tier data management tools available.	2019
M-BIO-9:Meta-Data + Quality of Service exascale file i/o demo.	2020
M-BIO-10: IO system resiliency proven for exascale capable systems.	2021

Energy and resiliency: milestones

M-ENR-MS-1: Quantification of computational advance and energy spent on it.	2017
M-ENR-MS-2: Methods to steer the energy spent.	2017
M-ENR-MS-3: Use of idle time to increase efficiency.	2018
M-ENR-AR-4: New levels of memory hierarchy to increase resiliency of computation.	2017
M-ENR-FT-5: Collection and Analysis of statistics related to failures.	2018
M-ENR-FT-6: Prediction of failures and fault prediction algorithms.	2019

M-ENR-FT-10: Application survival on unreliable hardware.	2019
M-ENR-AR-7: Quantification of savings from trade between energy and accuracy.	2018
M-ENR-AR-8: Power efficient numerical libraries.	2019
M-ENR-MS-9: Demonstration of a sizable HPC installation with explicit efficiency targets.	2019

System Software and Management, Programming Environment

- Major trends – a subset:
  - New node architectures demand innovative methods to solve scalability and concurrency issues
  - Network virtualisation and data security become critical system level challenges
  - Support for increasing use of ‘in situ’ data processing
  - Driven by HPDA, resource management needs to cope with highest levels of data allocation flexibility
  - Increased intelligence throughout the programming workflow
  - Productivity enhancements through use of domain specific languages (DSLs)
  - Interoperability and composability of programming models provide more flexibility to appl. developer

- Research topics to be addressed (examples)
  - Efficient OS support for heterogeneous architectures with complex memory hierarchies
  - Congestion control and adaptive /dynamic routing algorithms for exascale interconnects
  - Research on data-aware scheduling and resource management
  - Programming tool intelligence based on cost models for e.g. energy used, load-balancing, etc.
  - Programming models to allow for malleability (ability to adapt to changing resource availabilityy)

System Software and Management: milestones

M-SYS-OS-1: Kernel scheduling policy.	2016
M-SYS-OS-2: OS Low level standard API with run-time.	2017
M-SYS-OS-3: New memory management policy and libraries.	2017
M-SYS-OS-4: Container and virtualisation support; Hypervisor for HPC.	2016
M-SYS-OS-5: Offload programming model support.	2017-2019
M-SYS-OS-6: OS decomposition to add application performance and flexibility.	2019
M-SYS-OS-7: Investigate HPC specific security requirements on OS level.	2017-2019
M-SYS-IC-1: OS-bypass and hardware interface integrity protection.	2016
M-SYS-IC-2: Interconnect adaptive and dynamic routing algorithm and congestion control, power management.	2017
M-SYS-IC-3: Network virtualisation compliancy.	2017

M-SYS-CL-1: Flexible execution context configuration and management (from image to containers).	2018
M-SYS-CL-2: Prescriptive maintenance based on Big Data analytics technics.	2016
M-SYS-CL-3: Infrastructure security.	2017-2020
M-SYS-RM-1: New Scalable scheduling enhancement, with execution environment and data provisioning integration.	2017
M-SYS-RM-2: New multi-criteria adaptive algorithms: Heterogeneity-/memory- and locality-aware.	2017
M-SYS-RM-3: Resilient framework.	2020
M-SYS-Vis-1: Scalable “in situ” visualisation.	2016
M-SYS-Vis-2: Scaling for the compositing phase.	2017
M-SYS-Vis-3: Ray-tracing capabilities.	2018
M-SYS-Vis-4: High dimensional data, graphs and other complex data topologies.	2018

Programming Environment: milestones

M-PROG-API-1: Develop benchmarks and mini-apps for new programming models/languages.	2016
M-PROG-API-2: APIs and annotations for legacy codes.	2017
M-PROG-API-3: Advancement of MPI+X approaches (beyond current realisations).	2017
M-PROG-API-4: APIs for auto-tuning performance or energy.	2017
M-PROG-API-5: Domain-specific languages (specific languages and development frameworks).	2018
M-PROG-API-6: Efficient and standard implementation of PGAS.	2018
M-PROG-API-7: Non-conventional parallel programming approaches (i.e. not MPI, not OpenMP / pthread / PGAS - but targeting asynchronous models, data flow, functional programming, model based).	2019
M-PROG-LIB-1: Self- / auto-tuning libraries and components.	2018
M-PROG-LIB-2: Components / library interoperability APIs.	2017
M-PROG-LIB-3: Templates / skeleton / component based approaches and languages.	2019
M-PROG-RT-1: Run-time and compiler support for auto-tuning and self-adapting systems.	2018
M-PROG-RT-2: Management and monitoring of run-time systems in dynamic environments.	2018

M-PROG-RT-3: Run-time support for communication optimisation and data placement: data locality management, caching, and prefetching.	2019
M-PROG-RT-4: Enhanced interaction between run-time and OS or VM monitor (w.r.t. current practice).	2018
M-PROG-RT-5: Scalable scheduling of million-way multi-threading.	2020
M-PROG-DC-1: Data race condition detection tools with user-support for problem resolution.	2017
M-PROG-DC-2: Debugger tool performance and overheads (in CPU and memory) optimised to allow scaling of code debugging at peta- and exascale	2018
M-PROG-DC-3: Techniques for automated support for debugging (static, dynamic, hybrid) and anomaly detection, and also, for the checking of programming model assumptions.	2018
M-PROG-DC-4: Co-design of debugging and programming APIs to allow debugging to be presented in the application developers original code, and also, to support applications developed through high-level model descriptions.	2018
M-PROG-PT-1: Scalable trace collection and storage: sampling and folding.	2018
M-PROG-PT-2: Performance tools using programming model abstractions.	2018
M-PROG-PT-4: Performance analytics tools.	2018
M-PROG-PT-5: Performance analytics at extreme scale.	2019

Big Data and HPC Usage Models, Mathematics and Algorithms

- Major trends – a subset:
  - Data analytics, including visualisation increasingly will take place ‘in situ’
  - HPC systems with lots of memory and fast networks become ideal compute infrastructure for Big Data
  - Focus on math and algorithms for exascale system software (compilers, libraries, programming environment)
  - Advances in mathematical methods req. to improve energy efficiency by two orders of magnitude

- Research topics to be addressed (examples)
  - Research on new performance metrics to reflect data-centric use of HPC infrastructure
  - Data centric memory hierarchies and architectures, data structure transformation to enable HPDA
  - Systematic analysis of data flows in key Big Data applications to minimise data access and movement
  - Research on HPC and Big Data hybrids to allow simulation and data analytics at the same time
  - Mathematical support for data placement and data movement minimization
  - Research on the impact of algorithmic and mathematical advances to programming tools
  - Work on new algorithms to reduce energy to solution

Big Data and HPC Usage Models, mathematics and algorithms

M-BDUM-METRICS-1: Data movement aware performance metrics.	2017
M-BDUM-METRICS-2: HPC like performance metrics for Big Data systems.	2017
M-BDUM-METRICS-3: HPC-Big Data combined performance metrics.	2018
M-BDUM-MEM-1: Holistic HPC-Big Data memory models.	2017
M-BDUM-MEM-2: NVM-HPC memory and Big Data coherence protocols and APIs.	2017
M-BDUM-ALGS-1: Berkeley Dwarfs determination for Big Data applications.	2017
M-BDUM-ALGS-2: Implementations of Dwarfs in Big Data platforms.	2019

M-BDUM-PROG-1: Hybrid programming paradigms HPC-Big Data.	2017
M-BDUM-PROG-2: Hybrid programming paradigm with coherent memory and compute unified with Big Data programming environments.	2018
M-BDUM-PROG-3: Single programming paradigm across a hybrid HPC-Big Data system.	2021
M-BDUM-VIRT-1: Elastic HPC deployment.	2018
M-BDUM-VIRT-2: Full virtualisation of HPC usage.	2021
M-BDUM-DIFFUSIVE-1: Big Data - HPC hybrid prototype.	2017
M-BDUM-DIFFUSIVE-2: Big Data - HPC large-scale demonstrator.	2020

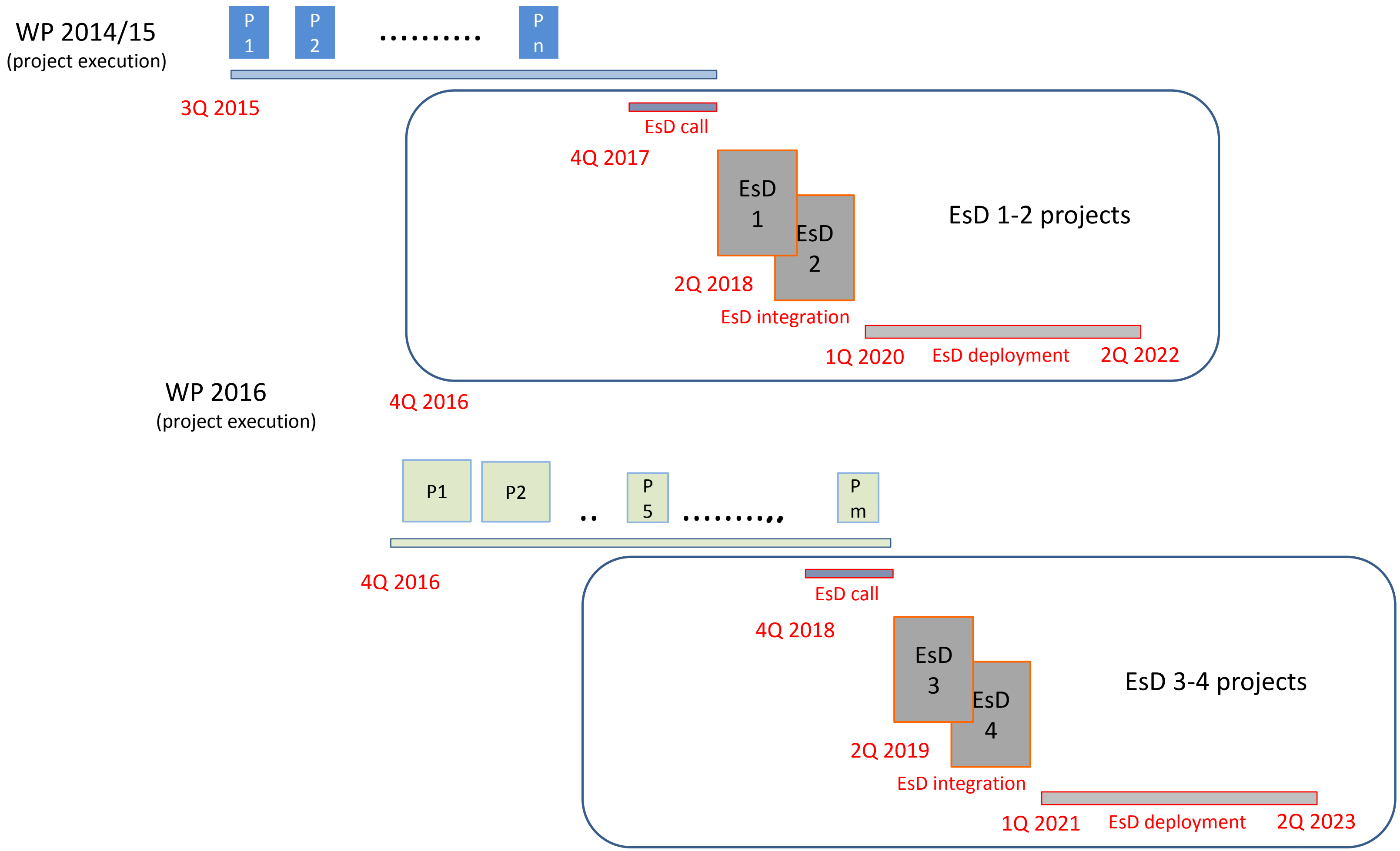
Mathematics and algorithms for extreme scale HPC systems: milestones

M-ALG-1: Scalability of algorithms demonstrated for forward in time computing for current architectures.	2017
M-ALG-2: Multiple relevant use cases demonstrated for improving performance by means of robust, inexact algorithms.	2018
M-ALG-3: Scalable algorithms demonstrated for graph-based analytics.	2019
M-ALG-4: Processes established for co-design of mathematical methods for data analytics and of HPC technologies/architectures.	2019
M-ALG-5: Classes of data, partitioning and scheduling problems categorised and their complexity ascertained.	2019
M-ALG-6: Mathematical and algorithmic approaches established for the scheduling of tasks on abstract resources and exploitation of multiple memory levels.	2020
M-ALG-7: Research on mathematical methods and algorithms exploited for compiler technologies, run-time environments and related tools.	2018
M-ALG-8: Reduction of energy-to-solution demonstrated by means of appropriately optimized algorithms demonstrated for a set of relevant use cases.	2017
M-ALG-9: Process for vertical integration of algorithms established together with the validation of scalability, ease of implementation, tuning and optimisation.	2019

Extreme-Scale Demonstrators

- Characteristics
  - Complete prototype HPC systems
  - high enough TRL to support stable production
  - using technologies developed in the previous projects
  - based on application – system co-design approach
  - large enough to address scalability issues (at least 1/10 of top performance systems)
- Two project phases:
  - phase A : development, integration (of results from R&D projects) and testing
  - phase B : deployment and use, code optimisation, assessment of the new technologies

Extreme scale Demonstrators call-integration-deployment schedule



SRA 2015 – Status

SRA 2015

- Posted on ETP4HPC website 24th Nov 2015 and disseminated via different media
- Public **Call for Comments** on SRA 2 - opened 9th Dec 2015 (http://www.etp4hpc.eu/strategic-research-agenda/) and also LinkedIn, Twitter and EXDCI project
- Next actions
  - 1Q 2016

➢ Facilitate interactions with WP14/15 projects

➢ Interactions with EXDCI WP3 (application development)

➢ next technical workshop with BDVA experts to prepare next SRA 3 updates

  - 3Q 2016

➢ based on feedback received and interactions (workshops): define areas needing updates

➢ prepare for next update cycle, target date 31st July 2017

Google

« Public Call for comments on SRA “

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www.**etp4hpc**.eu/strategic-research-agenda/
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The updated Strategic Research Agenda (SRA) of ETP4HPC is now available at the following location: http://www.**etp4hpc**.eu/strategic-research-agenda/

Public Call for Comments on ETP4HPC Strategic Research ...
primeurmagazine.com/flash/AE-PF-12-15-16.html
2 days ago - **Public Call for Comments** on ETP4HPC Strategic Research Agenda for exascale supercomputing in Europe December 2015. 13 Dec 2015 ...

Primeurflash 20151213 - Primeur Magazine
primeurmagazine.com/contentsflash20151213.html
2 days ago - **Public Call for Comments** on ETP4HPC Strategic Research Agenda for ... Agenda on November 24th 2015, the **ETP4HPC** organisation would ...

ETP4HPC, EXDCI and SESAME Net - new HPC initiatives in ...
e-irg.eu/.../**etp4hpc**-exdci-and-sesame-net-new-hpc-initiatives-in-europe-...
Apr 9, 2015 - The HPC Centres of Excellence **Call** amounts to 14 million euro. ... will require an investment of 15 million euro; the **Public** Procurement of innovative HPC systems has been estimated at 26 million; .... 698 Views, 0 **Comments**.
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Images for etp4hpc public call for comments Report images

Next SRA-related events – some thoughts

- HPC summit/May 2016
  - needs to be focussed primarily on the EsD topic (we need to make some progress here), not so much on the dissemination
  - at this event the three pillars for the EsD mission (CoE, HPC centres and the FETHPC1 project speakers) need to get together...
- ISC16
  - might be a general dissemination and discussion event
  - by then we have some feedback hopefully
  - depending on how much progress we make with BDVA we could set up a few "focussed discussions", e.g. on HPC and HPDA, EsDs, some statistics on the feedback received, news on influences from latest application trends....etc.

Conclusion

Collaboration opportunity

- Some of the challenges are similar
- We will welcome your comments on the current SRA

  http://www.etp4hpc.eu/strategic-research-agenda/
- You can participate in HPC events : HPC Summit, ISC2016
- You are welcome to participate in the expert group for the next version (targeted in 1H2017)

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THANK YOU!

For more information visit

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