- **WE GOT THE BOF - bof101s1 / European Exascale Projects and Their Global Contributions**
- **Tuesday lunch or dinner, Wednesday lunch or dinner, or Thursday lunch.**

- A professional Handbook is being prepared (cost shared EXDCI & ETP4HPC)

- BoF Presentation – a selection of 3-4 projects (out of 15 proposals) will present their tangible contributions. A call for participation to be closed very soon (there is a delay…).

European Extreme Data & Computing Initiative

Trends and design directions – European supercomputing technology

7th September 2017 – Barcelona

EXDCI Final Conference (20min)

EXDCI WP2

Marcin Ostasz

(Michael Malms)

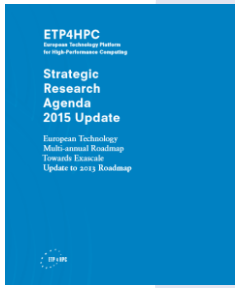
ETP4HPC

ETP 4 HPC – European Technology Platform for High Performance Computing

The EXDCI project has received funding from the European Unions Horizon 2020 research and innovation programmed under the grant agreement No 671558.

What you should know by the end of this presentation:

- The importance of **European HPC technology**
- The role of ETP4HPC's Strategic Research Agenda (**SRA**) (and also the role of ETP4HPC) – and how it fits into the landscape of European HPC
- The process of defining **SRA 3**
- (The **new, potential HPC model** we might use)
- The main priorities included in SRA 3 (input from Working Groups - HOMEWORK)
  - Focal Areas: and 1-**Big Data** and 2-**Extreme-scale Demonstrators** (EsDs)

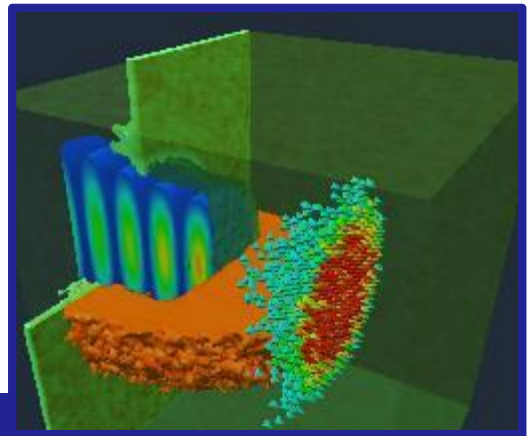


High-Performance Computing (HPC)

An essential tool for Science, Society and Industry

Supercomputers

A strategic driver



Simulations

Data analytics
Big data processing
Machine Learning and AI

Prototyping

Societal Challenges

New Technologies

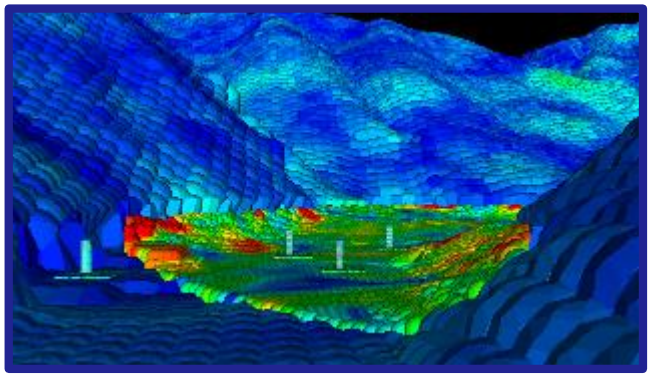
Big Data

Breaking the limits

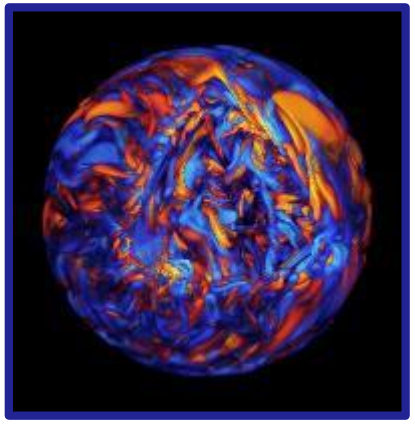
ETP 4 HPC — European Technology Platform for High Performance Computing

HPC : An enabler for all scientific fields
An essential tool for Science, Society and Industry

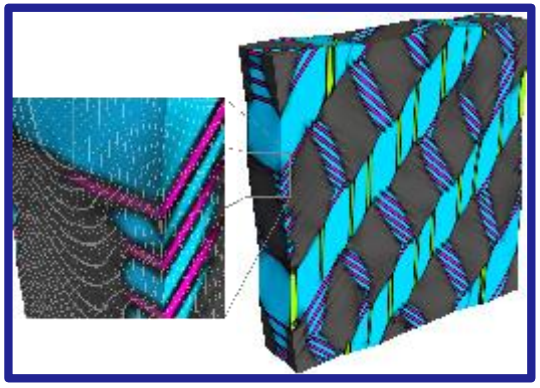
Life Sciences & Medicine



Earth Sciences



Astro, High Energy & Plasma Physics



Materials, Chemistry & Nanoscience

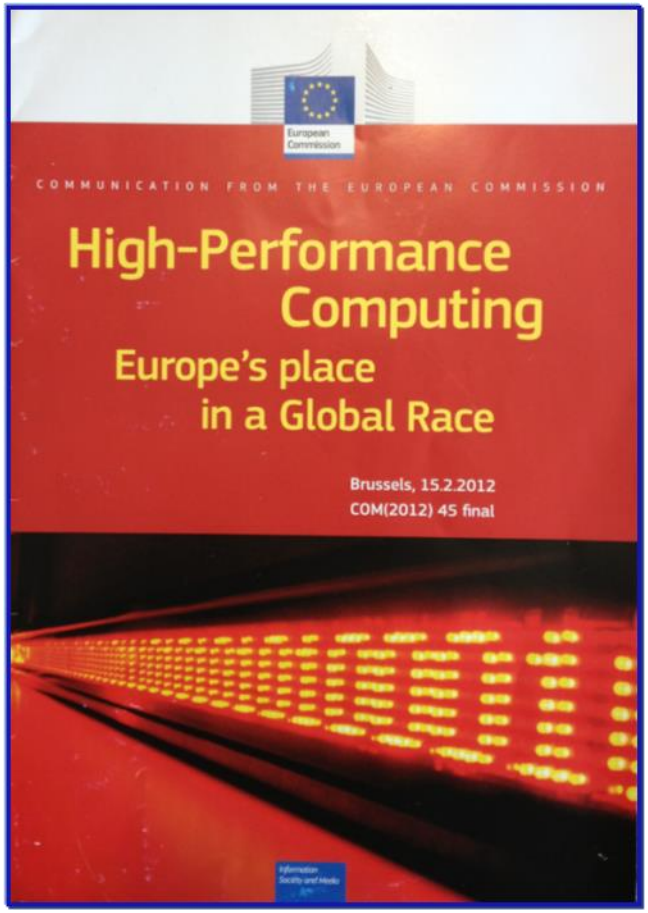
Engineering

- Advances leading to:
  - Improved Healthcare
  - Better Climate Forecasting
  - Superior Materials
  - Sustainable Energy
  - More Competitive Industry
  - …

KEY DOCUMENT:
2012 EC COMMUNICATION

EU needs independent access to HPC technologies, systems and services

=> ETP4HPC created end of 2012 to contribute to this objective



WHY DO WE NEED TO ACT NOW?

EU **consumes** 33% of global HPC resources

But **supplies** less than 5% of them

EUROPEAN HPC TECHNOLOGY MARKET SHARE

The broader European HPC market (servers, storage, software)

Table 4: The Supply Side: European Providers' Share of the Broader European HPC Market (€000)

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	CAGR 16-21
Total Europe HPC Market Revenues	5,459,448	4,769,288	5,006,703	5,117,873	5,302,209	5,557,748	6,081,022	6,470,984	6,901,020	7,398,417	6.9%
European Suppliers' Share of European HPC Market	222,814	209,295	236,079	239,131	259,117	273,225	325,924	538,860	461,109	549,474	16.2%
European Suppliers' % Of European HPC Market	4.1%	4.4%	4.7%	4.7%	4.9%	4.9%	5.4%	8.3%	6.7%	7.4%	8.7%

Source: Hyperion Research 2017

The broader global HPC market (servers, storage, software)

Table 6: The Supply Side: European Providers Share of the Broader Global HPC Market (€000)

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	CAGR 16-21
Global Broader HPC Market	18,629,323	17,992,356	17,822,060	18,596,886	19,094,718	20,244,907	21,266,439	22,548,097	24,458,265	25,987,947	6.4%
European Suppliers' Share of Global Broader Market	227,270	214,527	242,925	246,783	273,132	294,168	362,184	618,057	545,877	671,393	19.7%
Eurpoe Suppliers' % Of Global Broader Market	1.2%	1.2%	1.4%	1.3%	1.4%	1.5%	1.7%	2.7%	2.2%	2.6%	12.6%

Source: Hyperion Research 2017

ETP 4 HPC — EUROPEAN TECHNOLOGY PLATFORM FOR HIGH PERFORMANCE COMPUTING

From: **Final Report on the Impact of the Horizon 2020 HPC Program (draft May 2017 - Hyperion/IDC)**

EUROPEAN HPC ECO-SYSTEM

The contractual Public-Private Partnership covers two pillars of the European HPC eco-system: technology provision and application expertise

EC

EUROPEAN HPC ECO-SYSTEM

HPC Technology Supply Chain

HPC Applications

HPC Research Infrastructure

Tools for industrial simulation & prototyping

The strength of the European HPC Supply Chain (Technologies and applications)

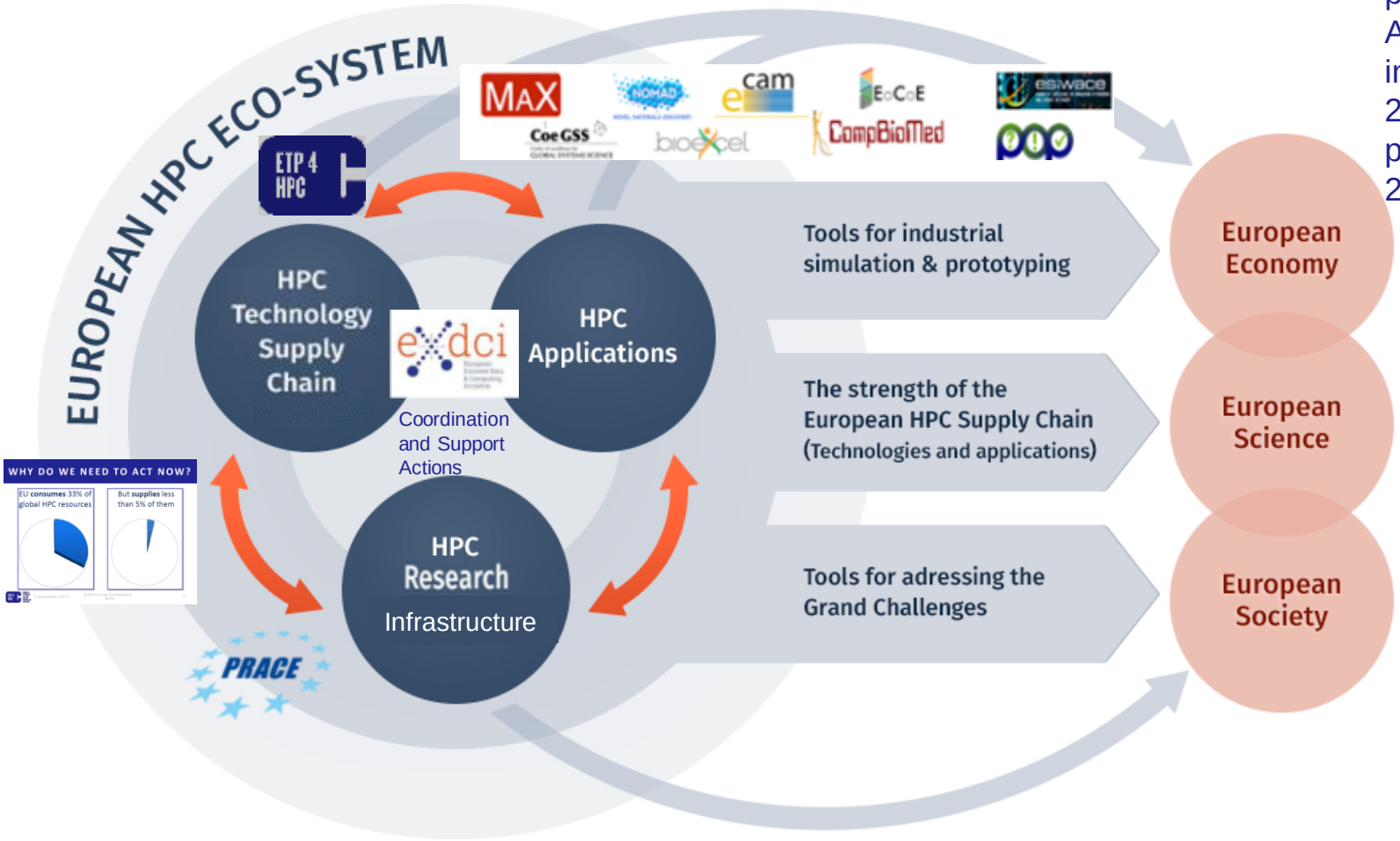
Tools for adressing the Grand Challenges

European Economy

European Science

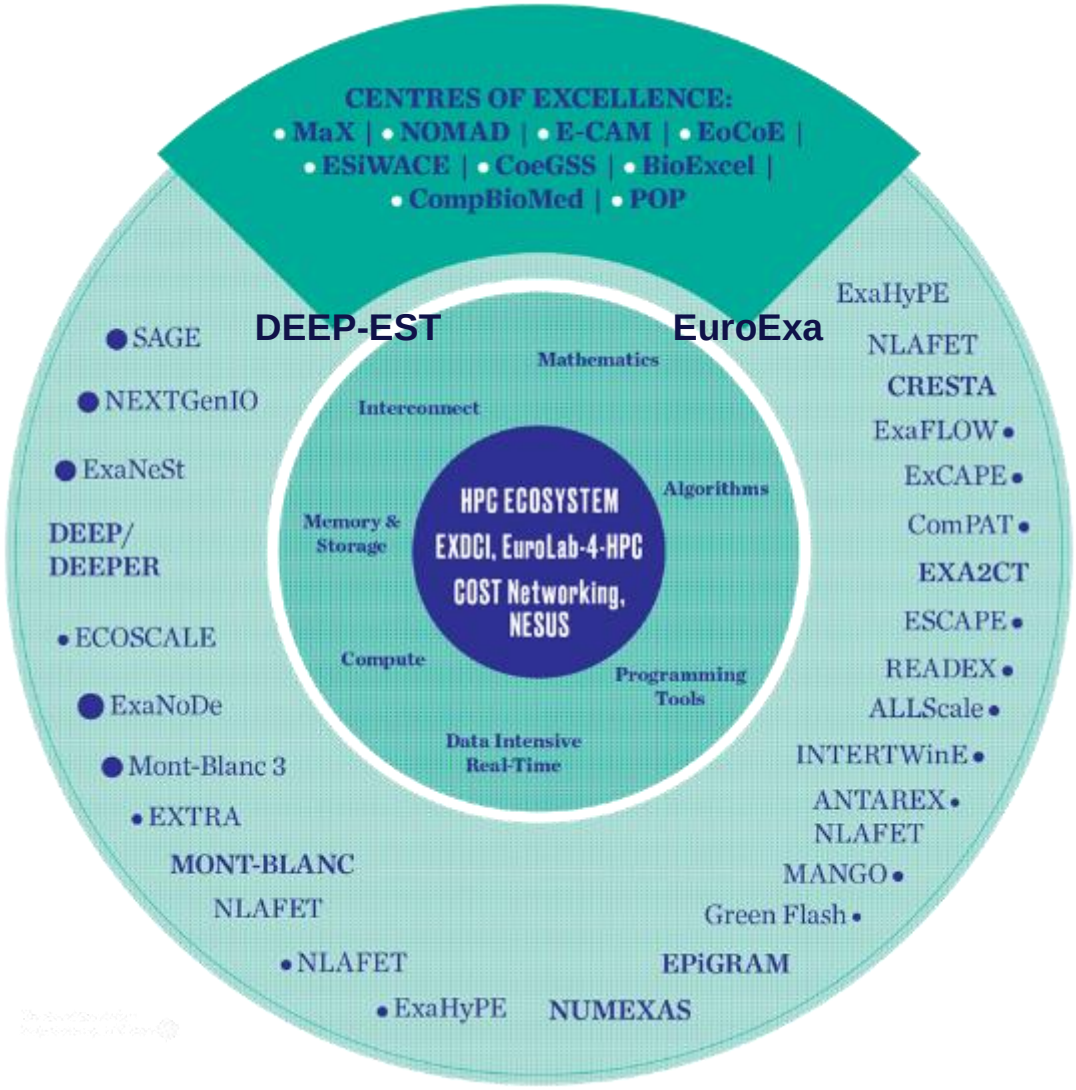
European Society

EUROPEAN HPC ECOSYSTEM



19 FETHPC projects running
And more coming in 2017-2020
2 Co-Design projects starting in 2017

THE CURRENT EUROPEAN HPC TECHNOLOGY LANDSCAPE



EXCELLENCE IN HPC APPLICATIONS (CENTRES OF EXCELLENCE)

- **Material sciences:** Materials design at the eXascale
- **Material sciences:** The Novel Materials Discovery Laboratory
- **Material sciences:** An e-infrastructure for software, training and consultancy in simulation and modelling
- **Energy:** Energy oriented Centre of Excellence for computer applications
- **Climate:** Excellence in Simulation of Weather and Climate in Europe
- **Global Systems Science:** Center of Excellence for Global Systems Science
- **Bioscience:** Centre of Excellence for Biomolecular Research
- **Biomedicine:** A Centre of Excellence in Computational Biomedicine
- **Performance:** Performance Optimisation and Productivity

ETP4HPC EUROPEAN TECHNOLOGY PLATFORM FOR HIGH PERFORMANCE COMPUTING

ETP4HPC - Key Activities

- **Foster growth of HPC technology Research and Development in Europe**
- Advise EC through cPPP
- **Define Strategic Research Agenda (SRA)**
- Propose H2020 Work Program contents
- Monitor ecosystem development

ETP4HPC

Established in 2011

Officially a Dutch Association since December 2012

80 Members
(as of July 2017)

- 53 Full
- 27 Associated

- 40 Private
- 26 SMEs

- 13 Larger companies
- 36 Research organisations

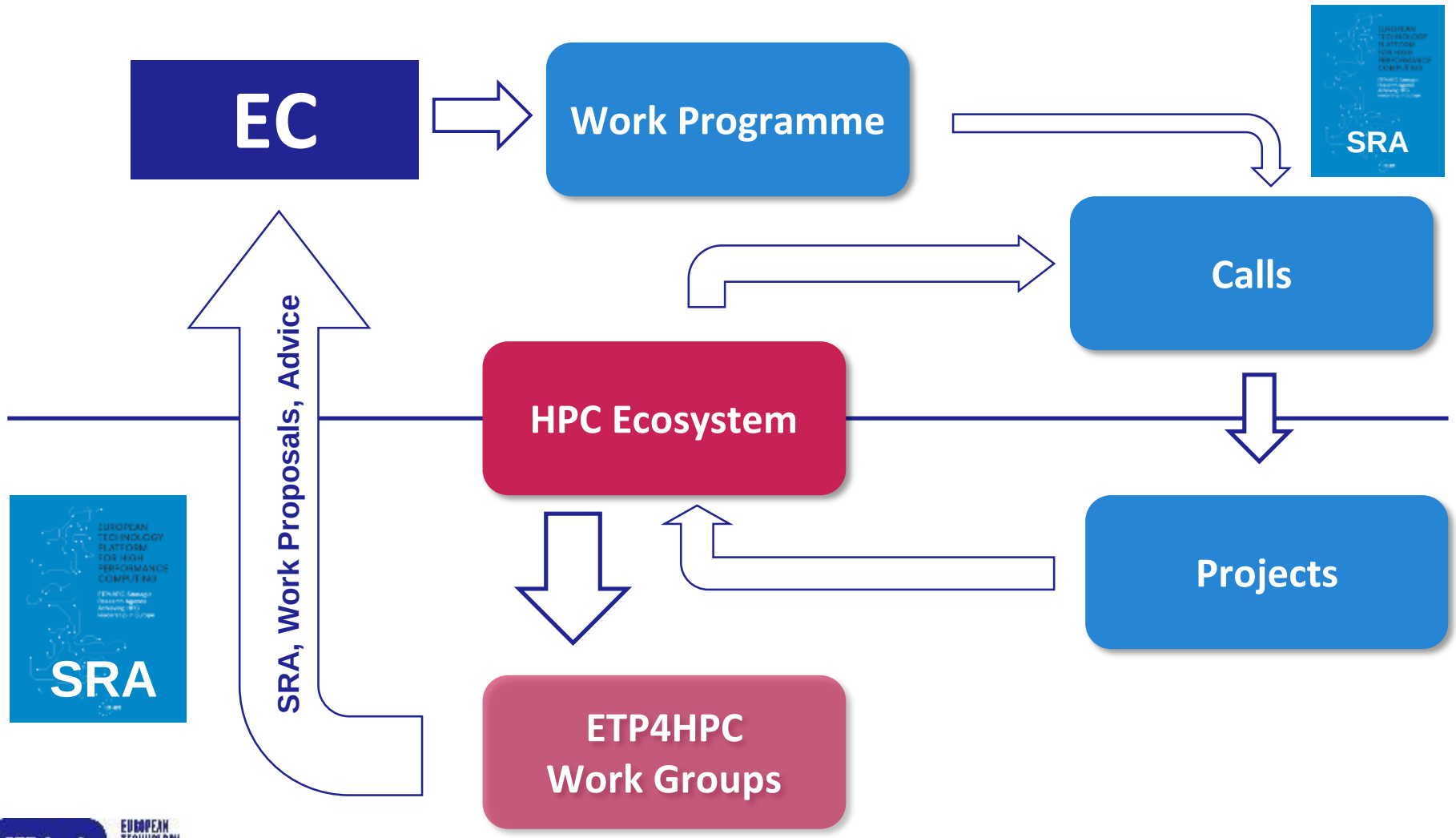
5 new members accepted today!

STRATEGIC RESEARCH AGENDA (SRA)

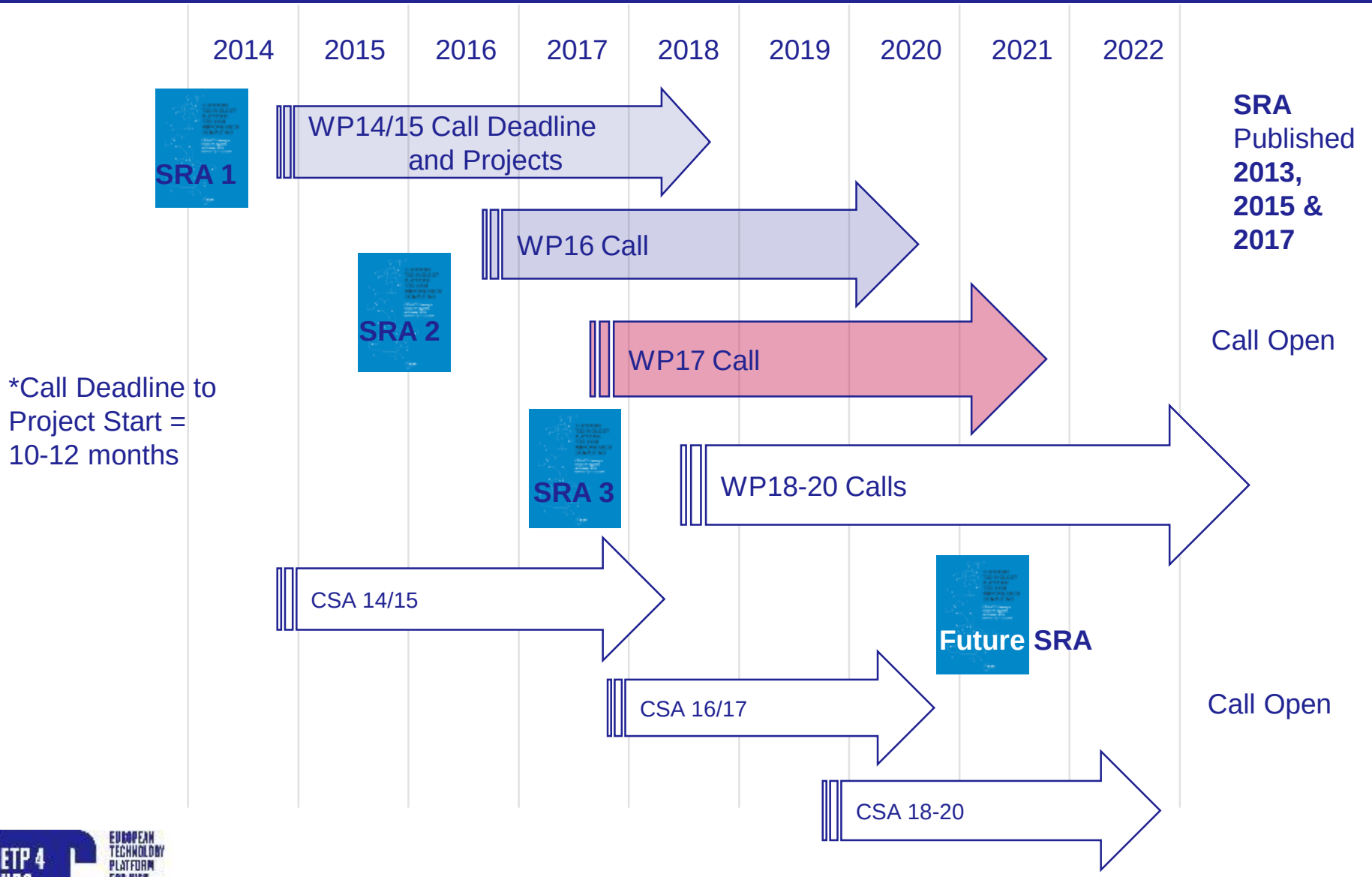
Our Multi-Annual HPC Technology Roadmap

www.etp4hpc.eu/sra

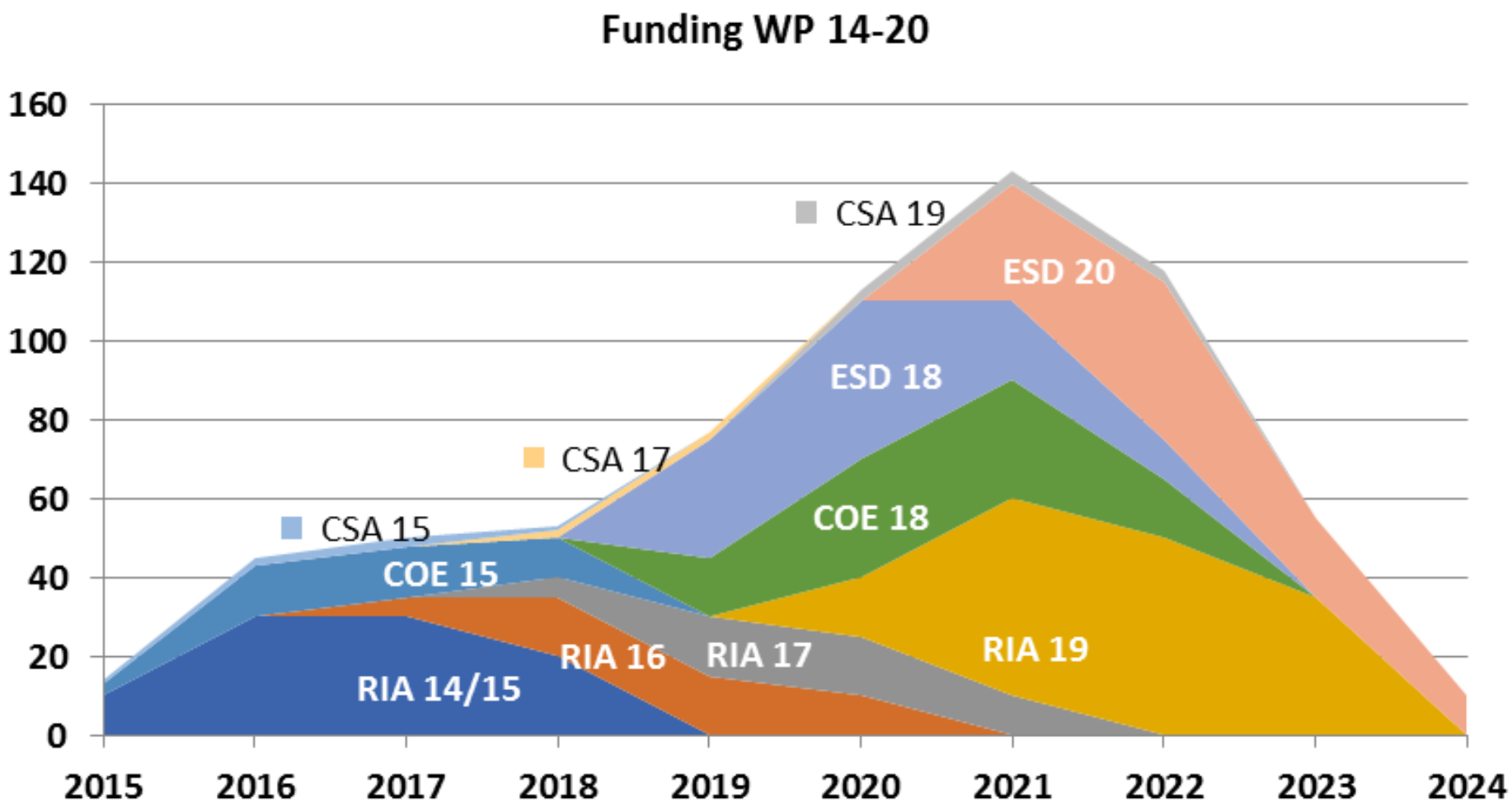
SRA's Role: Research Priorities



SRA in Horizon 2020 Timeline

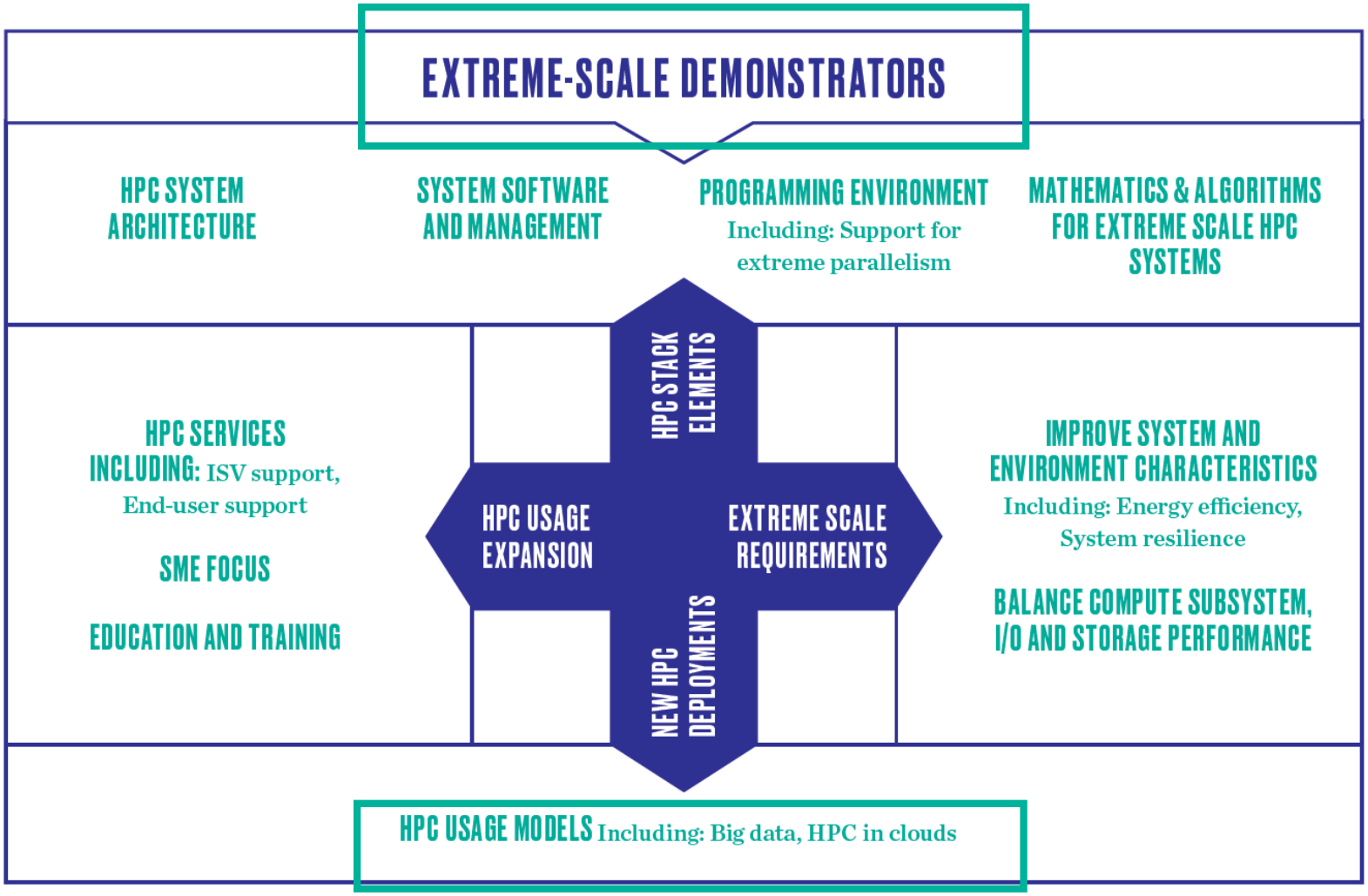


H2020 HPC Work Programme – Duration/Values (Euro Ms)



ETP4HPC Recommendation

MULTI-DIMENSIONAL SRA HPC MODEL



Input related to **Centres of Excellence** (CoEs) **in Computing Applications**

Extreme-scale Demonstrators (EsD) concept in WP18-20

How do we write an SRA?

- 8 topical ETP4HPC Working Groups reflecting the Dimensions: 150 to 200 experts
- Workshops and Conference Calls
- Recognised external sources
- SWOT Analysis to identify general strategy
- Collaboration with PRACE, BDVA, HiPEAC & Eurolab4HPC, Industrial End-Users, ISVs and external experts

The Process of SRA 3

- **March 20th**: Kickoff meeting at IBM IOT center in Munich

  (SRA –workgroup leads, application owners, CoE, HiPeac, BDVA, EUROLAB-4-HPC, BDEC)
- **March 27th**: New SRA working groups in place (based on WP18-20 workgroup participants)
- **April**: Gather input from working groups (questions /recommendations)
- **May 18th**: EsD - Roundtable during HPC summit (Barcelona)

  (FETHPC projects, CoE, HPC centers, system integrators, technology providers)
- **May 19th**: SRA-workgroup leaders' internal meeting (Barcelona)
- **June 22nd**: Workshop at ISC with industrial users ("how to benefit from EsDs?")
- **May-July**: writing, interlock with workgroups
- **July 4th**: Technical Interlock with BDVA
- **July 10th**: Internal workgroup leaders meeting at IBM Rueschlikon; freezing of milestones
- **Aug**: integration of chapters, tuning, review
- **Aug 31st**: completion target/integrated document sent out for end-to-end review till 15 Sept
- **September 15th to 29th** : final tuning and resolution of remaining issues
- **September 30th**: completion target, document ready for review by ETP4HPC steering board

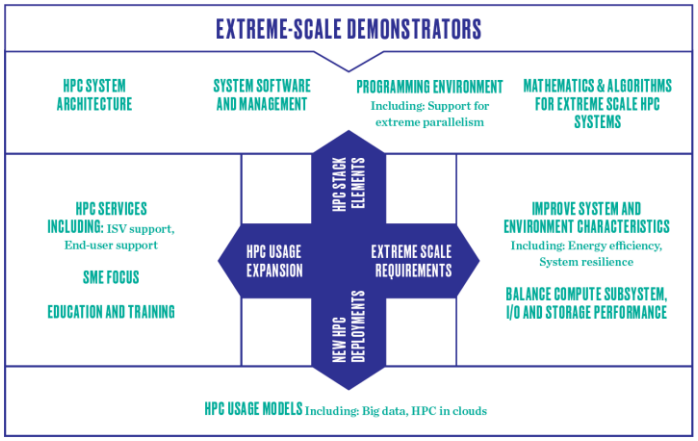
ETP 4 HPC EUROPEAN TECHNOLOGY PLATFORM FOR HIGH PERFORMANCE COMPUTING

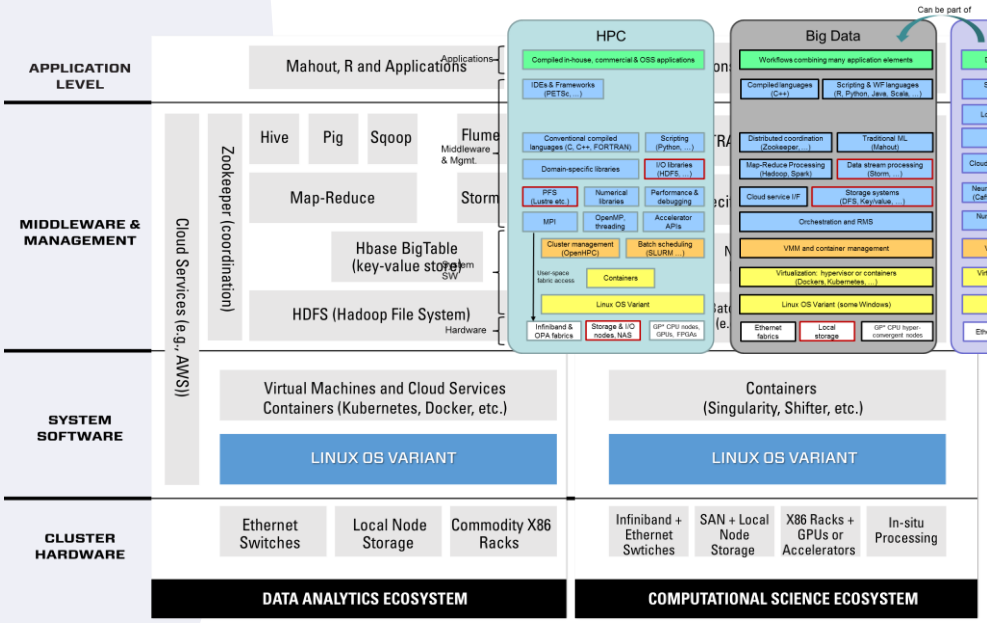
Where is HPC going in the future ?

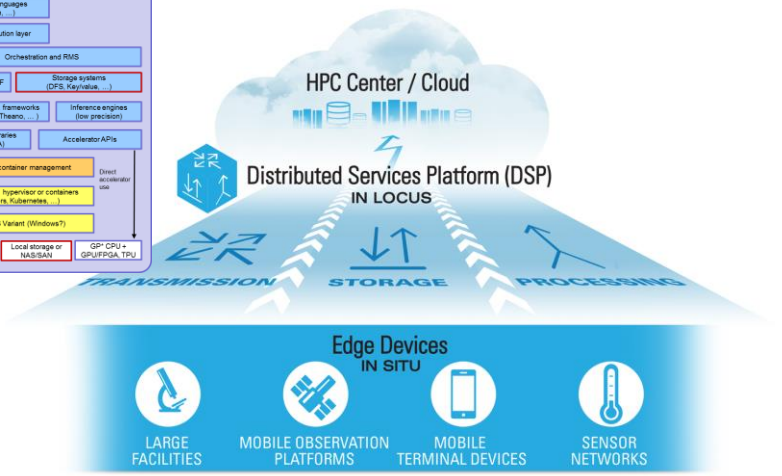
from HiPEAC – Vision 2017 (https://www.hipeac.net/publications/vision)

- **HPC embedded in real-time use scenarios**
- HPC in the **data centre** AND **at the edge** (“fog computing”),
- **Embedded infrastructure** and Internet of Things (**IOT**) will play a big role here
- **Dynamically adapted workflows** (not batch only)
- **High Performance Data Analytics** and **Deep Learning** drive demand for high performance, highly reliable communication

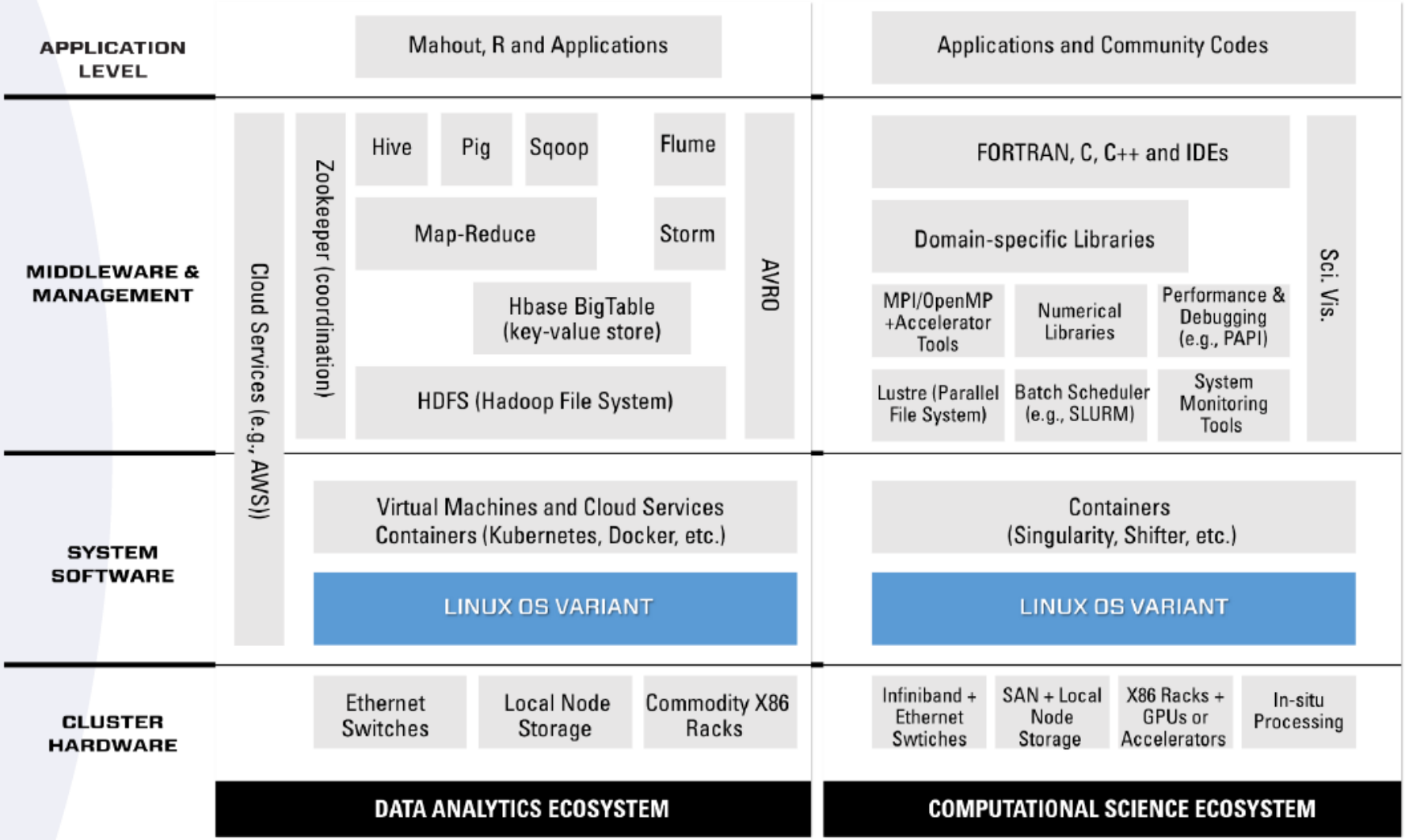
Focal Area 1: Big Data – IT WILL CHANGE OUR MODEL



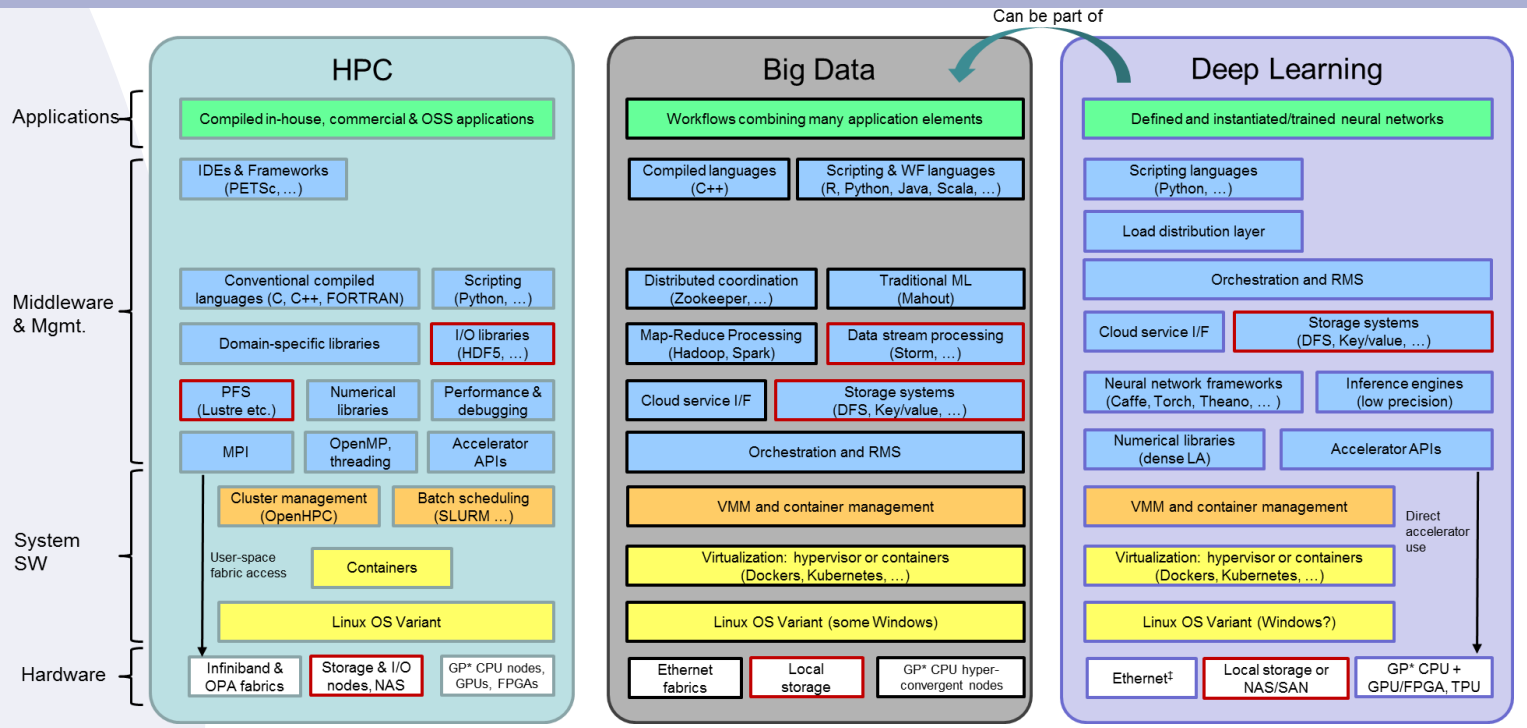




Data Analytics v. Computing



HPC, Big Data and Deep Learning stacks side by side



evolved from BDEC-conference - source

- **HPC** stack grew over past 40 years, with a continuous drive towards extreme performance
- Fast growing **BD**/HPDA market drives compute stack with different priorities for 15 years
- **Deep Learning** yet introduces new elements
- **New use cases** (e.g. **autonomous driving**) drive a growing need to exploit communality between stacks

HPC and Big Data - Trends

- Cross-Pollination between respective BD and HPC platforms can support **scenarios** that require tighter coupling of compute-intensive analytics (BD) and data-driven simulations (HPC) - billions of various smart things will require complex modelling and intensive simulations
- **The massive 'IoT-ization' of almost everything - real-time and complex interactions - There will be 34 billion devices connected to the internet by 2020, up from 10 billion in 2015. IoT devices will account for 24 billion**, while traditional computing devices (e.g. smartphones, tablets, smartwatches, etc.) will comprise 10 billion (http://www.businessinsider.com/jawbone-bet-big-on-fitness-trackers-and-lost-2017-7)
- A very promising example of this is the usage of **Digital Twin** concept - used for improving the design and real-time operation of complex products/systems, e.g. for continuous monitoring and real-time optimization of connected and autonomous cars (380 million connected cars will be on the road by 2021)

How can Big Data benefit from HPC?

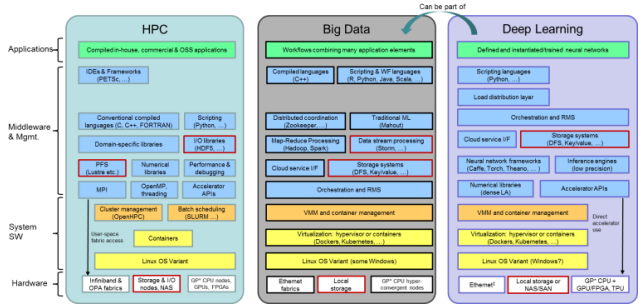
- **HPC capabilities are expected to be of assistance for faster decision making.**
- Big Data applications are expected to move towards more **compute-intensive algorithms for descriptive (data aggregation and mining) and predictive (statistics and forecasting) analysis**. Prescriptive (decision making algorithms) analytics could be integrated with them to provide a feedback loop across the full decision making process.

How can HPC benefit from Big Data?

- **Analytics is expected to become a fully-fledged software component of the HPC ecosystem** to process the massive results of large numerical simulations or to feed numerical models with complex data produced by other scientific tools.
- Iterative refinements of the models used by the HPC simulations could thus be done by benefitting from advanced data analytics tools and machine learning techniques. **HPC can benefit from Big Data Management approaches**, especially in the case of dynamic scenarios (HPC usually has the data close to processing, Big Data is much more flexible with the notions of data at rest, data on move, data in change).

Conclusion: Future roadmapping directions - guidelines

- **HPC, Big Data and fast growing world of the "Internet of Things" (IOT) cannot be seen as three separate silos.**
- While each of the domains will keep having is own focus areas and priorities in the future, the **interdependence** is very explicit, e.g.:
  - **Autonomous driving,**
  - **Square Kilometre Array Project**
  - **Energy management**

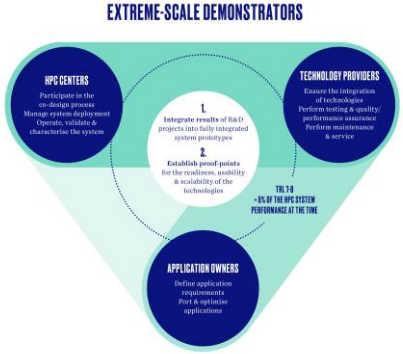


- Future **roadmapping** efforts will need to be carried out in a much **closer cooperation** among private/public bodies covering the domains of HPC, Big Data and IoT
- The work performed lately together with BDVA, BDEC and HiPEAC is a start in this direction.

Focal Area 2 – Extreme-Scale Demonstrators

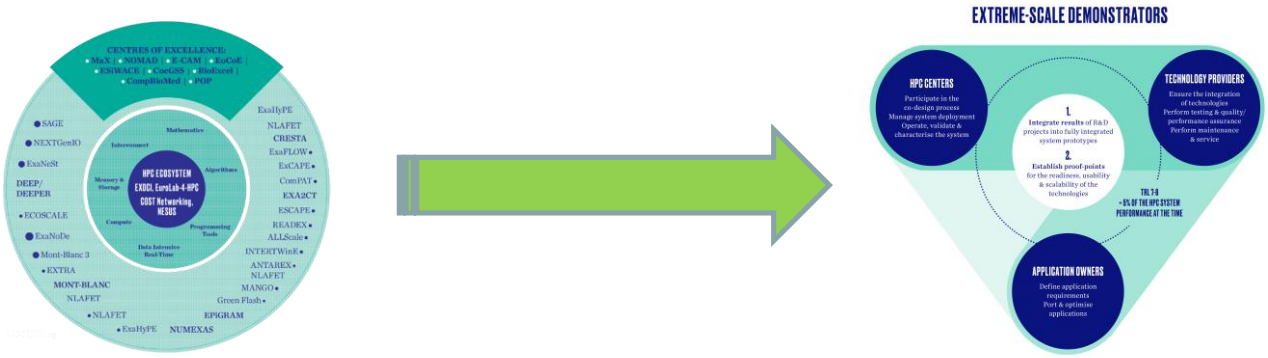
HPC H2020 Programme

integrated HPC system prototypes



"The "Extreme-Scale Demonstrators" (EsDs) are vehicles to **optimise and synergise the effectiveness of the** entire **HPC H2020 Programme** through the integration of isolated R&D outcomes into fully **integrated HPC system prototypes.**" ***(From the ETP4HPC SRA, chapter 8 p.67)***

Focal Area 2 – Extreme-Scale Demonstrators



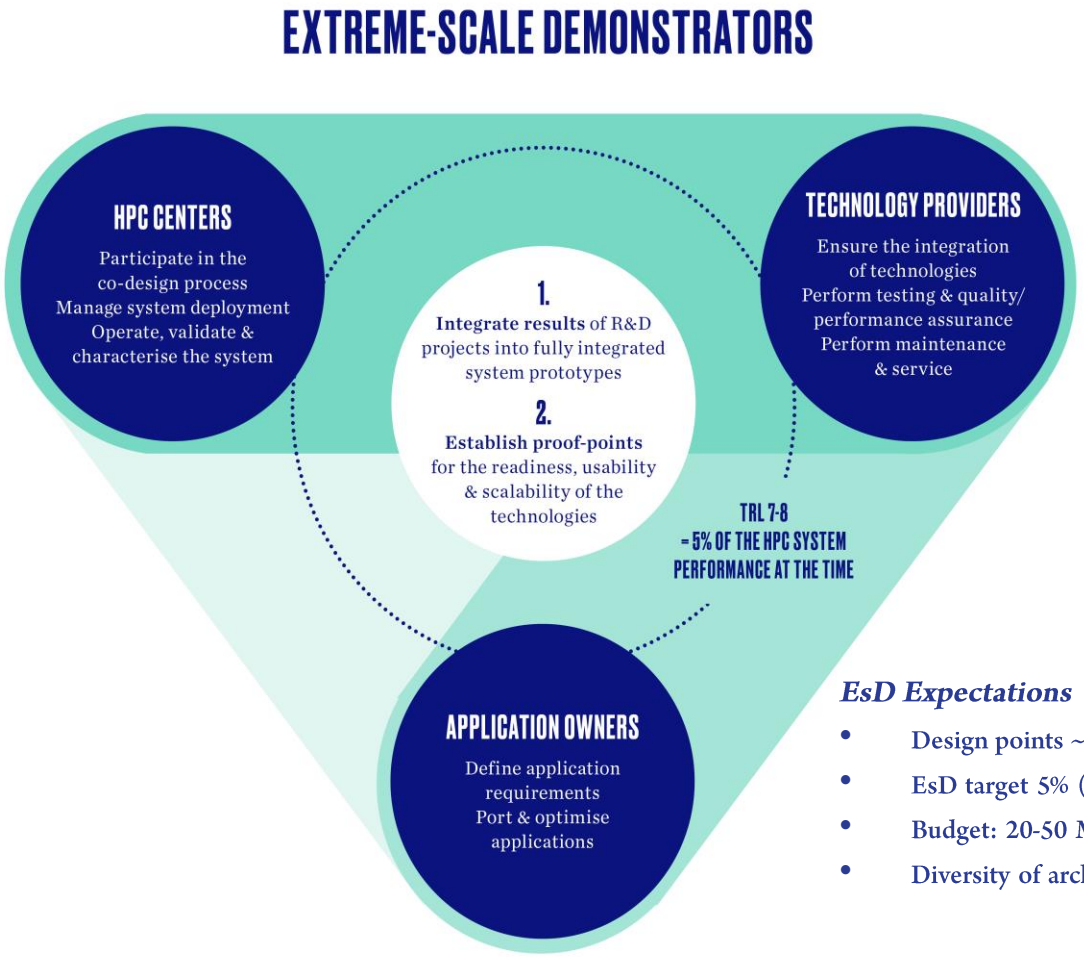
EsD will fill critical gaps in the HPC H2020 programme:

- **Combine results** from targeted R&D efforts into a complete system (European HPC technology ecosystem)
- Bring technologies from FET-HPC closer to **commercialisation (TRL 7-8)**
- Provide the missing link between the **3 HPC pillars**: Technology providers, infrastructure providers, user communities (co-design)

FOCAL AREA 2:

(phase A)

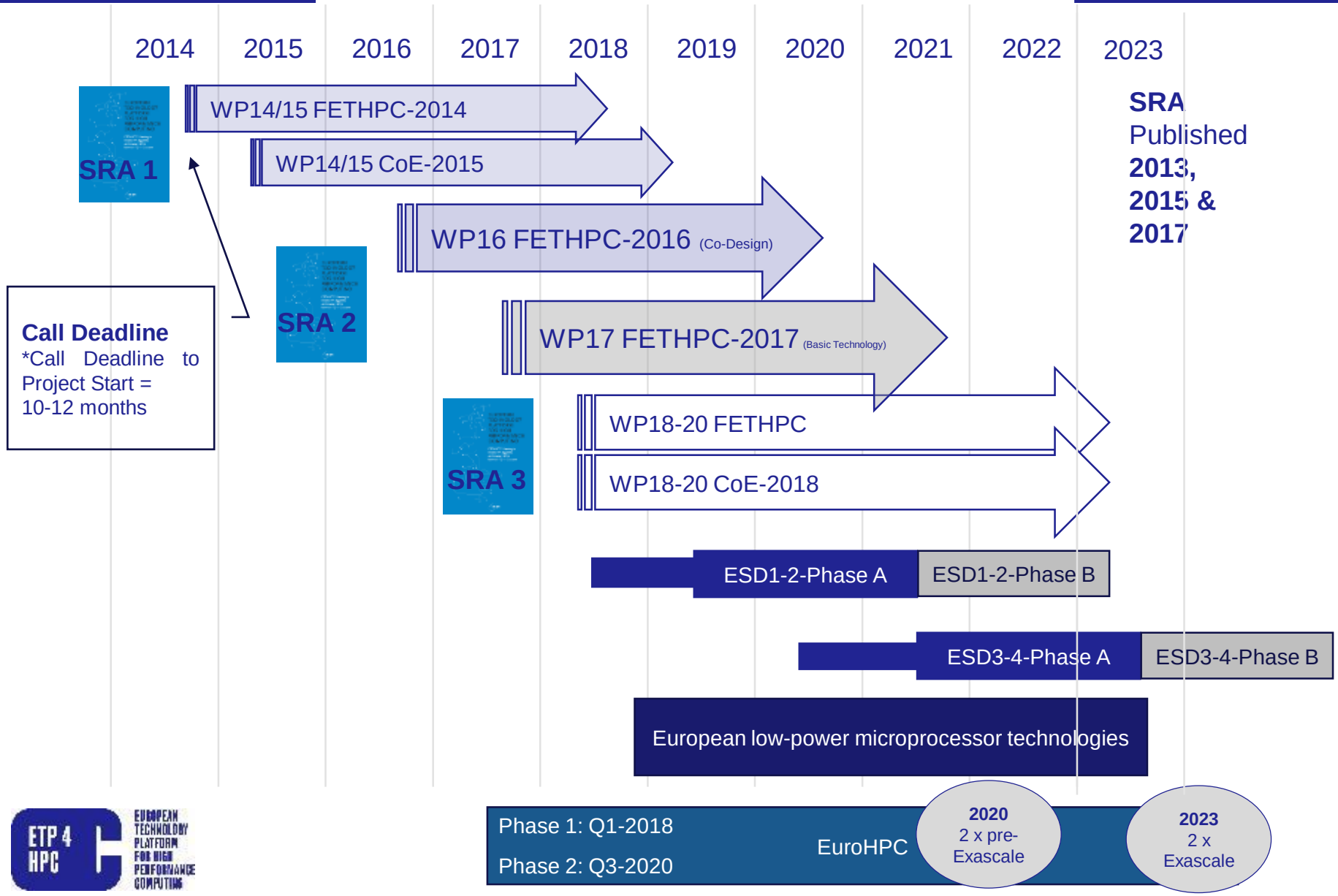
(phase B)



EsD Expectations

- Design points ~400-500 Pflops
- EsD target 5% (20-30 Pflops)
- Budget: 20-50 Mio. €
- Diversity of architectures

HORIZON 2020 TIMELINE – ESD AND RELATED DEVELOPMENTS



ETP 4 HPC
EUROPEAN TECHNOLOGY PLATFORM FOR HIGH PERFORMANCE COMPUTING

SRA 3 Priorities – Examples from various areas

(Homework?)

Main Technical Priorities – SRA 3

- **HPC System Architectures - 1**
  - **The compute component performance will continue to grow for both standalone many-cores or and accelerators by both increasing the number of threads and their individual performance**. The System on chip definition helped by 2.5/3D technologies will take benefit of emerging standards for connecting accelerators and/or network adaptors (PCIe Gen4, CCIX, OpenCAPI, Gen-Z…) and for connecting high bandwidth memory and Non Volatile memory
  - **As HPC system continue to grow in size , the HPC interconnect has to provide more bandwidth** with a good photonic support, larger **Quality** of Service and hardware support for enabling efficient direct access to the whole system memory (PGAS)

Main Technical Priorities – SRA 3

- **HPC System Architectures - 2**
  - A new definition of exascale performance target has been promoted : **100x more performance for relevant and real applications compared to today's state-of-the-art PRACE Tier-0 systems** (equivalent to 10 PFlop/s for real applications, one cent of one Exaflop)

Main Technical Priorities – SRA 3

- **Programming Environments**
  - (a) **High productivity programming environments that separate core algorithmic concerns from implementation and optimization**, ensuring maintainability and portability of real HPC applications across existing and future architectures and systems.
  - (b) **Interoperability** across the whole programming environment and composability of programming models and APIs.
  - (c) **Intelligent performance analytics tools** to understand performance issues and bridge the gap with the source code changes.
  - (d) **Dynamic workflow systems** that integrate HPC simulations, data analytics, visualization and persistent storage/databases.
  - In order to ensure take-up by the application communities, there should be a **path towards long-term formal or de-facto standardization of the programming models and APIs.**

Main Technical Priorities – SRA 3

- **Energy and Resiliency**
  - Energy Efficiency - **the ability to control the processor power and/or energy consumption from external policy setting** based on the comprehensive sensor network encompassing the infrastructure would be the most significant step forward.
  - Resiliency - **the uncoordinated checkpoint and restart capability** will significantly increase the efficiency of a parallel machine.

Images courtesy of BSC, CEA, Fraunhofer and JSC

ETP4HPC

www.etp4hpc.eu • office@etp4hpc.eu