



# ETP4HPC

## Strategic Research Agenda (SRA)

HPC Summit Prague, May 9<sup>th</sup> 2016

ETP4HPC – SRA workgroups

Dr. Michael Malms



May 9, 2016



# 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 Work programme 2018 - 2020
- Interlock with EC on "European Cloud Initiative "- Communication



# Strategic Research Agenda SRA

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

May 9, 2016



# ETP4HPC

European Technology Platform  
for High-Performance Computing

## Strategic Research Agenda 2015 Update

European Technology  
Multi-annual Roadmap  
Towards Exascale  
Update to 2013 Roadmap



H2020-FETHPC-2014

Coordination of the HPC strategy



EXDCI

European eXtreme Data and Computing Initiative

Grant Agreement Number: FETHPC-671558

D2.1

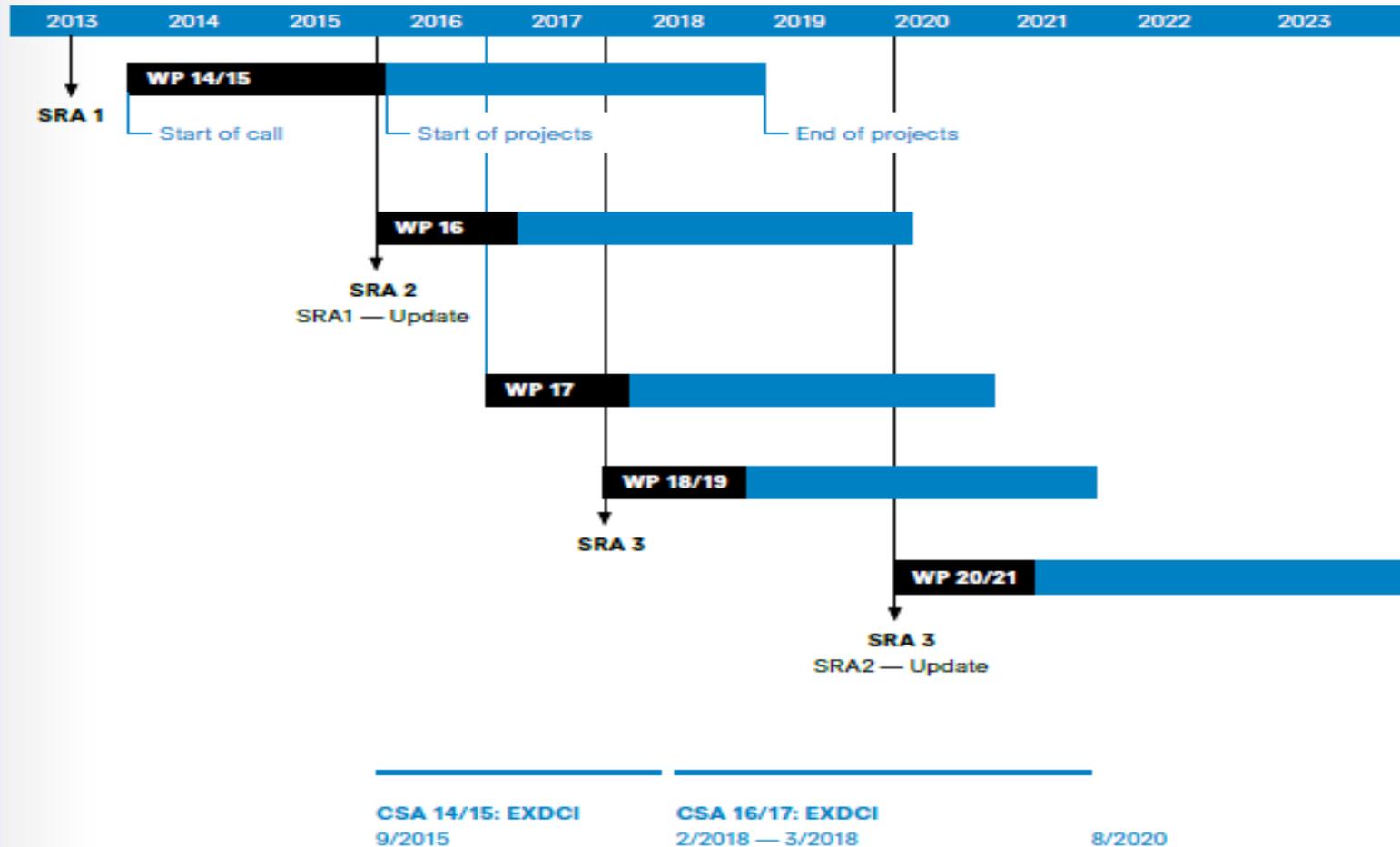
Update of Strategic Research Agenda (SRA2)

*Final*

Version: 1.1  
Author(s): Michael Malm, Jean-Philippe Nominé, Marcin Ostasz (ETP4HPC)  
Date: 19.01.2016

# Horizon 2020 WPs and SRAs

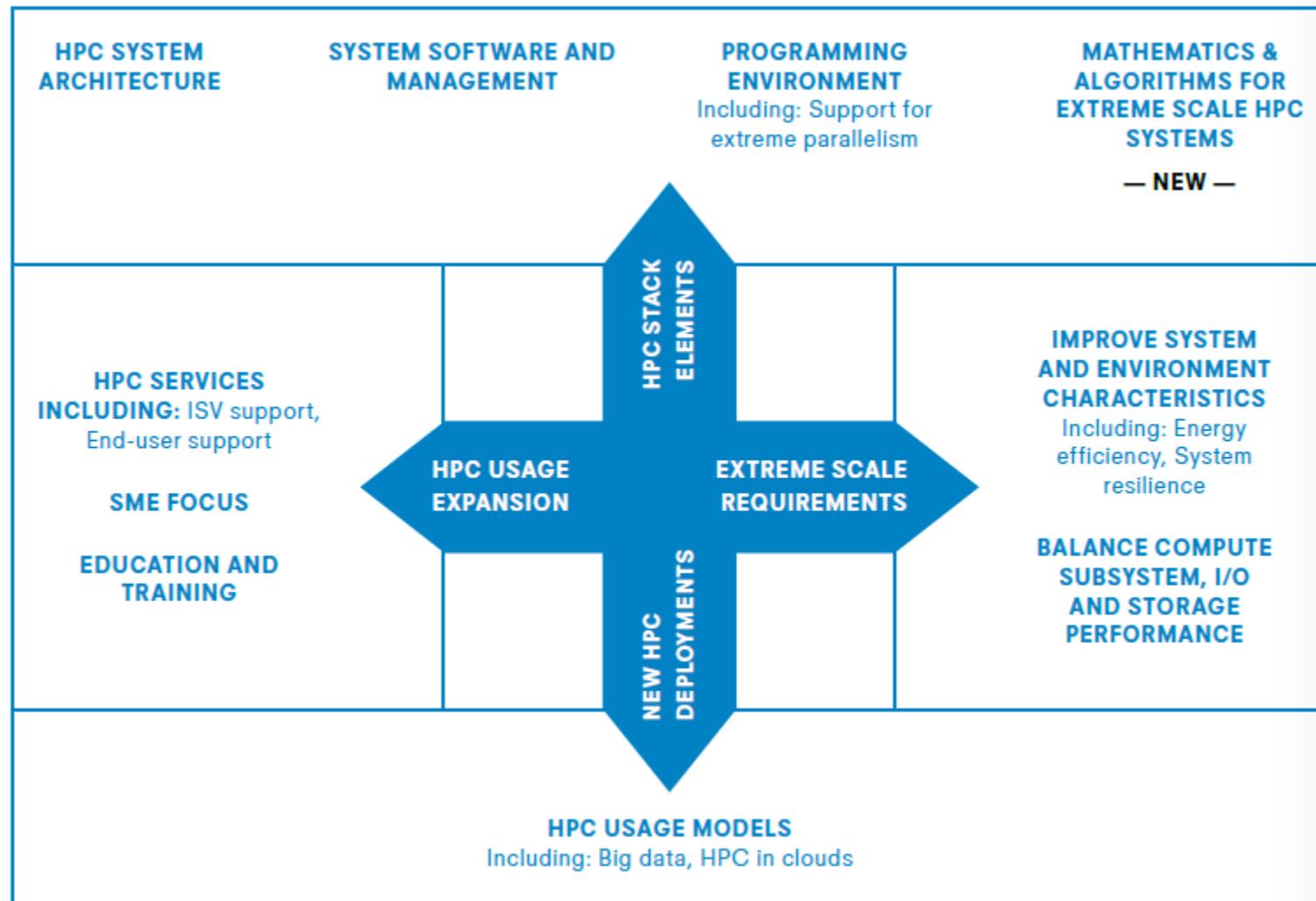
## HPC — HORIZON 2020 ROADMAP



# 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 has 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 has issued an update to their SRIA in Jan 2016



# The technical domains and the ESD proposal

## Trends and recommended research topics – a few examples

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# 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

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

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

# Energy and resiliency: milestones

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

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

# Extreme-Scale Demonstrators

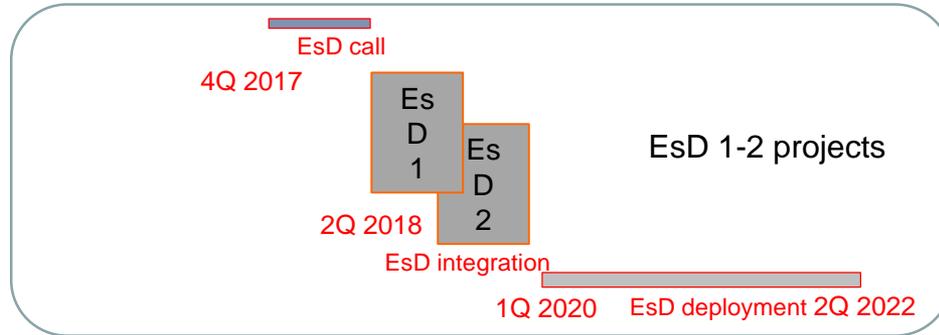
- **Characteristics**
  - Four complete prototype HPC systems, calls in 2018 & 2019
  - high enough TRL to support stable production
  - using technologies developed in the previous projects
  - based on application – system co-design approach
  - large enough to address scalability issues (at least 5% of top performance systems at that time)
- **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

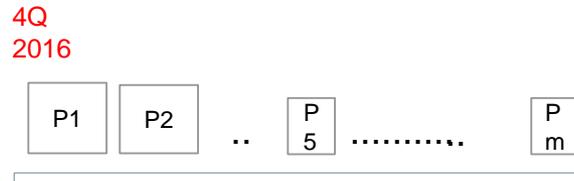
WP 2014/15  
(project execution)



3Q 2015

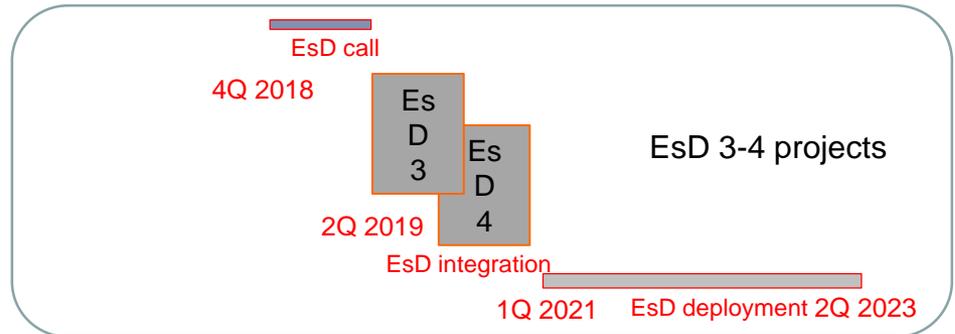


WP 2016  
(project execution)



4Q 2016

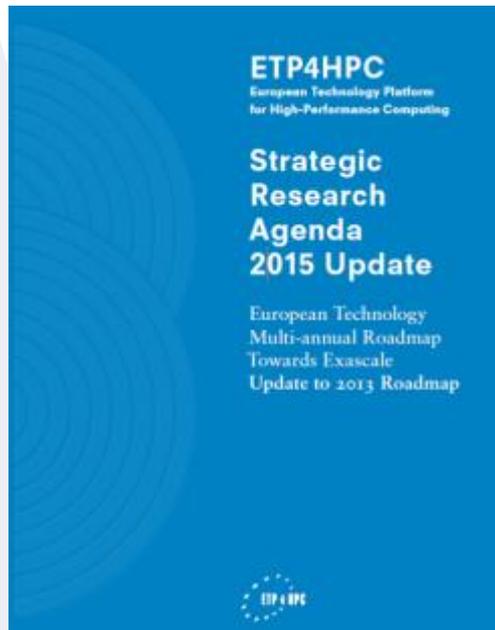
4Q 2016



# SRA – next actions

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We will welcome your comments on the current SRA  
<http://www.etp4hpc.eu/strategic-research-agenda/>

### Strategic Research Agenda | ETP4HPC

[www.etp4hpc.eu/strategic-research-agenda/](http://www.etp4hpc.eu/strategic-research-agenda/)

6 days ago - Public Call for Comments on ETP4HPC Strategic Research Agenda. Our organisation would like to receive feedback on this document from the ...

### Public Call for Comments for ETP4HPC Strategic Research ...

<https://www.surveymonkey.com/.../ETP4HPC-SRA2-PUBLIC-CALL4C...>

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](http://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](http://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-...](http://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.  
 You visited this page on 12/2/15.

### Catherine Gleeson | LinkedIn

<https://www.linkedin.com/in/catherine-gleeson-151229b7>

Amsterdam Area, Netherlands - ETP4HPC - European Technology Platform for HPC - ETP4HPC

Catherine Gleeson. ETP4HPC - European Technology Platform for HPC ... Public Call for Comments on ETP4HPC Strategic Research Agenda. December 11 ...

### eInfrastructures (@eInfraEU) | Twitter

<https://twitter.com/einfraeu>

"Public Call for Comments on ETP4HPC Strategic Research Agenda" by @Etp4H on ... New #H2020 #einfrastructures call for support to policy and international ...

### Images for etp4hpc public call for comments

Report images



# Next SRA-related events in 2016

- **HPC summit – Extreme scale Demonstrator workshop - May 12th**
  - focussed on the EsD definition (engage potential players, further implementation details)
  - at this event the three pillars for the EsD mission ( CoE, HPC centres and the FETHPC1 project speakers ) are invited . **More than 80 registered participants!**
- **Participation in BDEC conference - June 16 & 17**
- **ISC16 – June 23rd**
  - Scope: Feedback session on SRA directions, content and value to shape the next update
    - (Invited are: End-users, ISVs and International HPC experts)
  - 2nd EsD workshop (follow-on to May 12th workshop)
- **Level set with HPC application experts (EXDCI) – September 21 & 22**
- **Technical workshop with Big Data Value Association (BDVA) June/July**



THANK YOU!

For more information visit

[www.etp4hpc.eu](http://www.etp4hpc.eu)

**contact: office@etp4hpc.eu**

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# Backup

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## 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 availability)

# 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

## 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

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

