H2020-FETHPC-2014

Coordination of the HPC strategy

EXDCI

European eXtreme Data and Computing Initiative

Grant Agreement Number: FETHPC-671558

D7.2
First release of the HPC Ecosystem Balanced Scorecard

Final

Version:	1.0
Editor:	Jean-Philippe Nominé
Date:	23.06.2017

Project and Deliverable Information Sheet

EXDCI Project	**Project Ref. №: FETHPC-671558**	
	Project Title: European eXtreme Data and Computing Initiative	
	Project Web Site: http://www.exdci.eu	
	Deliverable ID: D7.2	
	Deliverable Nature: Report	
	Dissemination Level: PU *	**Contractual Date of Delivery:** 30/06/2017
		Actual Date of Delivery: 30/06/2017
	EC Project Officer: Evangelia Markidou	

* - **PU** – Public, as referred to in Commission Decision 2991/844/EC.

Document Control Sheet

Document	**Title: First release of the HPC Ecosystem Balanced Scorecard**	
	ID: D7.2	
	Version: 1.0	**Status**: Final
	Available at: http://www.exdci.eu	
	Software Tool: Microsoft Word 2013	
	File(s): D7.2.docx	
Authorship	**Edited by:**	Jean-Philippe Nominé, ETP4HPC
	Contributors:	Guy Lonsdale, SCAPOS Maike Gilliot, ETP4HPC Valeria Bartsch, Fraunhofer/ITWM Kai Kruger, Fraunhofer/ITWM
	Reviewed by:	Serge Bogaerts, PRACE aisbl Iñigo Yenes, EXDCI PMO
	Approved by:	MB/TB

Document Status Sheet

Version		Date	Status	Comments
0.1		23.03.2017	Draft	Creation of structure
0.2		14.06.2017	Draft	Partial draft
0.3		15.06.2017	Draft	Full draft for review
1.0		25.06.2017	Final	Corrected after internal review

Document Keywords

Keywords:	HPC cPPP, Monitoring, Impact Assessment, KPI, Scorecard

Table of Contents

List of Figures

List of Tables

References and Applicable Documents

[1] https://ec.europa.eu/digital-agenda/en/high-performance-computing-contractual-public-private-partnership-hpc-cppp/

[2] Kaplan, Robert S; Norton, D. P. (1992). "The Balanced Scorecard - Measures That Drive Performance". Harvard Business Review (January–February): 71–79.

[3] Performance Measurement with a Balanced Scorecard for Non-University Research Institutes, Kramer and Pfeffer, Journal of Business and Economics, ISSN 2155-7950, USA, February 2014, Volume 5, No. 2, pp. 162-177

[4] H2020 HPC R&I Activities https://ec.europa.eu/programmes/horizon2020/en/h2020-section/high-performance-computing-hpc

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

[6] Report prepared by IDC on: High Performance Computing in the EU: Progress on the Implementation of the European HPC strategy https://ec.europa.eu/digital-single-market/en/news/study-high-performance-computing-eu-progress-implementation-european-hpc-strategy-final-report

[7] http://ec.europa.eu/research/participants/portal/desktop/en/home.html

[8] http://cordis.europa.eu

[9] PRACE Annual Report 2015, pp 32-38 on Key Performance Indicators http://www.prace-ri.eu/IMG/pdf/Prace-annual-report2015_lowres.pdf and http://www.prace-ri.eu/prace-kpi/

[10] PRACE KPIs http://www.prace-ri.eu/prace-kpi/

[11] https://www.limesurvey.org/

[12] https://exdci.eu/activities/questionnaire-coe-fet-hpc

[13] EXDCI WP7 D7.1 deliverable “Initial methodology and monitoring tool-set”, August 2016

[14] http://www.bdva.eu/

[15] https://www.hipeac.net/

[16] https://www.eurolab4hpc.eu/

[17] http://www.exascale.org/bdec/

[18] https://ec.europa.eu/programmes/horizon2020/en/h2020-section/high-performance-computing-hpc

[19] https://ec.europa.eu/futurium/en/digital4science

[20] http://www.prace-ri.eu

[21] http://www.etp4hpc.eu/en/cppp.html

[22] https://ec.europa.eu/digital-single-market/en/digital-day

[23] https://ec.europa.eu/programmes/horizon2020/en/news/overview-eu-funded-centres-excellence-computing-applications

[24] http://exascale-projects.eu/EuroExaFinalBrochure_v1.0.pdf

[25] http://www.montblanc-project.eu/arm-based-platforms

[26] http://www.prace-ri.eu/prace-pcp-3rd-phase-awarded/

[27] https://trac.version.fz-juelich.de/hbp-pcp/wiki/Public
[28] https://exdci.eu/jobs-and-training/hpc-career-case-studies
[29] https://exdci.eu/jobs-and-training/job-portal
[30] https://exdci.eu/jobs-and-training/training-portal
[31] http://www.prace-ri.eu/prace-moocs-via-future-learn/
[32] http://www.prace-ri.eu/praceannualreports/
[33] http://www.eesi-project.eu/ (various reports)
[34] https://ec.europa.eu/digital-single-market/en/news/study-high-performance-computing-eu-progress-implementation-european-hpc-strategy-final-report

List of Acronyms and Abbreviations

BSC	Balanced Scorecard
CoE	Centres of Excellence (for Computing Applications)
cPPP	contractual Public Private Partnership
DX.Y	Deliverable Number X.Y (Number Y of Work Package X)
EC	European Commission
EU	European Union
EXDCI	European eXtreme Data and Computing Initiative
FET	Future and Emerging Technologies
FETHPC	HPC component of FET (Future and Emerging Technologies) programme in H2020
FP7	Framework Programme 7 – predecessor of H2020
H2020	Horizon 2020 – The EC Research and Innovation Programme in Europe following FP7
HPC	High Performance Computing
ISV	Independent Software Vendor
KPI	Key Performance Indicator
R&D	Research and Development
R&I	Research and Innovation
R&D&I	Research and Development and Innovation
SRA	Strategic Research Agenda (Multi Annual Roadmap)
WP	Work Package

Executive Summary

This report comprises the EXDCI Project Month 22 deliverable D7.2 “First release of the HPC Ecosystem Balanced Scorecard”, in the context of Work Package 7 which addresses impact monitoring of the H2020 R&I activities linked to the HPC contractual Public Private Partnership strategy. Deliverable D7.1 previously reported on the motivation for the initial methodology and tool-set and on its realisation. This methodology has been applied for the elaboration of the HPC cPPP 2016 Progress Report, already encompassing some improvements and complements - which will be documented in detail in D7.3 forthcoming deliverable.

The HPC Ecosystem Balanced Scorecard (BSC) is a central component of the developed methodology. Key Performance Indicators defined in the HPP contractual Public Privar Partnership (cPPP) are taken as boundary and mapped onto appropriate BSC perspectives.
This D7.2 deliverable focuses on the first findings directly derived from the latest cPPP progress report, and summarises them regarding the perspectives of industrial competitiveness and socio-economy impact, operational aspects of the programme, and management aspects of the programme.

This report positions HPC cPPP monitoring early elements in the perspective of a more general Balanced Score analysis to come, planned at the end of EXDCI. H2020 projects scrutinised for the 2016 progress report had indeed been running for 12 to 18 months only at the time surveys, data collection and interviews were achieved; whereas other activities regarding ecosystem development and stakeholders mobilisation started a bit earlier in 2014 – and 2013 for ETP4HPC real activation and first SRA elaboration.

As of this mid-2017 standpoint, EU HPC global ecosystem has gained an important momentum and made significant qualitative progress in terms of organisation, stakeholder mobilisation, project and related consortia dynamics. More quantitative effects of the H2020-funded projects can already be observed. Stakeholders from the industry (large companies and SMEs) have also taken a much more active role in the programme, compared with FP7 HPC programmes, which were smaller and not structured into a cPPP.

In 2016, then in 2017, major new policy developments in the area of EU High Performance Computing have also taken place, creating a favorable context for further development and impact of the HPC cPPP.

A future deliverable (D7.4) will provide a final synthesis and put the cPPP impact assessment and KPIs in the broader perspective of a global Balanced Scorecard discussion.

1 Introduction

The purpose of EXDCI WP7 (Work Package 7) is to generate and gather data and create the necessary analysis tools to support informed decision-making in relation to the development of the European HPC Ecosystem and the impact of the R&I activities linked to the HPC cPPP (contractual Public Private Partnership) strategy [1]; for the sake of completeness of the HPC landscape understanding, with its three pillars in close interaction – technologies, infrastructures, applications – a number of elements related to PRACE are considered, in addition to technologies and applications which are in the formal scope of the cPPP.

The Work Package 7 comprises two tasks, which are aligned with the two central objectives of WP7: providing a set of methodologies and processes to be used in the measurement of Ecosystem development and progress; perform the periodic monitoring of the implementation of the HPC cPPP strategy. The two tasks are:

- Task 7.1: Methodology and establishing data capture procedures and tools
- Task 7.2: Data capture and analysis

Deliverable D7.1 ([13], related to Task 7.1) previously reported on the motivation for the initial methodology and tool-set and on its realisation. This methodology has been applied for the elaboration of the HPC cPPP 2016 Progress Report – delivered in May 2017 - already encompassing some improvements and complements.

Task 7.2 thus applied a methodology to which Task 7.1 had contributed, contributing itself to the monitoring of the development of the European HPC ecosystem and the impact of the actions relating to the HPC cPPP. The output of that monitoring flew into the regular cPPP meetings, the annual cPPP reports and more particularly into the mid-term assessment of the HPC cPPP in 2017.

This D7.2 report is the first deliverable from Task 7.2 and focuses on the findings directly derived from the latest cPPP progress report, and summarises them. A future deliverable (D7.4) will provide a final synthesis and put the HPC cPPP impact assessment and KPIs in the broader perspective of a global Balanced Scorecard discussion.

Section 2 of this report briefly reminds the concepts and scope – Balanced Scorecard, HPC cPPP KPI approach: the minimum necessary for a self-contained understanding of the report, since methodological evolutions will be documented in detail in D7.3 future deliverable, and because this report focuses on current findings.

Section 3 thus summarises these main findings from cPPP progress reports – mainly the 2016 one, which built on, and benefitted from EXDCI support, while being the main input for 2017 HPC cPPP mid-term review (an on-going process until Autumn of 2017, together with all H2020 cPPPs).

2 Reminder of scope and main methodological elements

In this Section we provide a reminder of the balanced scorecard concept and then the use of the concept, taking into account the needs, and existing contractual guidelines, in creating the first HPC Ecosystem Balance Scorecard.

More details on the methodology will be delivered in D7.3, including updates and improvements with regard to D7.1 deliverable.

2.1 Balanced scorecard concept

The balanced scorecard (BSC) [2] is a strategic planning and management system that is used extensively in business and industry, government, and non-profit organizations worldwide to align business activities to the vision and strategy of the organization, improve internal and external communications, and monitor organization performance against strategic goals. It was originally developed by Robert Kaplan (Harvard Business School) and David Norton as a performance measurement framework that added strategic non-financial performance measures to traditional financial metrics to give managers and executives a more 'balanced' view of organizational performance. With the help of the view of perspectives it is ensured that selected goals are pursued. The goals are assigned to a perspective. The perspectives can be chosen so that they fit to the problem. The process model for the development of a balanced scorecard is shown in Figure 1.

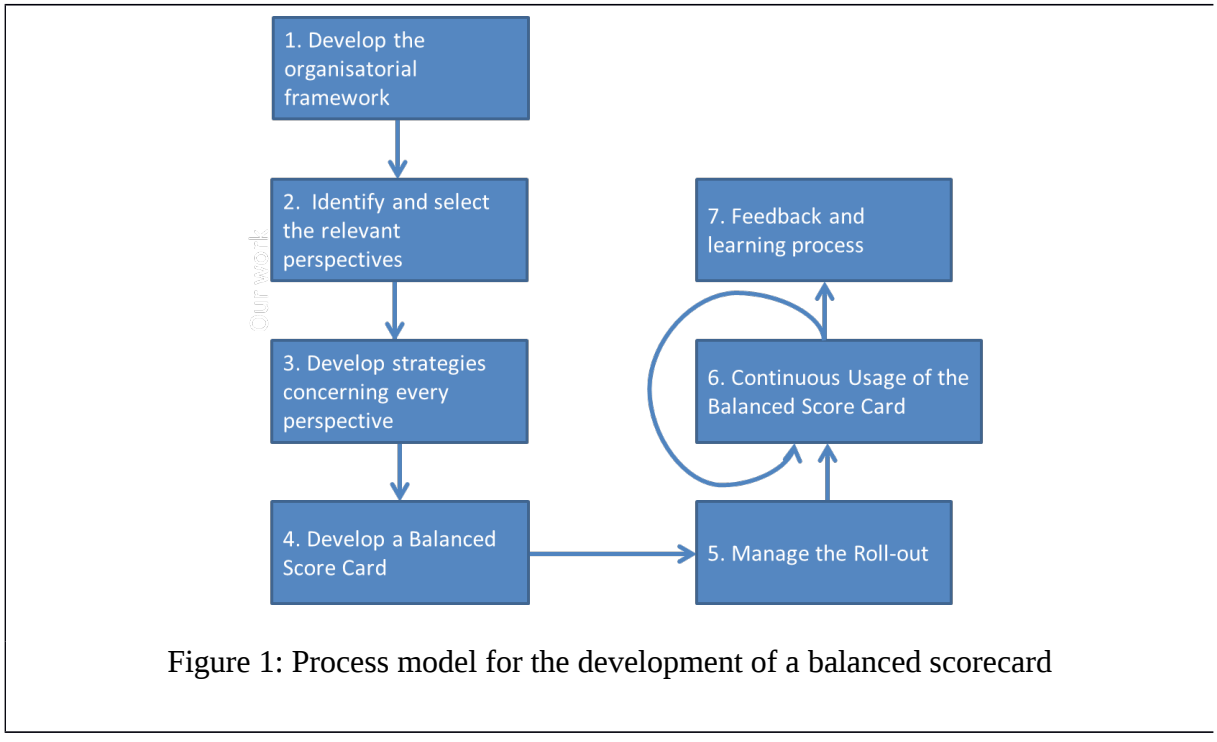

Figure 1: Process model for the development of a balanced scorecard

In general for businesses the following perspectives of a BSC are chosen: financial perspective, customer perspective, internal process perspective and learning & development perspective. Since functional goals dominate non-profit organisations, their ideal mission-oriented goal system differs greatly from the prevalent goal system existing at profit-oriented companies. This requires an adaptation of the perspectives of the BSC. Different suggestions to change the perspective have been made. E.g. an adaptation of the BSC with an impact

perspective, an enabler and resources perspective, an external stakeholder perspective and a main operating activities perspective was proposed [3].

2.2 The HPC Ecosystem BSC

In order to adopt the BSC concept for the purposes of EXDCI and its input for the HPC cPPP, a number of aspects and boundary conditions were taken into account - selecting appropriate perspectives and the definition of goals and KPIs per perspective.

In line with the goals of EXDCI WP7, as described above, the overall target is to support informed decision-making in relation to the development of the European HPC Ecosystem and the impact of the R&I activities linked to the HPC cPPP strategy. Thus, the BSC must look beyond the internal view of the EXDCI participating organisations and it must also look beyond the activities of the projects funded under the H2020 HPC Programme [4] – the FETHPC Projects and Centres of Excellence. The HPC cPPP performance and impact monitoring guidelines, defined during its establishment, already categorised their set of KPIs (included in the Annex to the report, Section 5.1). We have adopted that categorisation for the definition of the HPC Ecosystem BSC as illustrated in Figure 2. The selected perspectives are Industrial Competitiveness & Socio-Economy Impact, Operational Aspects of the Programme and Management Aspect of the Programme. These categories will be used to structure Section 3 of this report.

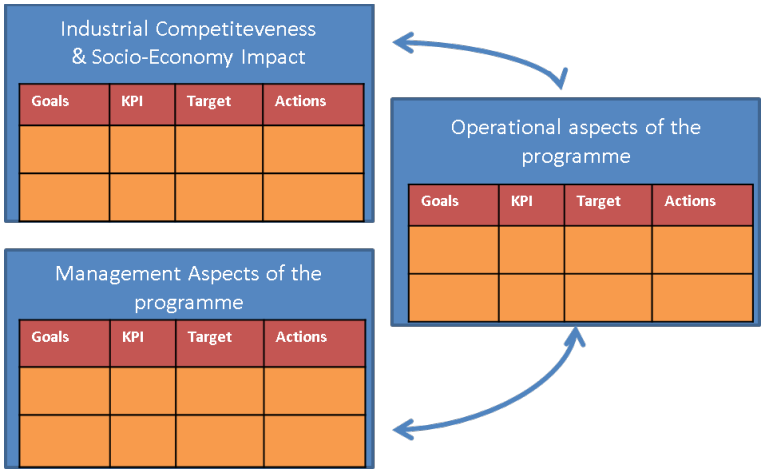

Figure 2: Identifying and selecting the relevant perspective for the European HPC infrastructure

In line with the standard procedure for selecting existing strategies, substantiating them and then developing goals that are mapped to perspectives, the ETP4HPC SRA visions and strategies combined with the cPPP strategic goals are used to create the goals per BSC perspective presented in Table 1.

Perspective	Goal
Industrial Competitiveness and Socio-Economy Impact	• Increase market share • Create innovation environment in HPC (exploited patents and standards) • Increase employment • Support growth of SMEs
Operational aspects of the programme	• Effective research programme and coverage • Develop performance of HPC technologies • Provide education, training, skills development • Increase use of HPC • Develop a HPC software ecosystem • Generate patent, inventions and contributions to standards
Management aspects of the programme	• Dissemination and Awareness • Effective execution

Table 1: Perspectives and Goals of the BSC

In order to be able to understand if a goal measures a target which has already been reached or a change (for example, in an identified company) will in future affect the goals, we need to determine cause and effect. As an example the goals for the perspective “Industrial competitiveness and socio-economy impact” are analysed concerning cause and effect: the creation of an innovation environment and support of growth of SMEs (cause) has the potential to lead to an increase in market share (effect).

Subsequently, and again building on the prior developments of the ETP4HPC SRA and the monitoring guidelines of the HPC cPPP, key performance indicators (KPIs) and corresponding targets are defined for all perspectives. In total 12 KPIs (with sub-KPIs) have been defined in the initial HPC cPPP BSC. These KPIs are presented in Table 2.

	Perspective	Key Performance Indicator (KPI)
1	Industrial Competitiveness and Socio-Economy Impact	Global market share of European HPC
2	Industrial Competitiveness and Socio-Economy Impact	HPC additional investments
3	Industrial Competitiveness and Socio-Economy Impact	Jobs
4	Industrial Competitiveness and Socio-Economy Impact	Innovation Environment in HPC (European HPC start-ups – creation – growing…)
5	Operational aspects of the programme	Research programme effectiveness and coverage
6	Operational aspects of the programme	Performance of HPC technologies developed
7	Operational aspects of the programme	People, education, training and skills development
8	Operational aspects of the programme	HPC use
9	Operational aspects of the programme	HPC Software ecosystem
10	Operational aspects of the programme	Patent, inventions and contributions to standards in HPC by H2020 funded project
11	Management aspects of the programme	Efficiency, openness and transparency of the PPP Consultation Process
12	Management aspects of the programme	Dissemination and Awareness

Table 2: Key Performance Indicators for the HPC Ecosystem BSC

2.3 Brief reminder of data sources and their exploitation for 2016 HPC cPPP progress report

HPC cPPP 2016 progress report is the cornerstone of the HPC cPPP programme impact assessment and ecosystem progress monitoring. The general KPI and impact methodology behind it will be documented in detail in D7.3 future deliverable – a global update of D7.1 [13]; this latter report contains already the bulk description of the approach.

The main sources of data used for HPC cPPP report 2016 are – recapitulated in Table 3 below:

- EC/DGCNECT H2020 calls data and statistics (and some FP7 Exa-scale projects facts and figures);
- PRACE KPIs – 2015 version [9];
- ETP4HPC periodic (annual) activity report, a coarse-grain monitoring of the ETP4HPC contribution to the ecosystem activity and to the cPPP
- ETP4HPC web-based surveys in 2015, 2016, and Q1 of 2017, targeting the members of the association (research organisations, SMEs, large companies); from this survey all quantitative data collected is only disclosed in anonymised ways;
- An EXDCI web-based survey in 2016, targeting FETHPC and Centres of Excellence projects funded under H2020 (not individual organisations; this survey does not include the kind of potentially commercial sensitive questions included in the ETP4HPC survey)
- A focused study contracted to IDC/Hyperion Q1 of 2017, encompassing a quantitative HPC market tracking update (worldwide and EU) on the one hand, and a qualitative/quantitative survey towards industrial beneficiaries of FETHPC funding on the other hand
- Public sources (web, reports…)

	KPI data sources							
	KPI	**Key Performance Indicator (KPI)**	EXDCI survey	ETPHPC Surveys and activity report	PRACE KPIs	EC H2020 stats	Analysts' study	Public sources Web etc.
Industrial Competitiveness and Socio-Economy Impact	**1**	Global market share of European HPC					***	*
	2	HPC additional investments		**			**	
	3	Jobs		**			**	
	4	Innovation Environment in HPC: start-ups…	**	**			**	*
Operational aspects of the programme	**5**	Research programme effectiveness and coverage: H2020 calls….				***		
	6	Performance of HPC technologies developed	*	*				**
	7	People, education, training and skills development			**			
	8	HPC use	*		**			
	9	HPC Software ecosystem	**		**			*
	10	Patent, inventions and contributions to standards in HPC by H2020 funded project	*	**			**	
Management aspects of the programme	**11**	Efficiency, openness and transparency of the PPP Consultation Process				***		
	12	Dissemination and Awareness	**	**	**			

	Not a data source
*	Complementary source
**	Important source
***	Main source

Table 3: Key Performance Indicators data sources

Compared with previous progress reports, the main new elements are:

- The ETP4HPC web-based survey of Q1 of 2017, very similar to 2016 and 2015 ones
- IDC/Hyperion study: with the support of EXDCI, an outsourced study was defined and contracted to Hyperion Research (formerly IDC). The study employs a mix of proven quantitative and qualitative methods.
  - ***Quantitative Market Tracking:*** the study exploits the close tracking and forecasting of the global and European HPC markets performed for more than 30 years by IDC.
  - ***Quantitative/Qualitative Survey:*** ETP4HPC provided Hyperion Research with a list of H2020 grant funding industrial recipients to pursue for interviews. The questionnaire asked questions whose responses were designed to be quantified on a rating scale, and which also elicited qualitative comments (Appendix 5.2 provides a collection of quotes from these comments).
  - Industrial companies interviewed (SMEs and non-SMEs) were selected, involved in 12 of the FETHPC projects.

3 Summary of main findings from cPPP progress reports

This section summarises the main findings from cPPP progress reports – mainly the 2016 one, which built on, and benefitted from EXDCI support, while being the main input for 2017 HPC cPPP mid-term review (an on-going process until Autumn of 2017, together with all H2020 cPPPs).

The results are a mix of qualitative and quantitative elements covering a significant part of the full list of KPIs. The HPC programme which is covered and observed is H2020 HPC cPPP one, but also encompasses some aspects of the projects from the end of FP7 (so-called 'exascale' projects, which have been prequels of H2020 HPC programme).

Then in the first half of H2020 (2014 to mid-2017), a number of projects have been granted funding in the scope of the HPC cPPP:

- 21 technology projects on different hardware and software building blocks for future exascale systems – from calls inspired by ETP4HPC SRA (Strategic Research Agenda - HPC Multi-Annual Roadmap); 19 projects actually started end of 2015, 2 more will start in 2017
- 9 Centres of Excellence for Computing Applications (CoEs); 8 starting end of 2105 and 1 in 2016
- 2 coordination and support actions started end of 2015

Figure 3 below gives an overview of the 'extended' programme projects, from FP7 to H2020, including projects from Work Programme 2014-2015, but not from 2016-2017 one.

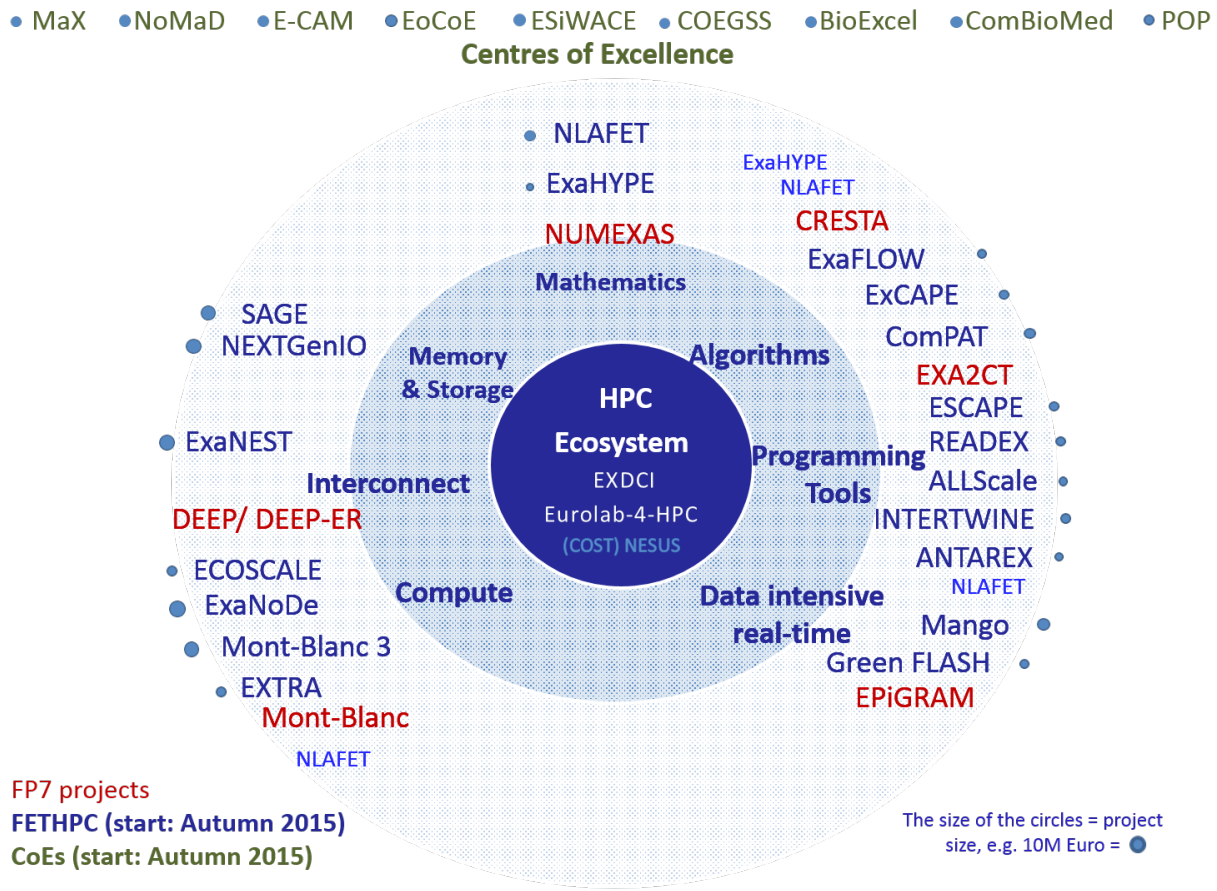

Figure 3: EU HPC landscape – portfolio of FP7+H2020 projects

3.1 Industrial Competitiveness and Socio-Economy impact

As a quick introduction to this section, let us make clear we are still at an early stage of the H2020 HPC cPPP programme.

The status of the cPPP funding and industrial participation is the following:

- 176 M€ of H2020 funding have been committed so far in the scope of the cPPP, out of which 142 engaged in 2015- 2016; a simple simulation of the progressive effective spending – used for manpower, equipment and any other direct cost - of the funding gives an optimistic estimate of at most 84 M€ mid-2017 (see Figure 4 below; the blue part of the curve is based on projections of future Work Programmes and is not meant to be used in the reasoning here). This might be a bit optimistic because even manpower setup and consumption may not be fully linear at the start of all projects, and ramp up progressively; not to mention equipment and for instance hardware prototypes for those projects which encompass some, and for which most expenditure is usually not performed before the mid-term of the project

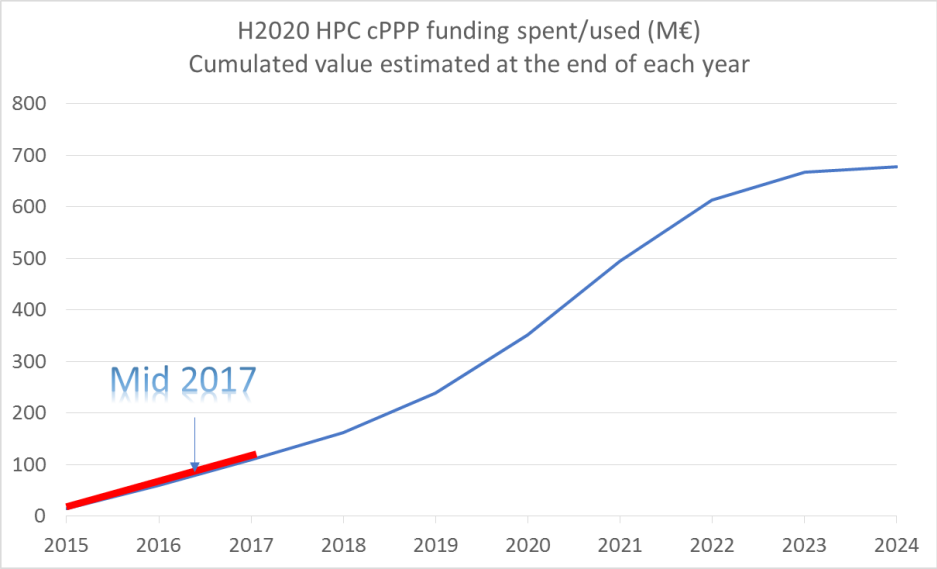

Figure 4: Evolution of HPC cPPP funding use

- Out of this funding, an average 33% goes to industry (2/3 of which to large companies, 1/3 to SMEs).

3.1.1 *Global market share of European HPC*

One of the main indicators used is the market share of European suppliers. We use IDC/Hyperion definition and figures of EU suppliers share in the EU HPC broader market (servers + storage + software). This share grew from 4.4% in 2013 to 4.9% in 2016, showing positive momentum prior to any HPC cPPP potential effects.

NB: EU fraction of global HPC market consumption grew from 26.5% in 2013 to 27.8% in 2016 according to IDC; one of the objectives of the cPPP is to improve this market share of European suppliers in EU, but with solutions that are globally competitive and can also be exported outside Europe. Forecasts indicate continued growth of this market share of EU

suppliers in Europe, with a lower bound of ca. 7-8% in 2019-2020 currently estimated by Hyperion – an underestimation in our opinion, not encompassing the future extra effects of the cPPP.

Another possible angle is a quick analysis of the recent history of EU vendors[1] in Top500 showing that, in terms of number of systems:

- EU represents 20% of all Top500 systems (raised to 25% in 2015, however recent China momentum and growth eroded this)
- Out of these European Top500 systems, 20% are provided by EU vendors (oscillated between 20 and 25% over the last 5 years)
- EU vendors represent ca. 5% of all the Top500 systems; their exportation outside EU (installations in South America and Asia) was 3 to 5 systems installed in 2015-2016

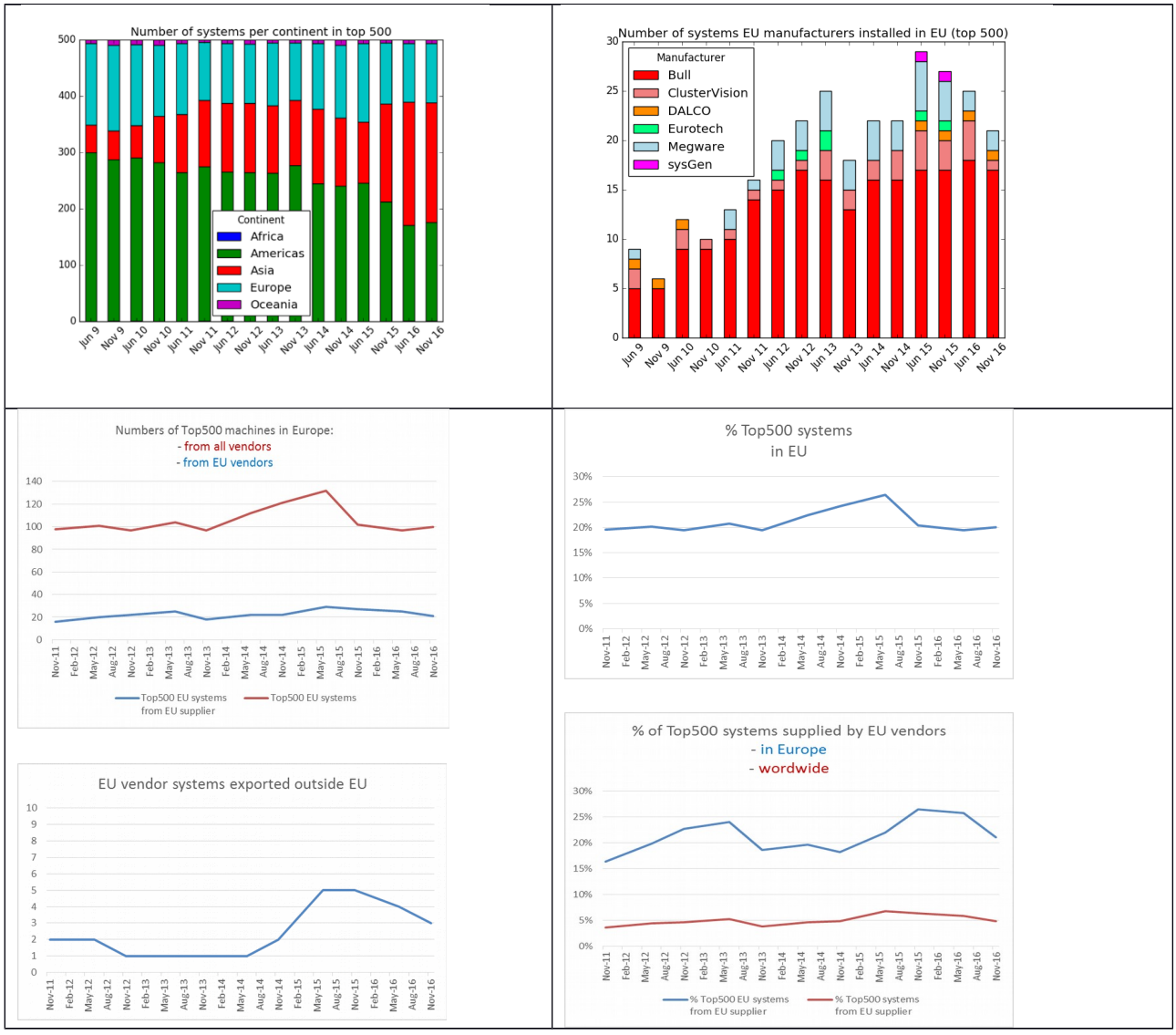

Figure 5: EU supercomputer vendors in the Top500

1 system vendors defined as suppliers headquartered in Europe and excluding suppliers that are active in Europe but headquartered elsewhere

There is thus a high potential for a fairer share of European market for European vendors. Not to mention potential for more exportation outside of Europe, which is already observed although minimally. It must be noted that the evolution - although globally positive - shows fluctuations, partly because of the small sized sample, partly because not all of the market is reflected in the Top500, and partly, because of the congruence and irregularities of investment cycles from large governmental agencies – and moreover, large industrial companies that are increasingly customers of the upper Top50 segment.

Atos-Bull accounts for a large majority of this, however smaller companies such as Eurotech, Clustervision or Megware, all ETP4HPC Steering Board members, have a recurring presence in the Top500 and even some exportation record outside Europe.

3.1.2 *HPC additional investments of stakeholders*

This section scrutinizes some aspects of extra investment of the 'private side' of the HPC EU ecosystem stakeholders – research organization and private companies.

ETP4HPC made an estimate of the EU ecosystem R&D effort, from its members, in 2014 and in 2015. This is to be understood as an order of magnitude – we only give ranges – and a probable lower bound, from ETP4HPC surveys answers: ETP4HPC represents a significant and visible fraction of EU HPC technology stakeholders, however, it cannot pretend to span its totality, and no hazardous extrapolation was carried out outside the known ETP4HPC membership.

Categories of activities considered were:

- "HPC Technology R&D": R&D for technologies covered by the technical research priorities of the ETP4HPC SRA or related and comparable technologies.
- "Other HPC R&D": Other R&D activities relating to the use of HPC and HPC Technologies, e.g. HPC applications development.
- "Other research - indirect HPC R&D - with an impact on HPC": other R&D activities in areas other than HPC that have an impact on HPC and/or the results of which might be used in HPC (such as more general micro-electronics development)

	Yearly R&D effort (M€)
HPC Technology R&D	165-210
Other HPC R&D	150-225
Other research - indirect HPC R&D - with an impact on HPC	Ca. 200

Table 4: EU ecosystem R&D effort

Attempts to estimate the levels of national, European (H2020), and self-financing have not led to results considered accurate, reproducible and reliable enough, but there are hints that EU funding could be in the range of 5-10% for industry (ETP4HPC member profile), and an average 20% for research organisations. Self-financing in the private sector (large industry & SMEs) would outweigh EU funding by a factor of 8.

A first indication from these global figures is that the 'private side' investment of the cPPP (reserarch+industry) will easily match the funding effort of the EC – €700 million during the whole H2020 programme.

From Hyperion/IDC study, focusing more on specific extra private (industrial) investment, it was found that five of the nine companies interviewed had already augmented the H2020 project funding with their own funds as of beginning of 2017. Some of the companies plan to invest substantial additional money in the R&D projects, either before the H2020 projects are completed or in subsequent efforts to develop products and bring them to market (a factor of 3-4 for extra investment is commonly mentioned). Since we are around the mid-term of the projects, an estimated four-fold effect in industrial effort per public Euro in the PPP is thus credible, aside the more global matching of the EC funding in the cPPP by the whole so-called private side (~€700 million by 2020, which will be directly spent progressively until at least 2023, considering projects with an average duration of 3+ years).

3.1.3 *Jobs*

From a sample of 9 interviewed companies – incl. 4 EU SMEs – involved in 12 FETHPC (technology) projects, accounting for 26 M€ of H2020 funding – which is most of the cPPP funding going to industry via FETHPC first round of projects, 61 jobs creations are expected. Hyperion/IDC and others confirm that most job creation related to advanced R&D happens after the R&D project is finished, especially when a commercial product or solution is being prepared for and introduced into the market. But SMEs in particular already reported actual recruitments – as of Q1 2017.

The effect of the HPC cPPP programme on jobs in research organisations has not been precisely measured; specific fluctuations in research organisations staff can indeed be important – many positions can be temporary and more or less synchronised with project duration. However an estimated 5% to 10% staff increase has been cast, in a population considered in the order of 1500 in “HPC Technology R&D” – R&D for technologies covered by the technical research priorities of the ETP4HPC SRA or related and comparable technologies - plus 2000 in “Other HPC R&D” – other R&D activities relating to the use of HPC and HPC Technologies, e.g. HPC applications development.

3.1.4 *Innovation Environment in HPC*

In 2016 EXDCI survey gathered information from the Centres of Excellence and the FETHPC projects on mature technologies within their projects for future start-ups.

A few projects had detected start-up matures technologies already. Most respondents answered that it was too early in the project’s activity to give a prediction on start-up mature technologies, as the projects only started end of 2015.

14 start-ups and SMEs in HPC took part in EXDCI guided interviews in 2016. According to those interviewed, access to market, clients with reluctance to innovation, and financial issues are the major concerns of the start-ups and SMEs. Thus, tight links to the ecosystem are perceived as key element to success. Due to intrinsic specificities of the HPC market, this is particularly important in HPC compared to other markets. In the recent past, it was observed for instance that a number of European computing software startups and SMEs failed – some of them in HPC. Others were acquired by major non-European companies. Such acquisition often can cause some loss of value via loss of employments, of competitive advantage or of know-how in Europe.

Large companies (such as ETP4HPC members ARM and Intel) are very active in the acquisition of external technologies (e.g. acquiring SMEs) in general, some of which are related to HPC. Salient examples in the HPC software are (ETP4HPC members) NICE Software acquired by Amazon Web Services, and Allinea acquired by ARM. The ARM

Allinea acquisition in particular is a clear example of technology development in Europe and the R&D capability remaining within Europe, with positive effects of leveraging and extending the scope of the tools developed – Allinea software tools will remain generic for all kinds of architectures and not only for ARM-based ones.

FP7 examples exist where European R&I projects in computing play a central role in bringing technology to the market. For example, Kaleao and ZeroPoint Technology startups are direct results of the FP7 EUROSERVER project (from "advanced computing" topic of LEIT-ICT parts of Horizon 2020; focussing on energy-efficient server design for datacentres, this call supports building blocks which are very complementary of FETHPC). As of today, the technology planned to be commercialised by Kaleao is used in three currently running HPC projects.

Eurolab-4-HPC Coordination and Support Action [16] has also developed a business prototyping action, to help research groups in HPC identify and evaluate business cases based on their research results. Around each technology, teams are to be formed consisting of the principle investigator, an entrepreneurial lead, and a mentor with industry experience. A recent call for such actions has been closed March of 2017.

3.2 Operational Aspects of the HPC cPPP programme

3.2.1 *Research programme effectiveness and coverage*

FETHPC projects (FETHPC-1-2014 call funded under Work Programme 2014-2015) covered the call different subtopics (inspired by ETP4HPC SRA):

a) High productivity programming environments for exascale
b) Exascale system software and management
c) Exascale I/O and storage in the presence of multiple tiers of data storage
d) Supercomputing for Extreme Data and emerging HPC use modes
e) Mathematics and algorithms for extreme scale HPC systems and applications working with extreme data

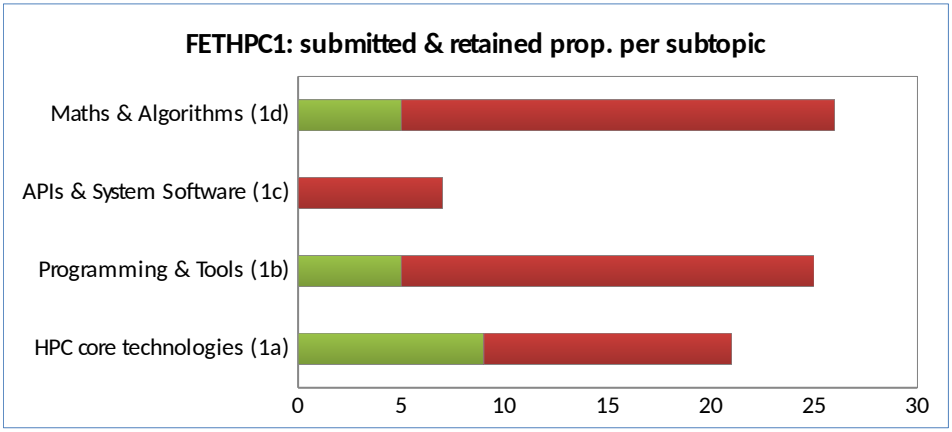

Figure 6: FETHPC1 (2015) topics coverage

The lack of selected projects in subtopic 1c) APIs & System Software was pinpointed by ETP4HPC as soon as the results were known. The low number of related proposals can explain this result. ETP4HPC insisted that by failing to cover this important SRA topic could lead to jeopardising extreme scale objectives.

More detailed analysis of projects contents and coverage have been done, that go beyond the scope of this report. ETP4HPC in general recommends that more effort should be put in actions to maximize project impacts and increase their early coordination. The Extreme Scale Demonstrators concept developed by ETP4HPC in its 2015 SRA is a possible path to put together FETHPC projects R&D outcome together in integrative projects leading to exploitable systems, with the collaboration of application owners and computing centres; but this should not be the only tool to achieve tighter and more consistent programme steering.

In 2016 the organigramme of the Directorate-General for Communications Networks, Content & Technology was reshaped to reflect the new policy priorities and developments (see Conclusion of this report). A as result, a new unit on High Performance Computing and Quantum Technology was established in the Directorate for Digital Excellence and Science Infrastructure. Since July 2016 all three elements of the three pillars of the European HPC strategy (Exascale challenge, Centres of Excellence and PRACE) are managed within this unit, which ensures a priori a strong consistency and single point of strategic vision for the programme.

Regarding “Centres of Excellence” [23]: it must be noted here that there was no specific topical priorities defined for the CoEs; H2020 general topics of societal challenges or focus areas can be considered as the background. CoEs cover important areas such as renewable energy, materials modelling and design, molecular and atomic modelling, climate change, global system science, biomedicine and bio-molecular research, and tools to improve HPC applications performance (POP is a transversal CoE dealing with Performance Optimisation and Productivity and deals with tools and methodologies for application improvement rather than direct application development).

The table below summarises relevant aggregate information on current projects:

# of H2020 calls implemented	3
Avg. time-to-grant	7 months
Total H2020 funding committed	€176.1 million
# of running projects	30
# of projects to start in 2017	2
Projects coordinated by ETP members	12
Participating organisations	321
Unique participations	186
non-ETP members participations	62%
Industry (non-SME) participations	22%

SME participations	11%

Table 5: H2020 HPC cPPP calls implementation statistics

A first check on all running RIA projects was carried out by the European Commission in 2016 assisted by external experts. The purpose was to assess the projects allowing experts to formulate recommendations early on in their implementation and possibly spot any issues and mitigate them.

In the case of Exascale technology projects, it is also possible to measure quantitatively the progress that was made involving industry in this initiative and to assess the impact of the cPPP in raising the visibility of HPC at a European level. Five Exascale projects were funded through a dedicated call during the previous Framework Programme – FP7. In 2015/2106, industry and SME participation in Exascale projects (both in terms of EC contribution and number of partners) increased from about 19% and 2% to 26% and 8.5%, respectively. Overall industry participation has increased by more than 60% and SME participation has increased by a factor of 4.

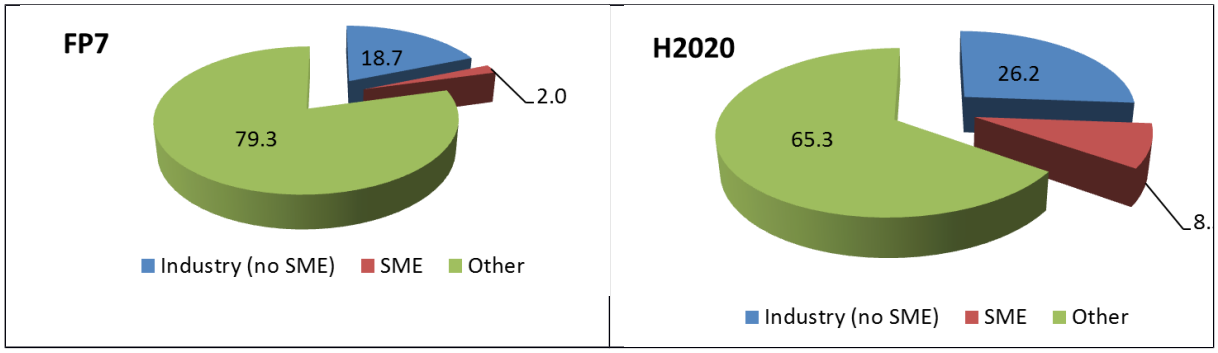

Figure 7: Evolution of industry and SME participation in Exascale projects FP7/H2020

3.2.2 *Performance of HPC technologies developed*

Hardware technologies developed with the support of recent H2020 funding are mostly at the stage of internal project prototypes of small size; there are several ones being setup in 2017.

H2020-funded Mont-Blanc 3 project builds on FP7 MontBlanc 1 and 2 projects; it will set up a system employing Bull's Sequana HPC hardware, which was announced in the fall of 2015 and which is the liquid-cooled hardware platform that the vendor has created to reach exascale. MontBlanc3 is thus quickly converging now towards a productisation in a 'standard' industrial architectural HPC framework [25].

FP7 previous funding on Exascale efforts (predating the cPPP setup) amounted to more than €50 million for 8 projects [24]. In addition to software development, 2 tracks of hardware prototypes arose from resp. DEEP/DEEP-ER and Mont-Blanc 1&2 projects and were made available to project partners and end users as well.

The acquisition of a 5 petaflops booster stemming from DEEP/DEEP-ER R&D has been announced by JSC (Jülich Supercomputing Centre), coordinator of the projects.

The Pre Commercial Procurement of PRACE-3IP was also co-funded under FP7, starting in 2012, for a total budget of €9 million [26]. PRACE announced that three contractors were awarded in the third and final phase of this PCP, started to obtain R&D services which should result in future PRACE HPC systems becoming more energy efficient. The awarded bidders

for the last phase during which the pilot for the three promising solutions will be built and deployed at the hosting centres are European vendors – 2 SMEs and a large company:

- BULL SAS
- E4 Computer Engineering SpA
- Maxeler Technologies Ltd.

The third phase of the execution stage is expected to end in December 2017.

Also worth mentioning in terms of H2020-funded HPC effort not directly related to the HPC cPPP is HBP PCP. The Human Brain Project launched a Pre-Commercial Procurement (PCP) of R&D services for interactive simulation applied to neuroscience applications. The final phase of this PCP ran from July 2015 until January 2017. During this phase, the 2 remaining competitors, Cray and a consortium of IBM and NVIDIA, each delivered a pilot system [27].

3.2.3 *People, education, training and skills development*

Since end of 2015, EXDCI coordination and support action (led by PRACE and co-led by ETP4HPC) developed other actions-for talent generation.

An EXDCI Career Case Studies gallery demonstrates the range of career opportunities that are open to people with HPC skills [28]. These case studies show that the paths that lead people to HPC are many and varied, with some people having a passion for computer programming from an early age, whilst others come via applied scientific domains. Similarly, people equipped with HPC skills will find that their career can move in many different directions.

End of 2016 EXDCI launched a Jobs Portal [29] and a Training Portal [30], carrying job and training offers from organisations around Europe. A convergence with PRACE is considered on these aspects to pool efforts and develop a common entry point.

Since 2008 PRACE has also been instrumental in developing new HPC curricula based upon short training sessions (duration: one to several days) for students and practitioners in the area of HPC, with a positive impact on growing know-how in Europe. This relates to the optimised and better educated use of Tier1 and Tier0 supercomputers, however also to raising technological awareness and fostering new approaches to modelling and simulation. The main vehicles are (detailed statistics can be found on PRACE web site and in PRACE annual reports [9] [32]):

- PRACE Advanced Training Centres (PATC) - have been operational since 2012 at BSC (Spain), CINECA (Italy), CSC (Finland), EPCC, University of Edinburgh (UK), Gauss Centre for Supercomputing (Germany) and Maison de la Simulation (France)
- the International HPC Summer School Seasonal Schools
- End of 2016 PRACE also launched MOOC courses via Future Learn

In the EXDCI 2016 survey (Q2), 18 of the running FETHPC projects specified that they were organising multi-disciplinary activities (like workshops) on their respective topics. The estimated total number of participants in all the workshop and training activities was about 1000 for the year 2016; about 700 for the year 2017 were already foreseen at this time – a preliminary and partial estimate, since it is not expected that the activity would decrease in

2017. Often the training activities of the projects are an addition to the PRACE training activities.

3.2.4 *HPC use*

As already said in section 3.2.2, solutions stemming from previous projects launched at the end of FP7 reached pre-production phase (DEEP, MontBlanc prototypes), with systems of limited size installed and open to users. PRACE 3IP Pre Commercial Procurement (FP7-funded) also led to the deployment of 3 prototype systems.

PRACE – the Tier-0/Tier-1 pan-european eInfrastructure for high performance computing - achievements in this area illustrate the European momentum and potential for future hosting of systems benefiting from cPPP technological developments. The main achievements of PRACE between 2010 and 2016 regarding access to infrastructure and related services, as well as application profiles granted computing cycles, are thoroughly documented on PRACE web pages and in PRACE annual reports [32].

3.2.5 *HPC Software ecosystem*

Software is a crucial aspect of HPC at two main levels:

- 'Internal': the software stack of the supercomputer and its environment (storage etc.) is a key element to make up an efficient solution; from operating system up to programming environments and via various middleware layers
- 'External': the solvers and application codes that run on the supercomputer, used by industrial or scientific users

The EU has acknowledged assets and strengths in both aspects [33][34]. Some European HPC software companies and teams are highly successful in Europe and across the world (scientific and engineering software teams, independent software vendors – ISVs).

Both levels of software are strongly supported and stimulated by the cPPP, through FETHPC projects and Centres of Excellence.

In FETHPC projects almost half of the funding from Work Programme 2014-2015 went to software projects ('internal' software stack but also applications or application building blocks) while more hardware-oriented projects all encompass significant software efforts – software stack elements, or application benchmarks used for co-design, typically). CoEs are naturally focussing on applications or application building blocks.

A complete cartography of contributions of the cPPP programme to the EU HPC software ecosystem is foreseen in the near future; it was not considered relevant or feasible before the mid-term of FETHPC and CoE projects.

3.2.6 *Patent, inventions and contributions to standards in HPC by H2020 funded projects*

From a sample of 9 interviewed companies – incl. 4 EU SMEs – involved in 12 FETHPC (technology) projects, accounting for 26 M€ of H2020 funding – which is most of the cPPP funding going to industry via FETHPC first round of projects, 11 patents were already secured with the help of Work Programme 2014-15 funding.

Many ETP4HPC organisations (from industry as well as from research) are represented in standardisation bodies. The mentioned standard bodies are essentially concerned with parallel programming models or languages (MPI Forum, GASPI Forum, Fortran standardisation

committee, OpenMP ARB), software frameworks for HPC (OpenHPC), file systems (EOFS, Lustre Centre of Excellence).

Standard body	Participating ETP4HPC organisations (from survey)	Participating ETP4HPC or other European organisations (from standard body web page)
MPI Forum	ATOS, BSC, EPCC, HLRS, CEA	INTEL, CRAY, IBM. INRIA. Forschungszentrum Jülich
OpenHPC	ATOS	ARM, BSC, CEA, CINECA, CRAY, DELLEMC, INTEL, LRZ, PARTEC
EOFS	BSC	ATOS, CEA, DKRZ, Eurotech, Forschungszentrum Jülich, INTEL, LRZ, PARTEC, SEAGATE
OpenMP ARB	BSC, EPCC	CRAY, IBM, INTEL
GASPI Forum	Fraunhofer ITWM, KTH	LRZ, DLR
Fortran	STFC	NAG, LRZ, STFC

Table 6: Participation in HPC software standardisation bodies

Some ETP4HPC companies are also active and proactive contributors to HPC related standards on CPU, memory, IO, interconnect and storage, such as OpenFabricsAlliance and JEDEC. Management Aspects of the programme.

3.3 Management Aspects of the programme

3.3.1 *Efficiency, openness and transparency of the PPP Consultation Process*

An “Info Day on Funding Opportunities for High Performance Computing (HPC) in Horizon 2020” was organised in Paris, April 9th, 2014, to launch the cPPP – including presentations on FETHPC call in Work Programme 2014-2015 and on Centres of Excellence. It had 140 participants from 20 EU countries.

The relationship with the EC, structured in the framework of the HPC cPPP, is now well established and on-going. According to Article 4 "Governance" of the Contractual Arrangement (CA) of the HPC cPPP, a Partnership Board (PB) has been established as the main mechanism for dialogue to attain the cPPP objectives. The composition and working rules of the cPPP governance were defined during the first half of 2014. The first Partnership Board took place in June 13th, 2014, in Brussels. PB meetings have been held twice a year since then. From November 2015 onward, the Centres of Excellence were invited to join the cPPP PB meetings. cPPP Partnership Board meetings are co-chaired by the EC and ETP4HPC Chair, with the participation of the ‘private side’: representatives from the ETP4HPC Steering Board, ETP4HPC Office, and representatives of the all the Centres of Excellence in Computing Applications (CoEs); PRACE representatives are also invited.

ETP4HPC is holding one or two General Assemblies per year, inviting all its members (80 as of 2016), EC and other selected guests.

Since 2015 the annual HPC Summit Week organisation gathers all stakeholders of the European HPC ecosystem. This event is supported by EXDCI H2020-funded Coordination and Support Action; PRACE (coordinator) and ETP4HPC join their expertise in this CSA.

The mobilisation of stakeholders inside and around the cPPP is now very strong along several axes:

- ETP4HPC, now in close collaboration with the Centres of Excellence, delivers R&I recommended activities for Work Programmes (recently: 2018-2020 in December

2016 - predating the detailed development of the next ETP4HPC SRA planned in 2017). SRA elaboration involves ca. 200 experts from ca. 60 of the ETP members, from the Centres of Excellence, PRACE, BDVA…the ETP4HPC SRA 2015 final dissemination was done in 2016, then starting preparation of SRA3, and providing intermediate WP18-20 input to the EC in the context of the cPPP;

- the active involvement of the Centres of Excellence in the cPPP governance since end of 2015;
- ETP4HPC own growth: the association was successful in attracting 11 new members in 2015 and 13 more in 2016 - reaching a total of 80 at the end of the year, with 15 industrial companies and 25 SMEs, aside 37 research organisations. The members are from 16 EU+ member states, and encompass 11 international companies;
- further development of actions in the EXDCI coordination and support action (European eXtreme Data and Computing Initiative) – catalysing global exchanges with all stakeholder – incl. European HPC Summit Week 2016;
- strong interlock with BDVA and interactions with HiPEAC:
  - BDVA – Big Data Value Association [14], the private side of Big Data PPP: BDVA participated actively in ETP4HPC and EXDCI technology and application roadmap discussions (e.g. during EXDCI Technical Workshop, of September 2016), and respective roadmaps of ETP4HPC and BDVA entities are cross-referenced;
  - HiPEAC embedded and advanced computing network of excellence [15]: ETP4HPC participated in HiPEAC events, and respective roadmaps of the two entities are cross-referenced;
- liaison with a number of other stakeholders in other regions (USA, Japan, China)via BDEC action and workshops [17] where Europeans are very active with the support of EXDCI.

3.3.2 *Dissemination and Awareness*

ETP4HPC, the EC, and EXDCI have combined actions that serve the global dissemination and awareness efforts of the cPPP and EU HPC programmes. FETHPC projects and Centres of Excellence have their own individual dissemination efforts. EXDCI in particular is a vehicle for better ‘all stakeholders’ events, and helps ensure augmented interaction between projects, while including PRACE and its users in a 360° EU HPC landscape vision.

EXDCI first workshop in September 2015 gathered 80 participants including all COE and FETHPC projects representatives for the first time.
The first edition of the European HPC Summit Week conference in May 2016 in Prague gathered over 300 participants in total. EXDCI organised its workshop that counted for 80 participants including all FETHPC projects and CoEs; the Summit also encompassed PRACE Days. The European HPC Summit Week conference is now planned annually.
EXDCI and ETP4HPC web sites and other social media activities serve and amplify the dissemination and awareness efforts of FETHPC and COE projects.
In particular:

- DGCNECT developed a single point of access to all information about the EC HPC strategy, work programmes and HPC related news Error: Reference source not found

and is also using Digital4Science platform for various community participation and information actions [19]

- PRACE website is continuously enriched [20] for the purpose of both PRACE aisbl and PRACE IP projects activities and general computational science community information
- ETP4HPC pursued the evolution of their website with a better visibility of the HPC cPPP in a dedicated branch [21]
- EXDCI and Eurolab-4-HPC web pages also play cross-cutting community roles

3.4 Summary of main KPI figures and facts

	Perspective	Key Performance Indicator (KPI)	
1	Industrial Competitiveness and Socio-Economy Impact	Global market share of European HPC	• from 4.4% in 2013 to 4.9% in 2016, showing positive momentum prior to HPC cPPP effects (to be measured later than current mid-term of first H2020 projects)
2	Industrial Competitiveness and Socio-Economy Impact	HPC additional investments	• EU ecosystem yearly R&D effort est. at least in the range of 165-210 M€ in HPC technologies and 150-225 M€ in Other HPC R&D • Est. 4-fold leveraging factor for industrial effort per public euro in the cPPP
3	Industrial Competitiveness and Socio-Economy Impact	Jobs	• 61 jobs creations in HPC technology industry for the first 26 M€ of H2020 funding
4	Industrial Competitiveness and Socio-Economy Impact	Innovation Environment in HPC (European HPC start-ups – creation – growing…)	• Several SME acquisitions by large companies • 2 SMEs bringing FP7 HPC R&D to the market
5	Operational aspects of the programme	Research programme effectiveness and coverage	• 3 calls implemented, 19 FETHPC projects, 2 CSAs, 9 CoEs running (30 projects for 141 M€ + 2 forthcoming for 35 M€) • 321 participating organization • 62% non-ETP members participations • 33% of industry participation (11% SME and 22% non-SME)
6	Operational aspects of the programme	Performance of HPC technologies developed	• FETHPC only led to internal prototypes for the time being • FP7 MontBlanc and Deep prototypes deployed • DEEP production Booster to be installed in FZJ • MontBlanc3 prototype will bring ARM-based processors into commercial SEQUANA architecture
	Operational aspects of the programme	People, education, training and skills development	• 6 PRACE Advanced Training Centres • Ca. 1000 participants in FETHPC and CoE projects training sessions and worlshops

8	Operational aspects of the programme	HPC use	• FP7 projects DEEP, MontBlanc prototypes open to user communities
9	Operational aspects of the programme	HPC Software ecosystem	• To be further elaborated
10	Operational aspects of the programme	Patent, inventions and contributions to standards in HPC by H2020 funded	• 11 patents secured with the help of 26 M€ of Work Programme 2014-15 funding
11	Management aspects of the programme	Efficiency, openness and transparency of the PPP Consultation Process	• Info Day April 2014 at the launch of HPC cPPP (140 participants from 20 EU countries) • 2 cPPP Partnership Boards per year since June 2014 (ETP4HPC members and CoE representatives seat on the private side) • 1 or 2 ETP4HPC General Assemblies per year • ETP4HPC Strategic Research Agenda involves ca. 200 experts
12	Management aspects of the programme	Dissemination and Awareness	• HPC Summit Week conference in May 2016 in Prague gathered over 300 participants in total • DGCNECT's single point of access to all information about the EC HPC strategy and work programmes • ETP4HPC website gathers community news and information - HPC cPPP in a dedicated branch • PRACE web site for community information, as well as EXDCI and Eurolab-4-HPC web pages

Table 7: Key Performance Indicators for the HPC Ecosystem BSC

4 Conclusion and next steps

This report positions HPC cPPP monitoring early elements in the perspective of a more general Balanced Score analysis to come, planned at the end of EXDCI. H2020 projects scrutinised for the 2016 progress report had indeed been running for 12 to 18 months only at the time surveys, data collection and interviews were performed; whereas other activities regarding ecosystem development and stakeholders mobilisation started a bit earlier in 2014 – and 2013 for ETP4HPC real activation and first SRA elaboration.

As of this mid-2017 standpoint, EU HPC global ecosystem has gained an important momentum and made significant qualitative progress in terms of organisation, stakeholder mobilisation, project and related consortia dynamics. More quantitative effects of the H2020-funded projects can already be observed, despite the very early stage of funding engagement and use (ca. 25% of the cPPP EC funding engaged but ca. 10% only effectively used within the project consortia). Stakeholders from the industry (large companies and SMEs) have also taken a much more active role in the programme, compared with FP7 HPC programmes, which were smaller and not structured into a cPPP.

In 2016 and then in 2017, major new policy developments in the area of EU High Performance Computing have taken place. Back in 2012 the European Commission already recognised the need for an EU-level policy in HPC to optimise national and European investments, addressing the entire HPC ecosystem:

- In order to strengthen European HPC value- and supply-chains and exploitation of research and innovation actions, the European Commission published a Communication on the "European Cloud Initiative – “Building a competitive data and knowledge economy in Europe", part of the Digitising European Industry strategy, that was adopted on 19 April 2016 and endorsed by the European Council in June 2016. The initiative aims to create, together with the EU Member States and European industry, a world-class European Data Infrastructure, that will gather the necessary resources and capabilities to close the chain from research and development to the delivery and operation of the exascale HPC systems co-designed with users and suppliers.
- At the Digital Day in March 2017 [22], which was part of the celebrations marking the 60th anniversary of the signature of the Treaties of Rome in March 2017, seven EU governments (Germany, France, Italy, Spain, Luxembourg, Netherlands and Portugal) signed a declaration of European cooperation on HPC – since then Belgium joined the agreement. They agreed to work towards the establishment of a cooperation framework – EuroHPC – for acquiring and deploying an integrated exascale supercomputing infrastructure that will be available across the EU for scientific communities as well as public and private partners.

Future impact assessment of the HPC cPPP will be achieved in the context of this favourable evolution and construction. The Balanced Score Card approach will be more extensively developed with the same mapping of HPC cPPP KPI onto perspectives and the definition of goals per perspective.

5 Annexes

5.1 HPC cPPP KPIs reminder

Based on the Multi-Annual Roadmap of the HPC cPPP and Partnership Board discussions, the following list of HPC cPPP KPIs was validated during the cPPP Partnership Board of November 2014.

Key Performance Indicators (KPIs) for the HPC PPP

A. Indicators for Industrial Competitiveness and Socio-Economy Impact

- ***KPI 1: Global market share of European HPC***
- ***KPI 2: HPC additional investments***
- ***KPI 3: Jobs***
- ***KPI 4: Innovation Environment in HPC***

B. Indicators for the operational aspects of the programme

- ***KPI 5: Research programme effectiveness and coverage***
- ***KPI 6: Performance of HPC technologies developed***
- ***KPI 7: People, education, training and skills development.***
- ***KPI 8: HPC use***
- ***KPI 9: HPC Software ecosystem***
- ***KPI 10: Patent, inventions and contributions to standards in HPC by H2020 funded projects***

C. Indicators for management aspects of the programme

- ***KPI 11: Efficiency, openness and transparency of the PPP Consultation Process***
- ***KPI 12: Dissemination and Awareness***

5.2 Quotes from interviews with industrial partners of FETHPC consortia

During the interviews performed during Q1 2017 by IDC/Hyperion with a group of companies (SMES or larger companies, European or international) participating in FETHPC projects, a number of quotes were collected.

R&D directions
"This is a new R&D direction we have never tried before. We'd been developing the software for a few years, but adapting it for exascale is a new direction." "We are contributing mainly an application we started work on 1.5 years before, but which we really couldn't pursue seriously until the Horizon funding arrived." **[SME]**

Importance of the HPC Work Programme Funding for the Participants' Research
"It's extremely important for our future. It's absolutely critical, because adapting our software for exascale requires working closely with the European HPC community. The Work Program isn't just the money, it's even more importantly about bringing all the European players together to pursue common goals that none of us could effectively pursue alone." "The funding is important because it allows us to integrate technologies from various partners in the project. We have made significant advances. It's allowed us to do a co-design approach with software partners in ETP4HPC and customers. The level of cooperation and co-development is much deeper than in usual projects so we can much better understand applications requirements and gain much more insight into computational outflows in the overall systems and to optimize architectures and development, so the importance is about access to the HPC technology, but the main benefit is the co-development/co-design approach that brought us together with other interested parties within Europe." "We're in a small European country where Horizon is the only source of funding we can tap for things like this. Banks here won't give us funding because of the financial crisis during the last four years in our country. You can't even borrow money anymore, much less find venture funding." **[SME]** "H2020 funding is extremely important for our future. Without it, we as an SME could not have afforded to engage in vital R&D with no short-term commercial value." **[SME]**

Course of Action Without Work Programme Funding
"Without the HPC Work Program funding, we would not have been able to pursue this R&D initiative, which is about how to improve algorithms for use on exascale supercomputers. It's at TRL 6 or 7." "We would not have pursued this R&D initiative. As a business, we would have been more product focused and would not have been able to afford this much R&D that really helps us as a smaller European supplier to jump ahead competitively. We'd have had to rely on our existing technology and knowledge." **[SME]** "We would have pursued this R&D initiative on a more limited basis and less effectively. It would have been delayed and more limited in scope. The Work Program funding has greatly accelerated the R&D." **[SME]** "We would have pursued this R&D initiative on a more limited basis. We may not have taken as much risk without the public funding, and we would have been slower and later in our R&D and the adaptation of our hardware to applications needs wouldn't have been as deep."

Leveraging Work Programme Funding by Adding Your Own Funds

"We're already begun investing in the product that's been made possible by the EC funding. It will be our flagship product and I estimate we will invest another million euros to get this to market, which is a lot for an SME like us." **[SME]**

"The substantial additional money we will add is for post-project productization that will require a significant effort, especially in QA/certification and manufacturing readiness. We will add roughly 3-4x what we received from the Horizon program."

"We don't need more funding, but the Horizon funding enabled us to leverage 1.5 years of work that happened before the project started. Without Horizon funding that time would have been wasted."

"We are investing an additional €1.5 million, about the same as the H2020 funding amount." **[SME]**

"Yes, we added funding. We will add two times the funding of the project to bring the product to market."

Importance of H2020 HPC Work Programme Funding

"It's a forcing factor for us to collaborate with European players that we might not otherwise collaborate with. 100% funding by the EC makes internal selling easier. Our team is also interested in external feedback we are getting through participation."

"The H2020 Work Program is very important. It's a really cool program. It's important for investing in the future. The impact goes far beyond HPC, even for our company, but HPC is where customers will first buy and test it. The program is really important, because it promotes longer-term technology development rather than the short-term R&D companies are forced to focus on." **[SME]**

"It's very important, primarily because private funding can help achieve only so much. Private funding can be gotten for very focused, short-term things, but if you're trying to build a next-generation supercomputer, getting private funding is unlikely and if you get it, it will be short-term and for specific goals only, not for something that goes out to 2023-24. This public funding is essential for bigger, longer-horizon R&D initiatives that can advance Europe's global position in technology innovation."

"It is very important. It helps cover risks for companies and lets us start R&D earlier and do things in a consortium that brings parties from different parts of the ecosystem together." **[SME]**

"This is the only program that funds European SMEs like ours. There is no other way for us to get funding and have a chance to collaborate with European industries. It would be a nightmare otherwise to ty to cooperate like this all across Europe." **[SME]**

"It's much better than FP7 for SMEs like us. The administrative staff have been very helpful. Europe is moving in the right direction with a program like this. This lets you do things that are very close to the commercial market." **[SME]**

"It is very important, so important if the Horizon work program had not funded this, we would have had to find another way to pursue this activity and that would have been very difficult."

What Specifically Did the Funding Enable You to Accomplish?
"The number one idea is to work closely with the European HPC ecosystem to develop new intellectual property – the parties combine their knowledge in a way that helps the companies and European HPC. The big idea is cooperating across Europe." "We already have some cooling technology, but lots of new R&D has occurred under the project. It's enabled our company to consider what electronics would look like if designed for liquid cooling and to advance innovation in liquid cooling. H2020 funding has brought us lots of new learning and new technology tools. We've achieved quite a bit within this project. From our perspective, the learning and results have been more valuable than we ever expected." **[SME]** "We achieved the first ARM V8 implementation. We have been able to explore a new architecture that is crucial for our future R&D investments, and we've been able to deeply study the software and make important modifications that will be important for designing algorithms and optimizing applications for efficient use on highly parallel computers." "We have ported our app to a highly parallel system. The app has to do with oil well modeling and simulation. With our app, we put it into a different language to run on GPU clusters and have achieved a speedup of 50x so far. It's our client's cluster for whom we're developing the app. The client won't own the app, just have a license, not an exclusive license. We can sell it to others." **[SME]** "There are several elements to this project that span the entire range of the TRL model, from basic architectural development to commercialization. Ultimately this was about helping ARM develop the IP for an HPC-based ARM processor architecture that will be usable and ready for the market." "A key benefit of the project was that that it drove the independent development of a technology rather than existing as a single procurement of a finished system by an established HPC vendor. This offers the promise of much broader benefits for European HPC and for the research." "For us as a company, we use this FPGA technology in our main market for ASIC prototyping for chips. Our goal is for our technology to apply to the HPC market and for us to become a European HPC supplier." **[SME]**