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COVER NOTE

From:	Secretary-General of the European Commission, signed by Mr Jordi AYET PUIGARNAU, Director
date of receipt:	11 January 2018
To:	Mr Jeppe TRANHOLM-MIKKELSEN, Secretary-General of the Council of the European Union
No. Cion doc.:	SWD(2018) 6 final - Part 2/4
Subject:	COMMISSION STAFF WORKING DOCUMENT IMPACT ASSESSMENT Accompanying the document Proposal for a Council Regulation on establishing the European High Performance Computing Joint Undertaking

Delegations will find attached document SWD(2018) 6 final - Part 2/4.

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EUROPEAN
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PART 2/4

COMMISSION STAFF WORKING DOCUMENT

IMPACT ASSESSMENT

Accompanying the document

Proposal for a Council Regulation

on establishing the European High Performance Computing Joint Undertaking

{COM(2018) 8 final} - {SWD(2018) 5 final}

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ANNEX 1:

PROCEDURAL INFORMATION

The initiative is led by DG CONNECT. The agenda planning reference is PLAN/2017/1304. The initiative on establishing EuroHPC was included in the Commission Work Programme for 2017.

The Impact Assessment was prepared by DG CONNECT and was closely coordinated with the Inter-Service Steering Group (ISG). In 2017, three meetings of the ISG were held. The first meeting took place on 28th July 2017, attended by DG CNECT, RTD, GROW, JRC, and the Secretariat General (SG). The second meeting was held on 21st September 2017, attended by representatives from DG CNECT, RTD, GROW, JRC, LS and the Secretariat General (SG). This was the last meeting of the ISG before the submission to the Regulatory Scrutiny Board on 27 September 2017. The third ISG meeting was held on 13th November 2017, focusing on the Draft Regulation for a EuroHPC Joint Undertaking. It was attended by representatives from DG CNECT, RTD, JRC, LS and the Secretariat General.

1. Recommendations of the Regulatory Scrutiny Board

The Regulatory Scrutiny Board (RSB) of the European Commission examined the draft Impact Assessment on 25 October 2017 and issued a positive opinion with reservations. These were addressed as follows:

RSB recommendations	Modification of the IA report
The report is not clear enough with regard to what decisions it is supposed to inform and what timing it covers.	*The report was redrafted to a large extent to describe what the decision sought is about and what are the problems that the decision will have to address. It focuses only on the decision related to setting up a self-standing joint structure that would operate with funding from this MFF, without depending on possible funding decisions of the next MFF. All the objectives that this joint structure will have to reach have been were re-written accordingly and the sections (e.g. sections 5 and 6) affected were revised.*
The report does not build sufficiently on past experiences and lessons from earlier applied research projects, such as Galileo, JUs, ERICs, or ECSEL.	*The report summarises existing activities and experiences built in when implementing the Union's HPC strategy since 2012. Wherever relevant, experiences were included from implementing past instruments such as JUs, ERIC or ECSEL and their applicability on the joint HPC structure and/or in running its operations.*
The report does not provide enough information about how the joint entity would operate. This makes it hard to judge how likely the public-private partnership	*This is now explicitly covered in particular in sections 4 and 8 of the revised Impact Assessment.*

is to deliver well on its different objectives.	
The report does not adequately present the views of the different groups of stakeholders.	*The analysis of the targeted consultation was expanded, detailing the responses per group of stakeholder – see Annex 2.*
The report should be refocused on the decision it is meant to inform, which is the legal form of the joint entity. The report needs to streamline its presentation of context and scope, and set these out vis-a-vis the decision at hand. The report should clarify relevant aspects of funding and the legal base. It should explain the purpose of the decision and why this needs to be taken now.	*In the introduction of the revised Impact Assessment the scope and context of the decision sought were re-expressed. In the same section a paragraph was added outlining the funding aspects. The need to act now is highlighted in a new section 3.1. Funding issues were clarified in the same section.*
The report should clearly explain that the current decision only covers the first phase (pre-exascale) and that this is a self-standing project. It should explain how this will not pre-empt the decision (or the financing) of the next step of the exascale HPC.	*In section 1 of the Impact Assessment a paragraph was introduced summarising that the decision is about setting up a self-standing joint structure that would operate with funding from this MFF, without depending on possible funding decisions of the next MFF. All the objectives that this joint structure will have to reach were re-written accordingly (section 4) and the other affected sections (e.g. sections 5 and 6) were revised.*
The report should better describe how the joint structure would work. This includes how it is to be funded, private and public participation, nature of activity and exit strategies. What is this structure supposed to do over time, and what would be its governance structure? Who should be partners and what are the criteria for the participation of private parties? What is the envisaged (exit) strategy when the HPC machines become obsolete? The report should also clarify the relations with third countries and what is meant by an 'indigenous' European project. The assessment criteria for the different legal options should reflect the functionalities that the envisaged structure would require. The intervention logic should adequately reflect the narrow scope of the decision at hand. A number of ambiguities and unnecessary complexities can	*Both the objectives and the specific objectives of the joint structure were revised (Section 4) and a new section (4.2) was introduced to describe in detail the functionalities that the joint structure should fulfil. Section 5 (available policy options) was partly rewritten and all options are now compared against the functionalities which should be fulfilled by the joint structure. Section 4.2 and section 8 (describing the preferred option) provide the requested details on the functioning of the joint structure (activities, partners, governance structure, exit strategy, etc.).*

therefore be removed.	
Given this narrower approach, there is no need to justify the decision to jointly invest with the Member States on HPC capability, except in terms of background and context. Repeated arguments on this can be placed in an annex or dropped.	*The background and context sections were rewritten to a large extent. The whole Impact Assessment document was streamlined, removing redundancies.*
The report should make clear that the project rests on a model that has already been tested and evaluated. In assessing which legal form is the most suitable, the report should review lessons learnt from past experiences about legal forms and pre-commercial procurement. It could usefully draw on experiences with such applied research projects as Galileo, previous JUs and ERICs, and the ECSEL joint undertaking.	*In section 5 of the Impact Assessment, describing the options, lessons learnt from past experiences with handling joint entities like ERICs or JUs (incl. ECSEL), were inserted.*
The report should clarify in which ways the joint entity will overcome existing barriers for applied research on coordination and synchronisation of Member States' research and HPC activities, in terms of open calls for research grants, and in terms of pre-commercial procurement and IPR rules.	*The redrafted sections 4 (Objectives) and 8 (preferred options) of the Impact Assessment clarify and detail how the joint structure will overcome existing barriers.*
The monitoring section should explain what success would look like. It should define some measurable success criteria, which could be divided into direct operational criteria for the HPC activity undertaken in itself and the wider indirect benefits for broader research and innovation in Europe.	*The success criteria were redefined to include measurable criteria, addressing both the HPC activities undertaken, as well as the wider benefits for research and innovation.*
The report should expand on how different groups of stakeholders have responded to the different options, highlighting both support and any concerns.	*The analysis of the targeted consultation was expanded, detailing the responses per group of stakeholder (Annex 2). This detailed breakdown reveals a large consensus among the different stakeholder groups. Where relevant, citations were included in the Impact Assessment.*

2. Evidence Base for the Impact Assessment

The Commission gathered qualitative and quantitative evidence from various recognised sources of the EU institutions:

- The *European Cloud Initiative (ECI)*[1] adopted by the Commission (EC) on 19 April 2016 as part of its Digitising European Industry strategy;
- The Communication adopted by the European Commission in April 2016 on the ECI[2] and underlying analytical study[3];
- The European Investment Bank study *Access-to-finance for European Cloud and High Performance Computing*[4];

Quantitative figures and arguments that have been used from other relevant officially recognised data sources include:

- Partnership for Advanced Computing in Europe (PRACE) official annual reports and data therein[5];
- The US Department of Energy program Advanced Scientific Computing Research (ASCR) statistics and data[6];
- Top 500 initiative's list of world's best supercomputers[7];
- STATISTA statistics and databases[8];

In addition, views were sought from the following type of stakeholders considered to represent to the best reasonable extent the European HPC community:

- National and EU-funded projects on HPC (*Projects*),
- Scientific user communities of HPC infrastructures (the 29 large ESFRI research infrastructures and the PRACE scientific users, each reaching hundreds of actors, EUDAT, EGI, etc.) *(Scientific Users)*,
- Public-private partnerships on HPC and Big Data (*PPPs*),
- Centres of excellence for supercomputing applications, supercomputing centres, service providers, access providers (*Intermediaries*),
- HPC research & industry associations (*Associations*),
- Member State & governmental institutions (*MS*).

The goal was to reach all identified stakeholders and elicit their contributions on time with respect to the further process of the planned development of the EuroHPC Regulation.

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[1] COM(2016)178

[2] SWD accompanying the ECI Communication: COM(2016)178

[3] High-Performance Computing in the EU: Progress on the Implementation of the European HPC Strategy, Report of a study carried out for the European Commission, IDC, 2015

[4] EIB study

[5] Available at http://www.prace-ri.eu/

[6] Available at https://science.energy.gov/user-facilities/user-statistics/data-archive/

[7] Available at https://www.top500.org/

[8] Available at https://www.statista.com

An on-line targeted consultation was conducted through the DSM website of the European Commission between 3 August and 5 September 2017[9].

This consultation represented only the last step in a wider series of workshops and meetings with a wide range of relevant stakeholders that started in 2016 in which the European HPC strategy was already presented and discussed according to its status at that time, as follows:

Stakeholder engagement activity	*Scientific Users*	*MS*	*Projects*	*PPPs*	*Interme-diaries*	*Associ-ations*
Workshop on the European micro-processor on 18 January 2017 in Brussels						
General assembly of ETP4HPC on 21 March 2017 in Munich						
Digital Day of 23 March 2017 in Rome in the presence of 250 HPC stakeholders						
Workshop on EuroHPC governance in Rome on 23 March 2017 with 50 participants						
PRACE days on 15-18 May 2017 in Barcelona, gathering the whole HPC community						
Six meetings with the Sherpas of the Member States						
European Open Science Cloud summit on 12 June 2017 in Brussels						
Multiple meetings with key stakeholders (PRACE, ETP4HPC, visits to supercomputing centres, international conferences…)						

The quality of the studies can be considered high as they represent the currently best available information on HPC in Europe and globally, originating mostly directly from the HPC practitioners (e.g. official PRACE (EU) and ASCR (US) statistical figures).

[9] https://ec.europa.eu/eusurvey/runner/Eurohpc

Annex 3

Who is affected by the initiative and how?

This annex describes the practical implications of a joint structure at European level.

The analysis follows the structure by the group of stakeholders that are likely to be directly or indirectly affected by the initiative.

MEMBER STATES

Member States are expected to significantly benefit from the initiative. The EuroHPC initiative will enable Member States to coordinate together with the Commission their HPC investments and strategies. The end goal is to establish in the EU a world-class HPC and data infrastructure that Member States on their own cannot afford –in particular those with little or no significant HPC resources in place. No single country in Europe has the capacity to sustainably build and maintain such infrastructure and develop the necessary human and technological ecosystem. Pooling and rationalising efforts at EU level is a must.

The initiative will allow the joint procurement of world-class HPC machines, providing all Member States access to supercomputers with a performance comparable to the best machines in the world. These machines, integrated in a pan-European infrastructure, will be available to the scientific and industrial researchers and the public sector independently of their location. The increased availability and accessibility of top HPC resources will motivate the users to keep their activities and data in Europe, helping to keep critical know-how and human potential in Member States.

Member States will benefit from a world-class competitive infrastructure to provide improved public services and to support key policy making, e.g. strategic decision-making for energy, smart cities, civil protection or climate change. HPC has also become indispensable for maintaining national sovereignty and in the context of national security applications. Supercomputers are in the first line of the increasingly critical areas of cyber-war and cyber-criminality, helping to prevent and fight today's sophisticated cyber-attacks and security breaches, insider threats and electronic fraud. Increased availability of HPC resources will thus have a positive impact on the security of Europe.

UNIVERSITIES AND RESEARCH CENTRES

Access to world-class HPC capabilities has become fundamental to conduct innovative and leading-edge science. Modern science relies heavily on shareable research data, open data analysis tools and connected supercomputing computing facilities. Europe's researchers have to be able to access HPC resources irrespective of their geographical location or scientific discipline. EuroHPC will provide our universities and research centres with a world-class infrastructure, ensuring a European-wide access to supercomputers and data with a guaranteed high level of resources, thanks to a legal infrastructure that ensures the sustainability and availability of resources in the short, medium and long terms. This factor is critical to ensure that our academic and scientific potential stays in Europe and is not exploited in other regions with more competitive HPC and data facilities.

With the implementation of the European HPC strategy scientific cooperation in the EU will become easier, particularly multi-disciplinary cooperation based on big- data. A pan-

European leading infrastructure will consolidate the already existing vibrant mix of national, regional and pan-European initiatives in intra-EU collaboration, and will provide EU-based teams with powerful resources to strengthen the European participation in international HPC-supported scientific collaborations extending far beyond Europe – notably the Intergovernmental Panel on Climate Change (IPCC), the International Thermonuclear Experimental Reactor (ITER), and the Square Kilometre Array (SKA) project.

INDUSTRY INCLUDING SMEs

In industry, HPC enables traditional computational-intensive sectors to significantly reduce R&D costs and development cycles, and to produce higher quality products and services, for example in manufacturing and engineering industries (e.g. automotive, aerospace), health and pharma (e.g. drug discovery), energy (e.g. discovery of oil and gas resources, renewable energy generation and distribution). HPC also paves the way for new business and innovative applications in high added-value areas (e.g., in personalized medicine, bio-engineering, smart cities/autonomous transport, etc.), reinforcing the industrial innovation capabilities, in particular of SMEs.

The new initiative will revitalise the European HPC ecosystem, where industry and in particular SMEs will benefit as both users and suppliers of HPC technology and applications.

- **As users;** Europe is leader in many HPC-empowered applications. EuroHPC will consolidate this leadership position, providing an enhanced HPC infrastructure with more resources for industrial use accessible at EU level, complemented with specific measures to widen the usage of HPC technologies. This is of critical importance to industry and particularly SMEs without in-house capabilities that will benefit from easy to use HPC resources, applications and analytics tools to create new innovative products and processes.
- **As suppliers;** a European-wide initiative with a focus on the supply of a European source of HPC technology such as EuroHPC will have the necessary critical mass and a catalytic effect on the European suppliers. EuroHPC will provide a clear roadmap for technological implementation of leading-edge technologies in Europe and their integration in European systems, providing a unique opportunity for industry, including SMEs, to participate in the co-design and development of such new technologies and systems, and to develop IPR and solutions to be further used in their business endeavours. The benefits of this IPR will not be limited to HPC, but will span to broader sectors such as e.g. the ICT market within a few years of their introduction in high-end HPC – giving a competitive advantage to those developing them at an early stage.

  As an example, there is a dynamic European independent software vendors (ISV) supply chain in Europe that is still competitive world-wide. To remain competitive European-based ISVs and European software developers and owners have to participate in the design of next-generation HPC systems, understand the critical software requirements that these new hardware platforms engender, identify and define technical specifications for various elements of an emerging exascale software stack, glean best case situations for collaborative efforts among various ISVs and develop early on a sense of leading EU-based exascale architectural and algorithmic development efforts. This close link between European hardware and software industries will strongly be fostered by EuroHPC.

<u>EUROPEAN COMMISSION</u>

The EuroHPC initiative would positively impact the workings of the European Commission. Currently, some the activities that EuroHPC will undertake are implemented through four different work-programmes (e-infrastructures, FET, and LEIT in Horizon 2020, and through the Connecting Europe Facility annual Calls). This implementation of the HPC strategy is particularly complex (e.g. discussion with four committees, synchronisation of budgets and activities with diverse budgetary and time constraints, etc.). The EuroHPC will provide a single structure to coordinate the different activities in synergy, and more importantly, will provide a single forum for strategic discussions with Member States and leverage EU and national efforts and resources.

HPC is becoming critical for an increasing number of applications. EuroHPC will be a privileged interlocutor for institutions, agencies and bodies addressing critical scientific, industrial or social-impact areas. EuroHPC will become a focal point for better supporting the EU policy development and implementation in areas like digitising industry (Digital Single Market), security, and many other related to societal challenges.

<u>SUPERCOMPUTING CENTRES</u>

Several European supercomputing centres that host the most powerful supercomputing infrastructures in Europe (e.g. the PRACE Tier-0 systems) enjoy a world-wide reputation. These centres not only operate HPC infrastructure but possess a very wide set of human capital and expertise –ranging from technological development, to academic excellence and research, and support to industry and SMEs). EuroHPC provides the opportunity to fully exploit this valuable asset in a synergetic way, encompassing the co-design and integration of technology with a coordinated procurement of supercomputers at European level. EuroHPC will provide the appropriate frame to strategically plan for the further development of these centres, for example with a necessary European-wide planning of the different architectures across Europe (avoiding isolated and uncoordinated procurements that may end up in dependencies on single vendors and technological suppliers).

In addition, the EuroHPC initiative will support the federation of these top-leading centres with a wider range of national (Tier-1) and regional (Tier-2) centres, providing a real pan-European infrastructure capable of responding to the increasing demands of scientific, industrial, public sector users, and other stakeholders.

<u>CITIZENS</u>

A true European coordinated effort such as EuroHPC will make sure that world-class HPC resources and data are available for applications that are of direct interest for citizens. Citizens expect sustained improvements in their everyday life while at the same time society is confronted with an increasing number of complex challenges – at the local urban and rural level as well as at the planetary scale. Policy makers need tools to make better decisions HPC has become indispensable to transforming these challenges to innovation and creation of business opportunity, thanks to its ability to process large amounts of data and carry out complex computations. Responding to these challenges will create innovation and therefore the growth and jobs that the EU economy needs.

Given the inter-disciplinary nature of HPC and the wide range of scientific and industrial applications, citizens will benefit from an increased level of resources provided by EuroHPC in areas like:

- Health, demographic change and wellbeing: the development of new therapies will heavily rely on HPC for understanding the nature of disease, discovering new drugs, and customising therapies to the specific needs of a patient
- Secure, clean and efficient energy: HPC is a critical tool in developing fusion energy, in designing high performance photovoltaic materials or optimising turbines for electricity production.
- Smart, green and integrated urban planning: the control of large transport infrastructure in smart cities will require the real time analysis of huge amounts of data in order to provide multivariable decision/data analytics support in your mobile or car.
- Climate: HPC underpins climate study and prediction (weather forecast, catastrophes prevention and civil protection planning, etc.).
- Food security, sustainable agriculture, marine research and the bio-economy: HPC is used to optimise the production of food and analyse sustainability factors (e.g. plagues and diseases control, etc.).

3RD COUNTRY ACTORS

Successfully building a European HPC ecosystem will have an effect on the non-EU supply industry. The availability and large take-up of European technology in the next generations of European supercomputers would decrease their market share of HPC components and systems in Europe, potentially worldwide if the European machines prove to be more competitive. A knock-on effect on the micro-electronics mass market could also be expected, as the downsizing of the HPC components for applications like the autonomous and connected car or the internet of things, would foster the position of European suppliers in this market segment also.

The increased protection of European IPR resulting from the R&I programmes supported by the EuroHPC, may deprive the non-EU suppliers of European know-how and competences in the design of supercomputers. Currently, non-EU suppliers take advantage of EU programmes to export the resulting IPR and improve their domestic developments.

Provided access conditions on equal terms become a global practice, the European HPC resources could become attractive for scientists from outside the EU, sending their data for processing to Europe. The risk Europe currently faces with losing its data sovereignty may thus be reversed.

ANNEX 4

STAFF AND BUDGETARY ESTIMATES FOR THE EURO HPC JU OPTION

A. STAFF

A first estimation of the staff needed to run the EuroHPC Joint Undertaking is presented below:

	Temporary Agent Administrator Grade (TA AD)	Contract Agent (CA)	Seconded National Expert (SNE)	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**
Directors' office											
Executive Director	X			1	1	1	1	1	1	1	1
Executive Assistant		X		1	1	1	1	1	1	1	1
Operations											
Head of programmes	X			1	1	1	1	1	1	1	1
Programme Officer	X			1	3	3	3	3	2	2	0
Assistant		X		1	1	1	1	1	1	1	1
Accounting & Finance											
Head of A&F (accountant)	X			1	1	1	1	1	1	1	1
Financial assistant		X		1	2	3	3	3	2	1	0
Administration											
Legal Officer	X		X	1	2	2	2	1	1	1	1
Administrative assistant		X		1	1	1	1	1	1	0	0
HR assistant		X		1	1	1	1	1	1	1	1
Secretariat		X		1	1	1	1	1	1	1	1
Total				**11**	**15**	**16**	**16**	**15**	**13**	**11**	**8**
	TA AD			4	4	4	4	4	4	4	3
	CA			7	10	11	11	11	9	7	5
	SNE			0	1	1	1	0	0	0	0

B. BUDGET

a) Commitment appropriations (M€)

This table presents the EU commitment appropriations. It should be noted that the amounts under title 3 (operational budget) will be complemented by equivalent amounts from the EuroHPC Member States. The total volume of operations is therefore of 2x476M€ = 952M€.

	2019	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**Total**
Title 1 - Staff Expenditure	**1.16**	**1.448**	**1.586**	**1.586**	**1.566**	**1.338**	**1.258**	**1.12**	**11.062**
11 Salaries & allowances	1.04	1.318	1.456	1.456	1.456	1.248	1.178	1.04	10.192
- of which establishment plan posts	0.69	0.828	0.966	0.966	0.966	0.828	0.828	0.69	6.762
- of which external personnel	0.35	0.49	0.49	0.49	0.49	0.42	0.35	0.35	3.43
12 Expenditure relating to Staff recruitment	0.04	0.04	0.02	0.02	0	0	0	0	0.12
13 Mission expenses	0.06	0.07	0.08	0.08	0.08	0.07	0.06	0.06	0.56
14 Socio-medical infrastructure & training	0.02	0.02	0.03	0.03	0.03	0.02	0.02	0.02	0.19
Title 2 - Infrastructure and operating expenditure	**1.185**	**1.235**	**1.345**	**1.355**	**1.405**	**1.395**	**1.345**	**0.935**	**10.2**
20 Rental of buildings and associated costs	0.3	0.35	0.45	0.45	0.5	0.5	0.45	0.04	3.04
21 Information and communication technology	0.08	0.08	0.09	0.09	0.09	0.08	0.08	0.08	0.67
22 Movable property and associated costs	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.08
23 Current administrative expenditure	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.12
24 Postage / Telecommunications	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.08
26 R&D support (evaluations and reviews)	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	3.2
27 Innovation	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.08
28 Communication	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	2.4
29 Audits	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.53

	2019	2020	2021	2022	2023	2024	2025	2026	Total
Title 3 - Operational expenditure	**196**	**280**	**0**	**0**	**0**	**0**	**0**	**0**	**476**
R&D									
H2020 FET	68	100							168
H2020 RI	8								8
H2020 LEIT ICT	120								120
Procurement									
H2020 RI		80							80
CEF		100							100
TOTAL EXPENDITURE	**198.345**	**282.683**	**2.931**	**2.941**	**2.971**	**2.733**	**2.603**	**2.055**	**497.262**

b) Payment appropriations

	2019	2020	2021	2022	2023	2024	2025	2026	Total
Title 1 - Staff Expenditure	1.16	1.448	1.586	1.586	1.566	1.338	1.258	1.12	**11.062**
Title 2 - Infrastructure and operating expenditure	1.185	1.235	1.345	1.355	1.405	1.395	1.345	0.935	**10.2**
Title 3 - Operational expenditure	98	198.8	103.6	47.6	28	0	0	0	**476**
Total	**100.345**	**201.483**	**106.531**	**50.541**	**30.971**	**2.733**	**2.603**	**2.055**	**497.262**

C. REMARKS

- The staff needs are based on the structure of existing JUs (ECSEL in particular) and on the necessary roles to ensure the operations of a JU.
- The budget for the functioning of the EuroHPC Joint Undertaking is estimated by extrapolating the staff needs presented above and the budget of the existing JU ECSEL. It is however important to highlight that the ECSEL JU benefits from significant economies of scales under title 2 by sharing several infrastructures (building, IT,…) and services (security,…) with other JUs. In the case EuroHPC would be seated at a separate place, the budgets under title2 may need to be increased.

For the payment appropriations, it is estimated that expenses under titles 1 and 2 are paid on the year of the commitment, whilst expenses under title 3 are paid for 50 on the year of commitment N, 30% on year N+1, and 10% on the years N+2 and N+3.

ANNEX 5

HPC AND ITS STRATEGIC VALUE FOR THE DIGITAL ECONOMY

1. STRATEGIC VALUE OF THE HPC

High Performance Computing (HPC) is a branch of computing that deals with scientific and engineering problems that are computationally so demanding that computations cannot be performed using general-purpose computers. Today, these computations typically run on very powerful systems with highly parallelized computing units of tens or hundreds of thousands of processors. Those computers are often referred to as supercomputers.

Supercomputers were introduced in the 1960s, roughly 15 years after the first general-purpose computers were built and operated in the UK and the USA. Since those early days, the development of hardware and software technologies supporting modelling for science and engineering, design and product development and decision-making have advanced to a level of sophistication and predictive power that early pioneers could only have dreamt of 50 years ago. For instance, the computing power of the world's top supercomputer 25 years ago can be found in an ordinary laptop today. The speed at which computing power increases is so fast that top-notch machines are obsolete after just 5-7 years on average.

HPC is essential to address major ***scientific and societal challenges*** such as early detection and treatment of diseases (e.g. understanding cancer generation and evolution), new therapies (based on personalised and precision medicine, genome sequencing, etc.), deciphering the human brain, forecasting climate evolution, observing the space, preventing and managing large-scale natural disasters, designing renewable energy parks, accelerating the design of new polymers, etc. Its use has a growing critical impact ***on industries and businesses*** by significantly reducing design and production cycles, minimising costs, increasing resource efficiency, as well as shortening and optimising decision processes. For example, HPC has enabled automakers to reduce the time for developing new vehicle platforms from an average of 60 to 24 months improving crashworthiness, environmental friendliness, and passenger comfort.

HPC is also essential for ***national security and defence***, for example in developing complex encryption technologies, in tracking and responding to cyberattacks and in deploying efficient forensics, or in nuclear simulations.

At a macroeconomic level, returns on investment in HPC are high. A recent study shows that **in Europe every Euro invested in HPC has generated close to EUR 870 in revenues for businesses and EUR 69 in profits**[10] and that the companies and countries that most invest in HPC spearhead science and economic success.

[10] Study conducted by IDC in 2015 (SMART number: 2014/0021) based on information from 143 European HPC projects

HPC is at the core of major advances and innovation in the digital age. It dramatically increases our ability to process large amounts of big data and carry out complex computations, which is critical for a large number of scientific, industrial and social domains. HPC is also a critical tool for understanding and responding to the increasing challenges faced by our citizens in modern societies, by transforming them into innovation opportunities. This makes of HPC the engine to power the new global digital economy, where to out-compute is to out-compete, and a key technology for science, industry, and society at large. The benefits in the different domains are illustrated below:

In science, many of the recent breakthroughs simply would not be possible without HPC. The simulation of complex models and the HPC analysis of huge amounts of data has made possible that ***scientists can have today much deeper insights into previously unexplored areas and systems of the highest complexity, driving the innovation and discovery in almost all scientific disciplines:***

- In life sciences and medical research: HPC is enabling enormous advances in new therapies: scientists heavily rely on HPC for understanding the nature of diseases, for discovering new drugs, and for moving to precision medicine, customising therapies to the specific needs of a patient. In genome science, HPC is used for enabling faster and more effective analysis of genome sequences and genome assembly, and for simulating protein unfolding (critical for understanding major diseases such as cancer or Alzheimer). In biomolecular research, HPC is used for investigating the dynamics of biomolecules and proteins in human cells to understand how they contribute to cellular signalling mechanisms. In brain research such as in the Human Brain Project (HBP) FET Flagship[11], HPC is used for multi-scale and high-resolution simulation and modelling of the human brain to understand its organisation and functioning. HPC is increasingly used in population scale data analysis for understanding cancer generation and metastasis evolution and for developing predictive oncology and cancer precision medicine, etc.

11 https://www.humanbrainproject.eu/

Throughout the application areas of ***the Human Brain Project (HBP) FET Flagship***, HPC is key to conduct collaborative research. There are two major application directions requiring access to advanced HPC capabilities: ***simulation and big data analytics***. Brain molecular simulations, cellular simulations (for example of the hippocampus), simulations of cortical columns and simulations operating at system level require the largest available highly parallel supercomputers in Europe, such as those located in the five Tier-0 supercomputing centres which are all members of HBP: Juelich (DE), BSC-Barcelona (ES), CEA (FR), Cineca (IT) and the Swiss National Supercomputing Centre (CH). Workflows for data analytics require mostly flexible parallel cluster computers where recently, the inclusion of deep learning techniques has contributed to increasing exponentially the request for application time of HBP users. Overall, HBP user groups of HPC require largest memory capacities, massive data storage and fast data access in the Peta-Bytes range including exchange of data on a European scale. HBP's Joint Platform will meet these demands via new dense memory technologies as well as a federated data infrastructure in the form of a cloudified infrastructure-as-a-service (IaaS), federated across the five Tier-0 supercomputer centres.

In 2010, the Centre for ***Pediatric Genomic Medicine*** at Children's Mercy Hospital, Kansas City, Missouri, was named one of Time magazine's top 10 medical breakthroughs. The centre uses HPC to help save the lives of critically ill children. Roughly 4,100 genetic diseases affect humans, one of the main causes of infant deaths. One infant suffering from liver failure was saved thanks to 25 hours of supercomputer time to analyse 120 billion nucleotide sequences and narrowed the cause of the illness down to two genetic variants. For 48% of the cases the centre works on, HPC-powered genetic diagnosis points the way toward a more effective treatment.

Swiss ***pharmaceutical*** giant Novartis & Schrödinger, a global life sciences and materials science software company, greatly accelerated the testing of drug candidates by using HPC. They tested 21 million drug candidate molecules, using a new technical computing (HPC) algorithm Schrödinger developed. The successful run cost only about EUR 10,000. Schrödinger has completed even larger runs since this.

- In earth sciences, HPC is used for ever higher resolution simulation in climate change (for example, studying the behaviour of the oceans), weather forecasting, earth resource evolution, but also for improving our knowledge of geophysical processes and of the structure of the interior of the Earth, for understanding earthquakes, etc.

More accurate models are needed to predict much in advance the path and the effects of the ***increasingly devastating hurricanes*** such as Irma and Harvey. The weather model from the European Centre for Medium-Range Weather Forecasts (UK) proved substantially more accurate than U.S.A. models in predicting the path of Hurricane Sandy that devastated America's East Coast in 2012. The MET Office, the UK's National Weather Service, relies on more than 10 million weather observations from sites around the world, a sophisticated atmospheric model and a £30 million IBM supercomputer to generate 3,000 tailored forecasts every day.

Agriculture is the principal means of livelihood in many regions of the developing world, and the future of our world depends on a sustainable agriculture at planetary level. HPC is becoming critical in agricultural activity, plague control, pesticides design and pesticides effects. Climate data are used to understand the impacts on water and agriculture in Middle East and North Africa, help local authorities in the management of water and agricultural resources, and assist vulnerable communities in the region through improved drought management and response.

- High Energy Physics (HEP) experiments are probably the main consumers of High Performance Computing (HPC) in the area of e-Science, considering numerical methods in real experiments and assisted analysis using complex simulation[12]. Starting with quarks discovery in the last century to Higgs Boson in 2012, all HEP experiments were modelled using numerical algorithms: numerical integration, interpolation, random number generation, eigenvalues computation, and so forth. Data collection from HEP experiments generates a huge volume, with a high velocity, variety, and variability and passes the common upper bounds to be considered Big Data. The numerical experiments using HPC for HEP represent a new challenge for Big Data Science.
- Future Energy technologies: HPC can hold the key in the future of energy for humankind – fusion. Today's nuclear power plants could soon be replaced by a safer, greener and virtually inexhaustible nuclear power on the horizon. Fusion power could be a global solution to future energy demand. With ITER slated to begin experimental tests around 2025, it is a critical time for the international teams of scientists and engineers who are planning how the reactor will perform at maximum efficiency

To develop the best ***predictive tools for ITER*** (and, by extension, other experimental fusion reactors), research teams are using HPC to resolve the behaviours of fusion plasma across the many spatial scales that impact reactor efficiency and plasma stability. Right now, it is only through HPC that researchers can simulate plasma kinetics for large experiments like ITER with enough simulated electrons to resolve important physics

Using the Mira supercomputer, ***physicists uncovered a new understanding about electron behaviour in edge plasma***, and new insights were gained into the properties of a self-generating electrical current that boosts power in a tokamak fusion reactor. Based on these discoveries, improvements were made that could enhance predictions of and, ultimately, increase fusion power efficiency.

- In materials science, HPC is used for example for molecular modelling and molecular dynamic simulation, for designing and studying the properties of new materials that can have an enormous impact in: renewable and clean energies (e.g. photovoltaics, new generation batteries); health (simulating the effect of new chemicals at molecular level); for understanding and exploiting superconductivity; for naval and marine engineering with new generation of super-hydrophobic coatings for underwater applications; etc.

Developments in the next generation of smartphones, fuel-efficient cars or powerful batteries for electric vehicles, as well as to catalysts for the production of methane or liquid fuels and high-performance solar cells, are practically always based on better, and

[12] High Performance Numerical Computing for High Energy Physics: A New Challenge for Big Data Science, https://www.hindawi.com/journals/ahep/2014/507690/

often ***completely new materials***. Several hundreds of thousands of different materials are known today, but that is only a fraction of all possible compounds. This can be changed by combining HPC with data mining technologies, enabling the prediction of unknown chemical compounds with desired properties or discover new properties of known substances. As an application case, candidate materials that can be easily exfoliated (like graphene) were reduced from 0.5 million to 1000 most promising through computational methods.

- <u>In other scientific domains</u>: HPC modelling and simulation techniques and data analytics approaches are the key for understanding phenomena and finding innovative solutions in many other scientific domains for high-impact science: for example in ***cosmology and astrophysics***, scientists are using HPC for simulating violent events following the Big Bang that may have produced gravitational waves, for detecting supernovae and binary star systems, or for estimating the neutrino mass and understanding dark matter and energy. Other scientific areas with important HPC use include ***renewable energy***, ***global systems science***, ***urban development***, etc.

In national security and cybersecurity: Mastering of HPC technologies and access to world-class HPC has become a national strategic priority for the most powerful nations. Supercomputers are in the first line for nuclear simulation and modelling, and for cyber-war, cyber-criminality and cyber-security. HPC is also increasingly used in the fight against terrorism and crime, for example for face recognition or for suspicious behaviour in cluttered public spaces.

Encryption of communications is necessary to safeguard business and personal online transactions, but there are some specific circumstances where it is desirable that authorities get access to encrypted communications. HPC can also help increasing the security of encryption, by learning how to build better, more efficient algorithms that require smaller keys.

In cybersecurity, HPC in combination with Artificial Intelligence and Machine Learning techniques is used to detect strange systems behaviour, insider threats and electronic fraud; very early cyber-attack patterns (in a matter of few hours, instead of a few days); or potential misuse of systems and take automated and immediate actions in order to act before hostile events occur. A recent report from the USA[13] states "… national security requires the best computing available, and loss of leadership in HPC will severely compromise our national security …".

The cyber-breach in June 2015 on USA Office of Personnel Management (affecting the data of four million federal employees) supports claims from senior military and intelligence officials that the U.S.A. is under more or less constant cyber assault. Several federal network intrusions and data breaches have been detected at the Inland Revenue Service, the Department of State and the White House. The scale of concern over the attacks suggests that they are 'far more serious…to national security' than 9/11 (Carolyn Maloney (D-NY)).

In industry, *HPC enables traditional computational-intensive sectors to significantly reduce R&D costs and development cycles, and to produce higher quality products and services,* for example in manufacturing and engineering industries (e.g. automotive, aerospace), health and pharma (e.g. drug discovery), energy (e.g. discovery of oil and gas

13 U.S. Leadership in HPC: A report from the NSA-DoE technical meeting on HPC, December 2016

resources, renewable energy generation and distribution). HPC also paves the way for new business and innovative applications in high added-value areas (e.g., in personalized medicine, bio-engineering, smart cities/autonomous transport, etc.), reinforcing the industrial innovation capabilities, in particular of SMEs.

- HPC has enabled automakers to reduce the time for developing new vehicle platforms from an average of 60 to 24 months, saving 40 billion EUR while improving crashworthiness, environmental friendliness, and passenger comfort;
- Airbus currently uses HPC to perform complex simulations across the various components and entire passenger and cargo jets. The design of the Airbus A380 has exploited HPC to carry twice as many passengers for the same noise level, using less than 3 litres of fuel per person per 100 km and less than 75g of CO_2 per person per km. A single large passenger jet has well over two million individual parts that need to be simulated individually or as part of a larger system. Further, those millions of parts must stand up to varied pressure and strain over the course of the typical jet's lifetime, which is between thirty to fifty years. This complexity, coupled with the need for operational reliability of over 99%, puts computational demands that reach the exascale level and beyond.
- Renault used 42 million core hours on the PRACE Tier-0 CURIE machine for performing the biggest multi-physics car optimization study ever made, consisting on hundreds crash simulations on meshes of 20 million finites elements applied to more than 120 different parameter to study. This first study provided to Renault unprecedented results in mass reduction, CO2 limitation, safety improvement, and will be determinant for fulfilling future EuroNCAP6 safety rules
- Intelligent analysis of real-time data produced by airplanes can predict faults before they happen (predictive maintenance). Spirit AeroSystems Inc. – one of the largest manufacturers of aero structures – achieved 25% shorter production flow times, 30% lower assembly inventory levels; and 40% lower overtime expenses as well as $2 million in savings on inventory by using high-performance data analytics
- Total recently tripled the power of its supercomputer to develop more complete visualizations of seismic landscapes and run simulations at 10 times the resolution of existing oil and gas reservoir models. This new capability will enable more efficient upstream oil and gas exploration, as well as the discovery of reserves under more challenging geological conditions.
- HPC-enabled applications are becoming part of agriculture using e.g. radio-frequency identification tags (RFIDs) which can hold and automatically download a mass of data on the bale's moisture content, weight and GPS position. In the future, micro-tags of the size of soil particles will be deployed extensively to measure things as moisture, disease burden and even whether the crop is ready to harvest or not.

HPC is a key factor for the digitisation of industry and its innovation and competitiveness, contributing decisively to the objectives of the Digital Single Market Strategy. Considerable progress has happened in the last few years. Several MS continued or set up new HPC competence centres that facilitate access of industry and specifically SMEs to HPC services, with supercomputing centres giving support and transfer expertise to them. Some of these centres are world leaders in collaboration with industry. These models of industrial collaborations in MS include HLRS (Stuttgart), Teratec (Paris), SURFsara (Amsterdam), CINECA (Bologna), LRZ (Munich), Hartree Centre (Daresbury), to name a few. Europe, like the rest of the world, also has many HPC centres that have recently added industrial outreach programmes to work with industry. Centres with strong industrial experience are well positioned to mentor less-experienced centres, and to assume leadership roles in any future HPC competence centres.

At European level, there are several successful examples of programmes supporting industrial access and collaboration, such as PRACE Industry Access[14], PRACE SHAPE[15], or Fortissimo.[16]

- ***The PRACE Industry Access*** allows European companies access to world-class HPC resources and services. PRACE opened R&D access to industrial users since January 2012 and has supported more than 50 companies with more than 318 million CPU hours, (309 million on Tier-0 supercomputers), including nearly 1.8 million CPU hours for SMEs in the SHAPE programme.
- ***SHAPE*** (SME HPC Adoption Programme in Europe) is a pan-European PRACE-based programme supporting HPC adoption by SMEs. SHAPE aims to raise awareness and equip European SMEs with the expertise necessary to take advantage of the innovation possibilities opened up by HPC, increasing thus their competitiveness.21 SMEs have participated in the SHAPE pilot for SME access; PRACE reports 10 success stories of SMEs from 6 different countries benefiting from PRACE HPC and know-how in the PRACE centres
- ***Fortissimo*** enables European manufacturing SMEs to benefit from the increased efficiency and competitive advantage inherent in the use of simulation. SMEs don't have the pool of skills and resources to access advanced simulation (e.g. expensive HPC equipment, licensing cost of tools, etc). Fortissimo provides simulation services running on a cloud infrastructure exploiting HPC systems and making appropriate skills and tools available in a distributed, internet-based cloud environment. Around 215 partners (120 SMEs) benefit from 123 Fortissimo experiments.

2. THE IMPACT OF HPC ON THE DATA ECONOMY – SOME EXAMPLES

Governments around the world are increasingly concluding that HPC is too strategic to be outsourced to foreign suppliers and that the development of an indigenous HPC supply chain needs to be fostered. For instance, the case of the U.S. government blocking Intel from exporting its processors to upgrade some of China's most powerful supercomputers accelerated China's initiatives to develop indigenous processors.

Europe is leader in the use of HPC-powered applications: the users of HPC systems and applications in Europe include the most profitable and vibrant industrial sectors, e.g. manufacturing, oil & gas, health and pharmaceutical industry, aerospace and defence, chemical industry, etc. HPC is used in the following industry sectors that contribute significantly to jobs and economic output in Europe:

[14] http://www.prace-ri.eu/industry-access

[15] http://www.prace-ri.eu/hpc-access/shape-programme/

[16] http://i4ms.eu/projects/projects_detail.php?post_id=6

Industry sector	Jobs supported	EU GDP
Manufacturing	25 million	13%
Health & pharma	17 million	10%
Automotive	12 million	4%
Oil & gas	0.17 million	2.8%
Aviation	5 million	2.1%
Chemical	1.15 million	1.1%

HPC has become already an integral component of business processes.[24] The three largest and most dynamically growing HPC sub-sectors are computer-aided engineering, bio-sciences as well as the energy sector[24]:

- Computer-aided engineering has a projected growth rate of HPC expenditure of 7.9% /year between 2013 and 2018. Bio-Sciences, including pharma and healthcare, have a projected growth rate of HPC expenditure of 5.1%. This trend is driven by the vision to provide individual patient treatment; consequently, a high computing demand is created to analyse each patient individually and find tailor-made solutions.
- The energy sector has a projected growth rate of HPC expenditure of ~5%: design and construction of intermittent renewable energy generation systems, testing of new and more efficient forms of materials for solar panels, optimisation of distributed generation, load management, etc.

Insurance and civil protection *is demanding more HPC simulations as demonstrated recently by the Harvey and Irma hurricanes. Severe weather forecasting on national and regional scales depends heavily on HPC, and Europe leads the world in numerical weather forecasting. From 1970 through 2012, severe weather cost 149,959 lives and €270 billion in economic damages in Europe.*

HPC simulation is an important alternative for ***animal testing****. The social and economic costs of experimental ("live") science and engineering research on animals have skyrocketed in the past decade. The EU REACH Regulation issued in 2006, the 7th Amendment of 2003 of the European Cosmetics Directive and the new European Regulation on cosmetic products issued in 2009 created an unprecedented need for alternatives to animal testing in Europe. On March 2013 a full ban on the marketing of cosmetics products tested on animals entered into force in the EU. This heavily triggered the development of alternative testing methods to reduce to a minimum the need for animal testing and, in the case of cosmetics, to fully substitute them. HPC is increasingly attractive here from both a social and financial viewpoint.*

The use of HPC is expanding to all industries as it becomes more accessible with today's and future broadband networks. **HPC is becoming a mainstream technology that Europe must master.**

European HPC investments are already producing excellent returns-on-investment (ROI) for science and industry. A 2015 study for the EC assessed the impact of recent HPC investments in scientific and industrial projects carried out within Europe.[17] Detailed ROI information was captured on 143 European HPC projects, of which 84 produced innovations and 59 produced quantifiable financial returns. In most cases, the investments consisted mainly of HPC systems and software acquired for the project, but payments for time on installed HPC systems also contributed to investments in some cases. The results are:

- *97% of the industrial companies using HPC consider it indispensable for their ability to innovate, compete and survive.*
- *Industrial sectors that leverage HPC could add up to 2-3% to Europe's GDP in 2020 by improving their products and services;*
- *Each euro invested in HPC on average returned €867 in increased revenue/income.*
- *Industrial projects averaged €75 in bottom-line profits or costs savings per €1 of HPC investment, and academic projects averaged €30 in cost savings per €1 invested.*
- *The total increased revenue for the 59 HPC-enabled, quantifiable projects was €133.1 billion, or about €230 million per project on average. Average increased profits/cost savings for the projects amounted to €69 billion.*

With almost 50% of the global HPC systems share owned by industry in 2017, the industrial sector has clearly shown over the last 23 years a growing interest in HPC. In contrast to this global picture, the majority of EU HPC capacity is currently installed at universities or academic research centres whereas the remaining minority is installed on a commercial basis in the context of commercial offerings or with HPC end users.[24]

Europe represents a favourable ground for a joint cooperation between academia and industry where the initiative would be of mutual benefit: on the one hand such cooperation would capitalize on the already existing infrastructures under a single European HPC structure, and on the other hand it would foster academic-industrial collaborations through knowledge and technology transfer to society.

Among all HPC actors, intermediaries[17] fulfil an important role as technology facilitators bringing together HPC centres (infrastructure owners), independent software vendors (ISV) and HPC customers for joint projects. This role is particularly important to help first-time users, primarily SMEs, to become acquainted with the potential of HPC for their business. With over 30000 potential beneficiaries SME type industrial companies provide a significant potential for the uptake of HPC in Europe. Large corporations which apply HPC to reduce research and development costs by simulating prototypes instead of physically building and testing them will also benefit from an EU-wide collaborative effort.

Regarding **the supply of HPC technology**, there is a potential for the European Union to build on its base of existing and planned European-wide HPC development programmes and to assemble exascale HPC capability that could, in some critical application sectors achieve world-class, if not global leadership.

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[17] HPC intermediaries provide the link between HPC centres as infrastructure providers and HPC customers. They mobilise and support SMEs to use the existing infrastructure or software development offering within their geographic vicinity, in their related sector or with those who share the same target group. Hence, their business model is to act as a facilitator for HPC customers seeking a service. Some are merely match-makers while others manage the co-development process with the customers, HPC centres and ISVs. Some intermediaries are grouped in independent Centres of Excellence, some are directly attached to an HPC centre.

In addition, there is a huge potential economic effect in the mass computing market from the investments in HPC technologies: **the development of exascale technologies is not for the sake of having the fastest supercomputer in the world**. The goal is to build "first of a kind" systems rather than "one of a kind". The transition to exascale computing is an opportunity for the European supply industry to leverage on technologies in the computing continuum from smart phones, to embedded systems (for example in the future driverless cars), and to servers, feeding the broader ICT market within a few years of their introduction in high-end HPC – giving a competitive advantage to those developing them at an early stage. The size of these target markets is of the order of EUR 1 trillion.

3. PUBLIC INVESTMENTS IN HPC IN EUROPE AND WORLDWIDE

Worldwide, the USA, China and Japan (and to a lesser degree the Russian Federation and India) have declared HPC to be a strategic priority for their country.· They fund programmes to develop national HPC ecosystems and work on the deployment of exascale supercomputers. **The current growth of European investment in HPC will not be enough to attain and maintain leadership, meaning at minimum parity with best-in-class HPC resources in the USA, Japan, or China, and fulfil the ambitious political goals of two pre-exascale systems around 2019-2020 and two exascale systems around 2022**.[18]

- U.S.A. government spending on HPC exceeded EUR 1.5 billion in fiscal year 2015 and more than EUR 1.7 billion in fiscal year 2016. (These figures do not count HPC spending by the U.S.A. intelligence community).

- Japan has set aside a EUR 1.2 billion undertaking for one near-exascale computer in 2022.

- China has fielded the two most powerful supercomputers and has extensive plans for the pre-exascale and the exascale systems (budget figures not available).

- **In 2015**[19]**,** the estimations of public and private investments for Europe to achieve leadership by 2020 were **of additional EUR 3.2 billion in 5 years (2016 to 2020) or EUR 5.3 billion in 7 years (2016 to 2022)** in order to match the developments of Europe's main competitors for HPC leadership in competitive time frames. These amounts entail a **funding gap** with respect to current investments in the order of **additional EUR 700 million per year.**

Regarding HPC infrastructures, Europe achieved a healthy HPC funding growth up until the period 2010-2012. The result was an increase of Europe's overall HPC capabilities by means of the purchase by MS of (then) most powerful supercomputers. [20] The predominant

[18] European Commission, Staff Working Document on the Implementation of the Action Plan for the European High-Performance Computing Strategy, SWD(2016) 106 final, 19 April 2016

[19] Study SMART 2014/0021 for the EC "High-Performance Computing in the EU: Progress on the Implementation of the European HPC Strategy"; IDC 2015.

[20] Study SMART 2014/0021 for the EC "High-Performance Computing in the EU: Progress on the Implementation of the European HPC Strategy"; IDC 2015.

funding model in the MS is one in which the central government finances 50% or more of the national supercomputing centre's entire budget, including the acquisition and upgrading of Tier-1[21] national supercomputing resources as well as operating costs. Given the important role supercomputing plays, central governments typically view this funding as a necessary investment in the economic future of their country (see Annex 6)[22] for a brief review of the organization type, funding sources and budgets of some of the most prominent national supercomputing centres in Europe, as well as national centres in some smaller countries.

Additionally, several MS are collaborating at European level through the PRACE agreement established in 2010.[23] PRACE establishes a pan-European computing and data management resource and services through a peer review process for large-scale scientific and engineering applications at the highest performance level, accessible to all researchers in Europe independently of their location. The PRACE top computer systems (Tier-0) were provided by four PRACE hosting members (BSC representing Spain, CINECA Italy, GCS Germany, GENCI France) who committed a total funding of EUR 400 million of computing time for the initial PRACE systems and operations until 2015. This agreement has been renewed recently until 2020 with the incorporation of a fifth hosting member (CSCS Switzerland). The PRACE programme is supported by the EU. PRACE also has specific programmes to strengthen the European users of HPC in industry through various initiatives (i.e. SHAPE for European SMEs).

Finally, Europe (both MS and the EC) are also investing in GÉANT[24], the pan-European data network for the research and education community linking national research and education networks as well as supercomputing centres across Europe.

Regarding the R&I actions to support the implementation of the HPC strategy, the EC has signed a cooperation agreement with two contractual private partnerships (cPPP): ETP4HPC and BDVA.

The ETP4HPC contractual Public Private Partnership[25] (HPC cPPP)[26] is based on the Contractual Arrangement signed on 17 December 2013 between the EC and the ETP4HPC Association.[27] The HPC cPPP formally started on 01 January 2014. The HPC cPPP focuses on the development of exascale technologies and the development of the applications. The HPC cPPP is complementary to PRACE, the former covering the R&I and the latter the pan-European HPC infrastructure. The two together reach all aspects of the HPC value chain. ETP4HPC is an industry-led think tank and advisory group made up of companies and research centres involved in HPC technology research in Europe. It was formed in 2011 with the aim to build a world-class HPC technology supply chain in Europe, increase the global share of European HPC and HPC technology vendors as well as maximising the benefits that

21 Tier-1 systems are top supercomputers in which the access is managed by national authorities

22 Extracted from the IDC study

23 PRACE (http://www.prace-ri.eu/) offers a pan-European supercomputing infrastructure, providing access to computing and data management resources and services for large-scale scientific and engineering applications at the highest performance level. It is an association of 24 member countries.

24 https://www.geant.org

25 Contractual partnerships with industry in research and innovation, http://europa.eu/rapid/press-release_MEMO-13-1159_en.htm

26 High Performance Computing cPPP: Mastering the next generation of computing technologies for innovative products and scientific discovery, http://ec.europa.eu/research/press/2013/pdf/ppp/hpc_factsheet.pdf

27 http://www.etp4hpc.eu/

HPC technology brings to the European HPC user community. Today, ETP4HPC has more than 80 members from industry and research; 35% of the total number of members is SMEs.

The Big Data Value Association (BDVA)[28] is an industry-led contractual counterpart to the EC for the implementation of the Big Data Value PPP cPPP. As of December 2015, the BDVA has over 120 members including large and SME industry together with research institutions and academia. The Big Data Value PPP is a partnership between the EC and the BDVA which aims to strengthen the data value chain, cooperate in data research and innovation, enhance community building around data and set the grounds for a thriving data-driven economy in Europe. The BDV cPPP is driven by the conviction that research and innovation, focusing on a combination of business and usage needs, is the best long-term strategy to deliver value from Big Data and create jobs and prosperity.

Activities funded by the EU programmes: currently, the main instrument at EU level to implement the HPC strategy is Horizon 2020 (H2020). The activities covered span from fundamental research to development, integration and prototyping, addressing components to full scale systems, acquisition and deployment of equipment and infrastructure, as well as support services to the user community.

As the activities mentioned above are different in scope they are funded by different H2020 Programmes: FET, LEIT and e-Infrastructure.

The H2020 work-programmes (WP) 2018-2020 support the implementation of the HPC strategy along 3 main axes:

1. Developing the next generation of key HPC technologies and systems towards exascale: The LEIT-ICT WP supports a Framework Partnership Agreement (FPA) action for the development of European low-power microprocessors and related technologies, and Extreme Scale Demonstrators to integrate with a co-design approach the technology building blocks developed in the FET and LEIT ICT R&I actions for operational environments. The FET WP complements the microprocessor FPA to address the whole technology spectrum from software, algorithms, programming models and tools, to novel system architectures.

2. Acquiring and providing access to world-class supercomputing facilities and services for academia and industry: The e-Infrastructure WP supports PRACE (ensuring access to the best European HPC infrastructures for European researchers), GÉANT for high speed and highly resilient pan-European communication and the acquisition of innovative HPC solutions through a Public Procurement for Innovation action.

3. Achieving excellence in HPC applications, and preparing and widening HPC use: The e-infrastructure WP supports HPC Centres of Excellence (CoEs), developing, preparing and optimising the HPC codes and applications for future exascale systems, complemented with actions for increasing the innovation potential of SMEs using advanced HPC services and focusing on the areas addressed by CoEs. The LEIT-ICT WP supports the development of large-scale HPC-enabled industrial pilot test-beds for big data applications and services, providing secure access and provisioning of highly demanding data use cases for companies and especially SMEs.

This is complemented by actions supported through CEF, addressing the use of supercomputers to process open data for public services.

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28 http://www.bdva.eu/

Currently, around 110 M€ are allocated in CEF and another 770 M€ is foreseen in the H2020 WP 2018-2020 for technology and infrastructure support, as follows:

- ~460 M€ for technology and application development through H2020 calls (LEIT ICT and FET) and ~230 M€ from H2020 e-Infrastructures for supporting European HPC Centres of Excellence, PRACE, GÉANT, and actions for supporting the innovation potential of engineering SMEs as users of advanced HPC services.
- Another financial envelope of ~80 M€ is to be allocated to the acquisition through joint procurement with the Member States of two pre-exascale computing machines and their data infrastructures. The main source of funds is H2020 (e-Infrastructure part) and CEF.

The following is a simplified comparative summary of investments in HPC[29]. Note that HPC investments in public programmes in different countries are not implemented in the same way, i.e. the EU is through multi-annual programmes whereas the US programmes' budgets are discussed and approved annually, therefore comparison is difficult.

<table>
<tr><th colspan="5">Annual investments in HPC programmes</th></tr>
<tr><th></th><th>U.S.A[30]</th><th>China</th><th>Japan</th><th>EU[31]</th></tr>
<tr><td>R&D (public and private)</td><td>1-2 b$/year (2016)</td><td>Over 1 b€ per year (2016)</td><td rowspan="2">0.24 b€ (1.2 b€ in 5 years)[32]</td><td rowspan="2">(EC ~0.3 b€ + MS 0.21 b€) per year (2014-2020)</td></tr>
<tr><td>Acquisition for pre-exascale and exascale systems</td><td>525 m$ for 2017-2018 (CORAL) and ~0.5-1 b$ for 2021[33]</td><td>1-1.5 b$ for 2017-2019 and 0.5-1 b$ for 2020[34]</td></tr>
</table>

[29] Source: Hyperion "Major Trends in the Worldwide HPC Market", April 2017

[30] These figures do not include the HPC spending of the USA intelligence agencies (NSA, FBI, CIA).

[31] Total R&D investments in EU programmes for the period 2014-2020 are in the order of 1 b€, with matching funds from private stakeholders. The Member States figures are an estimation in the high range for HPC in general; no specific budgets have been committed to pre-exascale or exascale systems yet

[32] Japan gives a single figure of ~1.2 b€ for R&D and the procurement of 1 exascale system plus a few smaller systems until 2021

[33] This only includes the Department of Energy (DoE) procurement CORAL. Budget for exascale machines has not been released

[34] Includes the estimations of pre-exascale and exascale systems as planned

In Annex 6, a detailed account is provided of the different major HPC initiatives in the USA, China and Japan as well as in the main European countries.

The Figure below provides an illustration of comparison of some of the biggest public programmes worldwide in HPC[35]. For the US, the NSCI is just one of the multiple federal programmes, and provides only a low estimation of public investments in HPC (see box in the beginning of section 3 above). Note also that public HPC programmes in different countries are not implemented in the same way, i.e. the EU is through multi-annual programmes whereas the NSCI US programme's budget is discussed and approved annually. To illustrate the underinvestment of European programmes with respect to the U.S.A., the NSCI (one of the several federal initiatives supporting HPC) invests ~285 m€ per year, whereas the Horizon 2020 programme would average only ~130 m€ per year (893 m€ across 7 years).

Summary of National HPC Strategies, by Country (Selection)

Country	HPC Strategy/Program and Description	Investment Level[1)]
United States	National Strategic Computing Initiative (NSCI)	approx. EUR 285 m/year
China	13th Five-Year-Development Plan (Develop Multiple Exascale Systems)	approx. EUR 178 m/year (for next five years)
Japan	Flagship2020 Program	approx. EUR 178 m/year (for next five years)
European Union	ExaNeSt, PRACE, ETP4HPC	approx. EUR 893 m total allocated through 2020 (annual allocations N/A)
India	National Supercomputing Mission	approx. EUR 124 m/year (for five years from 2016-2020)
South Korea	National Supercomputing Act	approx. 18 m/year (for five years from 2016-2020)
Russia	HPC Focus of Medvedev Modernisation Programme	N/A

1) USD amounts converted to EUR based on current exchange rate (08.06.2017)

Figure: Comparison of the several worldwide national programmes in HPC

35 EIB study 2017

ANNEX 6

BRIEF REVIEW OF THE FUNDING SOURCES AND BUDGETS OF HPC INITIATIVES WORLDWIDE AND IN EUROPE

USA

The USA is the world leader in HPC systems and technologies (both use and supply). It has established a National Strategic Computing Initiative (NSCI) and the Exascale Computing Project (ECP)[36], a multi-agency strategic vision and Federal investment strategy to maximize the benefits of HPC for economic competitiveness and scientific discovery, and the delivery of the first exascale systems for the US.

Several exascale systems will be installed from 2023 onwards by different Federal agencies, mainly in DoE research labs (but also for homeland security agencies like NSA, defence, etc. but no corresponding information has been disclosed). The investments in R&D for HPC towards exascale amount to $1 to $2 billion per year (mostly public but this figure includes supplier's investments).[37] For pre-exascale systems, the DoE is deploying several pre-exascale systems with CORAL, a single $525 million procurement process to acquire three next-generation supercomputers operational in 2017, each capable of performing 0.1 to 0.25 Exaflops.

The US government has long-standing models for R&D collaborations with indigenous HPC vendors, many of which include supercomputer procurements with strong R&D requirements, typically for the national laboratories of the US Department of Energy (DoE). The Exascale Computing Project is a collaborative effort of two DoE organizations – the Office of Science and the National Nuclear Security Administration. It is a 7-years project that follows the co-design approach and runs through 2023 involving all major US HPC vendors: Intel, Cray, HPE, IBM, NVIDIA, and AMD. US HPC system vendors have the lion share of today's EU market. Four out of the seven PRACE Tier-0[38] systems installed in Europe are from US vendors.

CHINA

China is ramping up HPC spending faster than any other nation or region and already hosts the two most powerful machines that together account for 87% of the top 500 aggregate performance in the EU. However, utilization of Chinese supercomputers is typically much lower than in Europe, the USA or Japan. The first Chinese prototype with peak exaflop performance (although not in normal operation) is expected already by the end of 2020. Several exascale systems will be installed from 2023 onwards. The investments in R&D for HPC towards exascale will be over $1 billion per year (mostly public).[39] Three pre-exascale computers (already in development) are planned for deployment by the end of 2017 and during 2018, in a competition exercise to select the best architecture for the future machines.

China has developed indigenous technology that will come in the next few years into the mass ICT market and also has a strong HPC vendor base: Lenovo, Inspur, Huawei, and Sugon.

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36 https://exascaleproject.org/

37 Source: Hyperion "Major Trends in the Worldwide HPC Market", April 2017

38 Tier-0 systems are world-class supercomputers accessible at EU level through the PRACE pan-European HPC infrastructure

39 Source: Hyperion "Major Trends in the Worldwide HPC Market", April 2017

Lenovo is taking assertive steps in the European market; after its 2014 acquisition of the IBM x86 server business it became one of the world's top 4 HPC server system vendors. For instance, Lenovo built two of the PRACE Tier-0 systems and is establishing a global HPC innovation centre in Stuttgart. China plans to deploy the first exascale level supercomputer in 2020.

JAPAN

Japan had twice in the past the world's most powerful supercomputer, most recently in 2011. The Ministry of Education, Culture, Sports, Science and Technology supports two exascale projects:

- First, the FLAGSHIP 2020 Project initiated in 2014. RIKEN, the largest comprehensive research institution in Japan, is the main organization for leading the development of next generation flagship supercomputers. A wide range of applications will address both science and industry. The deployment of the first exascale machine will be in 2022 with a cost of EUR 1.2 billion (this includes the R&D and the acquisition of the machine).[40]
- Second, the emerging supercomputer vendor ExaScaler Inc. and Keio University will develop another supercomputing design with exascale aspirations.

Fujitsu and NEC had considerable success in the past selling into EU markets, but they largely retreated when x86-based HPC systems began displacing their technology. Japan has three major HPC vendors, Fujitsu, NEC and Softbank's ARM, which was a leading European vendor until mid-2016.

GERMANY

- National Supercomputing Centre: Germany's Gauss Centre for Supercomputing (GCS) is an alliance of the country's three national HPC centres: HLRS (Stuttgart), LRZ (Munich) and FZJ (Jülich).

- Funding Sources and Management: GCS is jointly funded and managed by the German Ministry of Education and Science (Bundesministerium für Bildung und Forschung, BMBF) and the corresponding ministries of the three national states of Bavaria, Baden-Wuerttemberg and North Rhine-Westphalia. The states provide half of the funding for their respective centres and the German federal government provides the other half.
  Furthermore the federal government has started a Special Programme on Exascale Computing (SPPEXA www.sppexa.de) for the development of software. This complements a special program by the Federal Ministry of Science which has since 2010 started three calls for projects on scalable software with a special focus on industrial applications (details at https://www.gauss-allianz.de/en/projects).
- Budget: For the period 2007-2017, the federal government and the three state governments together have provided €400 million in funding for GCS. GCS also represents Germany in the PRACE alliance and has benefited from EC financing for PRACE.

- Other: The BMBF is separately investing €100 million over the next five years for the D-Grid infrastructure to support scientific collaboration. Germany was one of four European nations that committed to contribute €100 million in resources to the PRACE 1.0 budget. GCS represents Germany in the PRACE alliance and provides three of the current seven Tier-0 systems of PRACE.

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[40] Source: Hyperion "Major Trends in the Worldwide HPC Market", April 2017

FRANCE

- National Supercomputing Centre: France has two sites that function as national supercomputing centres: CEA, a secure site that addresses national nuclear security needs, and CINES, The National Computer Centre of Higher Education. Another important actor is Agence Nationale de la Recherche (ANR). In the end, however, GENCI (Grand Equipement National de Calcul Intensif) has the central role in HPC in France. Plan Investissement d'avenir is investing €50 million for HPC and is managed by CEA. Also noteworthy is Teratec, an association which unites over eighty technological and industrial companies, laboratories and research centres, universities and engineering schools who want to combine their resources in simulation and high performance computing.
- Funding Sources and Management: GENCI is a civil company (société civile) and is 49% owned by the State, represented by the Ministère en charge de l'Enseignement supérieur et de la recherche, 20% by the CEA, 20% by CNRS, 10% by participating universities, and 1% by INRIA. GENCI is invested with a central coordinating function by these organizations.
- Budget: ANR provides €25 million in HPC financing per year.
- Other: France was one of four European nations that committed to contribute €100 million in resources to the PRACE 1.0 budget. The Curie supercomputer, owned by GENCI and operated by CEA, is the first French Tier-0 system open to scientists through the French participation in the PRACE research infrastructure. Launched in October 2011 for a three year period, with a budget of €14.5 million euros, the purpose of the Mont-Blanc project, coordinated by BSC (Spain) and including GENCI together with the CEA, is to evaluate the potential of low energy components, such as the technologies used in our mobile phones, for the next generation of supercomputers.

UNITED KINGDOM

- National Supercomputing Centre: The UK has no permanent national supercomputing centre. Instead, major centres compete periodically for the contract for provide the HPC national academic service across the UK. At present, the Edinburgh Parallel Computing Centre has that role. Also of note, the Science and Technology Facilities Council's Daresbury campus manages the Hartree Centre, which has a major role in supporting the HPC needs of industry (as well as academia) in the UK.
- Funding Sources and Management: The UK Research Councils coordinate HPC academic research activities.
- Budget: The Engineering and Physical Science Research Council manages the budget for national capability, described as "support for excellent, long-term disciplinary and multidisciplinary research in engineering and the physical sciences." The allocation for this HPC- related budget item has been substantial and covers not just investments in supercomputers but also grants for research performed using supercomputers. The largest HPC-specific initiative within this budget is ARCHER, the UK's national academic supercomputing service. The UK government allocated £113 million (€157 million) for this program in 2014. The Hartree Centre was founded in 2012 with €52 million in funding from the UK's Science and Technology Facilities Council (STFC) to "develop, deploy and demonstrate HPC solutions," typically in partnership with industry.
- Other: The UK is a PRACE member but has not been a contributing/hosting member within the PRACE 1.0 period.

NETHERLANDS

- National Supercomputing Centre: SURFsara is the national supercomputing and e-science support centre in the Netherlands. SURFsara's customers include all Dutch universities, a number of large research, educational and government institutions, and the business community. SURFsara has been a partner in large European e-Infrastructure projects including PRACE 1IP, PRACE 2IP, PRACE 3IP, EESI2, EGI.InSPIRE and EUDAT, and partner in HPC- EUROPA2. The 1.6PF Cartesius supercomputer managed by SURFsara is the country's most powerful.
- Funding Sources and Management: Cartesius was funded by SURF, with contributions from the Dutch Organization for Scientific Research (NWO), the Ministry of Education, Culture and Science and the Ministry of Economic Affairs. SURF is the organization in the Netherlands which supports higher education and research in the area of e-infrastructures.
- Budget: About €7 million (€3-4 million operating funds plus an average €3 million/year for acquiring supercomputing resources).

SPAIN

- National Supercomputing Centre: BSC-CNS (Barcelona Supercomputing Centre - Centro Nacional de Supercomputación) is the national supercomputing facility in Spain and hosts the MareNostrum supercomputer. The mission of BSC-CNS is to investigate, develop and manage information technology in order to facilitate scientific progress.
- Funding Sources and Management: In 2004, the Ministry of Education and Science, Generalitat de Catalunya (Catalan Government) and Technical University of Catalonia founded the National Supercomputing Center in Barcelona. In 2004, the Ministry of Education and Science, Generalitat de Catalunya (Catalan Government) and Technical University of Catalonia founded the National Supercomputing Centre in Barcelona.
- Budget: BCS had an initial operational budget of €5.5 million/year to cover the period 20052011. The income of the BSC-CNS in 2009 was €20.1 million of which €6.6 M corresponded to the ordinary budget coming from the patrons of the BSC-CNS, the Spanish and Catalan Governments; and €8.1 million from competitive projects. Of particular note, €3.9 million of funding was derived from projects with private companies. In 2009, the BSC-CNS participated in 23 competitively funded EU projects, 37 collaborative projects with industry and 14 national projects.
- Other: In 2012, BCS upgraded MareNostrum at a cost of €22.7 million. The Spanish Supercomputing Network links MareNostrum to more than a dozen smaller HPC sites in Spain. BCS is a PRACE tier-0 host member.

ITALY

- National Supercomputing Centre: CINECA is Italy's national supercomputing centre and the country's PRACE host site. CINECA's Fermi supercomputer is one of the world's most powerful.
- Funding Sources and Management: CINECA is a non-profit consortium made up of 70 Italian universities, four Italian Research Institutions and the Italian Ministry of Education. 70% of CINECA's budget is funded by the Italian Ministry of Education

University and Research, for services to science and industry. The remaining 30% of the budget comes for providing other services. A framework agreement governs how CINECA and other Italian HPC centres collaborate with industry (PPPs). CINECA is led by a Board of Directors composed of the rectors of the member universities or their delegates, by a representative of CNR (National Research Council) and one of the Ministry of Education, University and Research (MIUR).The Board of Directors is represented by the Chairman, while the General Manager is responsible for the development, organisation and management of the Consortium's activities.

- Budget: As a PRACE hosting member, Italy made a commitment to spend €100 million during the course of PRACE 1.0. IDC estimates that Italy's annual monetary budget for HPC is about €20 million.
- Other: CINECA also acted as the procuring entity for the PRACE 3IP PCP (pre-commercial procurement) submission of March 9, 2015, representing partners CSC (Finland), GENCI (France), FZJ (Germany) and the University of Edinburgh. The goal of this PCP is "Whole System Design for Energy Efficient HPC." The budget is total €9.0 million over 26-months duration. CINECA is led by a Board of Directors composed of the rectors of the member universities or their delegates, by a representative of CNR (National Research Council) and one of the Ministry of Education, University and Research (MIUR).The Board of Directors is represented by the Chairman, while the General Manager is responsible for the development, organisation and management of the Consortium's activities.

FINLAND

- National Supercomputing Centre: CSC, the Finnish IT Centre for Science, is Finland's national supercomputing centre and supports both science and industry. CSC supports a European-wide customer base of thousands of researchers in disciplines such as biosciences, linguistics, chemistry and mathematical modelling.
- Funding Sources and Management: CSC is a non-profit limited company whose shares are fully owned by the Finnish state. CSC is directly governed by the Finnish Ministry of Education. The Finnish Funding Agency for Technology and Innovation (Tekes) provides about half of the HPC funding for Finnish universities, research institutes, and industry. Finland's innovative MASI (modelling and simulation) program, 2005-2010, was aimed at boosting the global competitiveness of Finnish firms through the use of HPC. Financing for MASI totalled €100 million over five years, with Tekes providing €53 million of that amount.
- Annual Budget: €31 million

DENMARK

- National Supercomputing Centre: Danish Centre for Scientific Computing (DCSC).
- Funding Sources and Management: DCSC is under the Danish Ministry of Education with government funding allocated for data processing capacity within the area of scientific computing for research assignments.
- Annual Budget: €3 million (estimated)

NORWAY

- National Supercomputing Centre: Norway has no single national supercomputing centre. NOTUR, the Norwegian Metacentre for Computational Science, oversees time allocation for Norway's four supercomputer centres. They are located at the Norwegian University of Science and Technology (NTNU) in Trondheim, the University of Bergen, the University of Tromsoe, and the University of Oslo.

- Funding Sources and Management. The Research Council of Norway (Norges forskningsråd), like its Finnish counterpart, provides about half the funding for Norwegian HPC initiatives of national interest. A major thrust is the eVITA program aimed at developing innovative tools to support HPC use in science and industry.
- Annual Budget: The eVITA annual budget is about €17 million. The Norwegian Intelligence Service's (NIS) annual budget was quadrupled in 2014 to more than €90 million, from which NIS plans to use a substantial but unspecified amount to acquire a powerful new supercomputer ("STEEL WINTER") for crypto-analysis.

SWEDEN

- National Supercomputing Centre: Like Norway, Sweden has no single national supercomputing centre.
- Funding Sources and Management: The Swedish National Infrastructure for Computing (SNIC) is a distributed infrastructure that is funded in part by the Swedish Research Council (Vetenskapsrådet) and in part by the participating universities: Chalmers University of Technology, KTH Royal Institute of Technology, Linköping University, Lund University, Umeå University and Uppsala University. SNIC is part of the Swedish Science Council, whose task is to coordinate and develop high-end computing capacity for Swedish research. Prominent among the universities aligned with SNIC is the KTH Royal Institute of Technology in Stockholm.
- Budget: In October 2014, KTH installed a 2PF supercomputer, the largest to that date in the Nordic countries. The budget for acquiring the computer and four years of operations (with spending over four years) is about €18 million and comes primarily from SNIC.
- Annual Budget: The SNIC annual budget is €4.8 million (45 MSEK).

GREECE

- National Supercomputing Centre: Greece has no designated national supercomputing centre, but in 2014 the state-owned company Greek Research and Technology Network (GRNET S.A.) teamed with Cosmos Business Systems to acquire a national supercomputer. IDC estimates the market value of the 180TF, Xeon-based supercomputer at about €6 million.
- Funding Sources and Management: The GRNET S.A. state-owned company operates under the auspices of the Greek Ministry of Education - General Secretariat for Research and Technology. Its mission is to provide high-quality infrastructure and services to the academic, research and educational community of Greece, and to disseminate ICT to the general public, including HPC. In 2014, GRNET signed a contract for Greece's first national supercomputer. The national supercomputer was developed under the “PRACE-GR - Developing National Supercomputing Infrastructure and Related Services for the Greek Research and Academic Community” project, which is co-funded by the Operational Programme “Attica” and the European Regional Development Fund (ERDF).
- Annual Budget: IDC estimates GR-NET's budget at €2-3 million per year.

Switzerland

- National Supercomputing Centre: The Swiss National Supercomputing Centre (Italian: Centro Svizzero di Calcolo Scientifico; CSCS) acts in this capacity.
- Funding Sources and Management: CSCS is an autonomous unit of the Swiss Federal Institute of Technology in Zurich (ETH Zurich) and closely collaborates with the local University of Lugano (USI). In addition to the computers of the National User Lab, CSCS operates dedicated compute resources for strategic research projects and tasks of national interest. Since 2000, the calculations for the numerical weather prediction of the Swiss meteorological survey MeteoSwiss take place at the Swiss National Supercomputing Centre.

Annual Budget: €23.2 million