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PRACE role in the European HPC strategy and implementation

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Author(s): Veronica Teodor, JUELICH, Oriol Pineda, BSC
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	Contributors:	Chris Johnson, EPCC Cristiano Padrin, CINECA Debora Testi, CINECA Enver Ozdemir, UHeM Evangelia Athanasaki, GRNET Gabriel Hauteux, CINES Joost VandeVondele, ETH Zürich Katarzyna Pawlikowska, ETH Zürich Manuel Fiolhais, UC-LCA Marie Sandberg, CSC Marjolein Oorsprong, PRACE aisbl Philippe Segers, GENCI Stelios Erotokritou, CaSToRC Tiina Leiponen, CSC Vania Markova, NCSA Wahid Rofagha, PRACE aisbl
	Reviewed by:	Simon Wong, ICHEC Florian Berberich, JUELICH

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List of Acronyms and Abbreviations

AAA	authentication, authorisation, and accounting
AAI	Authentication Authorisation Infrastructure
AI	Artificial Intelligence
aisbl	Association International Sans But Lucratif (legal form of the PRACE-RI)
BDO	Business Development Officer
BDVA	Big Data Value Association
BoD	PRACE Board of Directors
BoF	Birds of a Feather
CA	Collaboration Agreement
CERN	Conseil Européen pour la Recherche Nucléaire (French: European Organisation for Nuclear Research)
CoE	Centre of Excellence
CPU	Central Processing Unit
DECI	Distributed European Computing Initiative
DL	Deep Learning
DMP	Data Management Plan
DSM	Digital Single Market
EC	European Commission
ECDC	European Centre for Disease Prevention and Control
EDI	European Data Infrastructure
EOSC	European Open Science Cloud
EPI	European Processor Initiative
ETP4HPC	European Technology Platform for High Performance Computing
EUDAT	European Data Infrastructure
EXDCI	European eXtreme Data and Computing Initiative
FAIR	Findable, Accessible, Interoperable and Reusable
FETHPC	Future and Emerging Technologies HPC
GB	Governing Board
GDPR	General Data Protection Regulation
GÉANT	Collaboration between National Research and Education Networks to build a multi-gigabit pan-European network. The current EC-funded project as of 2015 is GN4
GP	PRACE General Partners
GPU	Graphic Processing Unit
H2020	Horizon 2020
HL-LHC	High Luminosity LHC
HLST	High Level Support Team
HM	PRACE Hosting Members
HPC	High Performance Computing; Computing at a high performance level at any given time; often used synonym with Supercomputing
HPL	High Performance LINPACK
IAC	PRACE Industrial Advisory Committee
ICEI	Interactive Computing E-Infrastructure for the Human Brain Project
INFRAG	Infrastructure Advisory Group

JU	Joint Undertaking
LINPACK	Software library for Linear Algebra
MB	Management Board (highest decision making body of the project)
MGA	Model Grant Agreement
ML	Machine Learning
NCP	National Contact Point in Horizon 2020
PA	Preparatory Access (to PRACE resources)
PTC	PRACE Training Centres
PMO	Project Management Office
PPR	PRACE Peer Review
PRACE	Partnership for Advanced Computing in Europe; Project Acronym
PRACE 1	The initial period of the PRACE Research Infrastructure
PRACE 2	The second period of the PRACE Research Infrastructure following the initial five year period.
RI	Research Infrastructure
RIA	Research an Innovation Action, an H2020 funding scheme
RIAG	Research and Innovation Advisory Group
SHAPE	PRACE SME HPC Adoption Programme in Europe
SKA	Square Kilometre Array
SME	Small and medium-sized enterprises
SSC	PRACE Scientific Steering Committee
SWG	PRACE Strategy Working Group
TB	Technical Board (group of Work Package leaders)
TC	Third Country
Tier-0	Denotes the apex of a conceptual pyramid of HPC systems. In this context the Supercomputing Research Infrastructure would host the Tier-0 systems; national or topical HPC centres would constitute Tier-1
Tier-1	National or topical HPC centres
WG	Working Group
WP	Work Package

List of Project Partner Acronyms

BADW-LRZ	Leibniz-Rechenzentrum der Bayerischen Akademie der Wissenschaften, Germany (3 rd Party to GCS)
BILKENT	Bilkent University, Turkey (3 rd Party to UHEM)
BSC	Barcelona Supercomputing Center - Centro Nacional de Supercomputacion, Spain
CaSToRC	The Computation-based Science and Technology Research Center (CaSToRC), The Cyprus Institute, Cyprus
CCSAS	Computing Centre of the Slovak Academy of Sciences, Slovakia
CEA	Commissariat à l’Energie Atomique et aux Energies Alternatives, France (3 rd Party to GENCI)
CENAERO	Centre de Recherche en Aéronautique ASBL, Belgium (3 rd Party to UANTWERPEN)
CESGA	Fundacion Publica Gallega Centro Tecnológico de Supercomputación de Galicia, Spain, (3 rd Party to BSC)

D2.1**PRACE role in the European HPC strategy and implementation**

CINECA	CINECA Consorzio Interuniversitario, Italy
CINES	Centre Informatique National de l'Enseignement Supérieur, France (3 rd Party to GENCI)
CNRS	Centre National de la Recherche Scientifique, France (3 rd Party to GENCI)
CSC	CSC Scientific Computing Ltd., Finland
CSIC	Spanish Council for Scientific Research (3 rd Party to BSC)
CYFRONET	Academic Computing Centre CYFRONET AGH, Poland (3 rd Party to PNSC)
DTU	Technical University of Denmark (3 rd Party of UCPH)
EPCC	EPCC at The University of Edinburgh, UK
EUDAT	EUDAT OY
ETH Zurich (CSCS)	Eidgenössische Technische Hochschule Zürich – CSCS, Switzerland
GCS	Gauss Centre for Supercomputing e.V., Germany
GÉANT	GÉANT Vereniging
GENCI	Grand Equipement National de Calcul Intensiv, France
GRNET	National Infrastructures for Research and Technology, Greece
ICREA	Catalan Institution for Research and Advanced Studies (3 rd Party to BSC)
INRIA	Institut National de Recherche en Informatique et Automatique, France (3 rd Party to GENCI)
IST-ID	Instituto Superior Técnico for Research and Development, Portugal (3 rd Party to UC-LCA)
IT4I	Vysoka Skola Banská - Technická Univerzita Ostrava, Czech Republic
IUCC	Machba - Inter University Computation Centre, Israel
JUELICH	Forschungszentrum Juelich GmbH, Germany
KIFÜ (NIIFI)	Governmental Information Technology Development Agency, Hungary
KTH	Royal Institute of Technology, Sweden (3 rd Party to SNIC-UU)
KULEUVEN	Katholieke Universiteit Leuven, Belgium (3 rd Party to UANTWERPEN)
LiU	Linköping University, Sweden (3 rd Party to SNIC-UU)
MPCDF	Max Planck Gesellschaft zur Förderung der Wissenschaften e.V., Germany (3 rd Party to GCS)
NCSA	NATIONAL CENTRE FOR SUPERCOMPUTING APPLICATIONS, Bulgaria
NTNU	The Norwegian University of Science and Technology, Norway (3 rd Party to SIGMA2)
NUI-Galway	National University of Ireland Galway, Ireland
PRACE	Partnership for Advanced Computing in Europe aisbl, Belgium
PSNC	Poznan Supercomputing and Networking Center, Poland
SDU	University of Southern Denmark (3 rd Party to UCPH)
SIGMA2	UNINETT Sigma2 AS, Norway
SNIC-UU	Uppsala Universitet, Sweden
STFC	Science and Technology Facilities Council, UK (3 rd Party to UEDIN)
SURFsara	Dutch national high-performance computing and e-Science support center, part of the SURF cooperative, Netherlands
TASK	Politechnika Gdańska (3 rd Party to PNSC)
TU Wien	Technische Universität Wien, Austria
UANTWERPEN	Universiteit Antwerpen, Belgium
UC-LCA	Universidade de Coimbra, Laboratório de Computação Avançada, Portugal

UCPH	Københavns Universitet, Denmark
UEDIN	The University of Edinburgh
UHEM	Istanbul Technical University, Ayazaga Campus, Turkey
UIBK	Universität Innsbruck, Austria (3 rd Party to TU Wien)
UiO	University of Oslo, Norway (3 rd Party to SIGMA2)
UL	UNIVERZA V LJUBLJANI, Slovenia
ULIEGE	Université de Liège; Belgium (3 rd Party to UANTWERPEN)
U Luxembourg	University of Luxembourg
UM	Universidade do Minho, Portugal, (3 rd Party to UC-LCA)
UmU	Umea University, Sweden (3 rd Party to SNIC-UU)
UnivEvora	Universidade de Évora, Portugal (3 rd Party to UC-LCA)
UnivPorto	Universidade do Porto, Portugal (3 rd Party to UC-LCA)
UPC	Universitat Politècnica de Catalunya, Spain (3 rd Party to BSC)
USTUTT-HLRS	Universitaet Stuttgart – HLRS, Germany (3 rd Party to GCS)
WCSS	Politechnika Wroclawska, Poland (3 rd Party to PNSC)

Executive Summary

This deliverable reports on four main activities of Work Package 2 (WP2) during the first reporting period of the PRACE-6IP project:

- Status of PRACE 2;
- Support in defining PRACE role in the European HPC ecosystem in the EuroHPC era;
- PRACE services for EuroHPC;
- Legal support to PRACE Infrastructure and other work packages of the project.

The reporting on the PRACE 2 status within the PRACE Implementation Phase projects was initiated during PRACE-4IP (D2.2 “Second Report on PRACE 2.0 Development” [1]) and continued during PRACE-5IP (D2.1 “Report on PRACE 2, TNA, DECI and KPIs Year 1”¹ and D2.3 “Report on PRACE 2, TNA and DECI Year 2” [2]). This deliverable provides an update on this activity undertaken within the first year of the PRACE-6IP project. It reports on the status of the implementation and developments in the Second Period of operations of the PRACE pan-European Research Infrastructure, called PRACE 2, which began in 2017 and succeeded the PRACE agreement for the Initial Period (referred to as PRACE 1).

The main focus of this deliverable represents the European HPC ecosystem in the EuroHPC era and PRACE’s role in relation to other HPC stakeholders and EuroHPC. After the organisation of several meetings with the European HPC stakeholders, PRACE defines its position towards EuroHPC and services it could offer, as well as the relations and overlaps of all main actors in the ecosystem. The new “HPC in Europe” portal (under development at [3]) established by PRACE is meant to reflect the well-established roles and provide the users a good overview of the current HPC services at a European level.

The COVID-19 pandemic caused new and exceptional circumstances all over the world. A dedicated section reports on the legal and financial implications of the COVID-19 pandemic on the project. We also report on the practices of different project partners related to COVID-19 and on several initiatives that PRACE or PRACE partners started or joined in order to support the fight against the COVID-19.

¹ Confidential document, only for members of the consortium (including the Commission Services)

1 Introduction

During the first year of PRACE-6IP, WP2 continued the support carried out in PRACE-5IP to the PRACE aisbl, Council and the PRACE Board of Directors (BoD) towards the implementation and development of the PRACE strategy. Furthermore, WP2 provided support to identify PRACE's role within the European HPC ecosystem in the EuroHPC era.

This deliverable, describing the activity of WP2 during the first year of the PRACE-6IP project, is structured as follows:

- Section 2, after recalling the mission and objectives of PRACE, concentrates on the PRACE 2 Programme with detailed analysis of the PRACE 2 Project Access calls and a report on the work of High Level Support Teams (HLSTs) at Research Infrastructure (RI) and PRACE-6IP level;
- Section 3 gives an overview of the European HPC ecosystem and reports on the outcomes of meetings organised by PRACE in order to define the different roles of the main stakeholders in this ecosystem. One important outcome is the new HPC in Europe Portal;
- Section 4 updates the reader concerning the latest status of the EuroHPC Joint Undertaking and informs about the current relation between PRACE and EuroHPC;
- Section 5 focuses on the PRACE services which can be offered to EuroHPC such as the peer review process, technology watch, training, PRACE operations, new services to Industry towards Open R&D and user support – which are highlighted and further analysed;
- Section 6 reports on the legal support provided by WP2 regarding issues of a legal nature in the different work packages of the PRACE-6IP project. A main focus is on several initiatives that PRACE or PRACE partners started or joined in order to support the fight against the COVID-19;
- Finally, some conclusions are drawn in Section 7.

For some of the analyses presented in this deliverable, WP2 consulted the legal advisor firm Bird & Bird LLP assisting PRACE.

2 PRACE 2 Programme Report

This section provides an update of different aspects of the PRACE 2 Programme since the last report in PRACE-5IP D2.3 in February 2019 [2].

After seven years of operation of the “Agreement for the Initial Period” (the so-called “PRACE 1” Programme) and a significant fraction of its commitment executed by four countries (Germany, France, Italy and Spain), the PRACE Council certified the continuation of the European HPC infrastructure in its 25th meeting, on 3 March 2017 with the PRACE 2 Programme. Starting with Call 14, this second programme includes the commitment of five countries (France, Germany, Italy, Spain and Switzerland) to contribute 40% of the capacity of their world-class Tier-0 HPC systems through PRACE, representing a 2.5-fold increase of the resources made available through PRACE calls. The second novelty of the PRACE 2 Programme is the High Level Support Teams programme, funded by PRACE General Partners (GPs) and created with the objective of providing European scientific communities with support in code enabling and optimisation of scientific applications, in order to fully benefit from the performance of the PRACE HPC Tier-0 systems.

The PRACE 2 Programme has allowed Europe to remain competitive in the global HPC race, with an aggregated peak performance above 160 PFLOP/s (June 2020), at the same order of magnitude as the most powerful systems in the world. This leadership position is pivotal to fully benefit from the strong investments that Europe will contribute through the recently created EuroHPC Joint Undertaking (JU), with an initial budget of 1.4 billion Euros for its first phase.

2.1 Mission and Objectives of PRACE

The overarching goal of PRACE is to provide a federated European supercomputing infrastructure that is science driven and globally competitive. It aims to strengthen European science by providing access to high-end computing and data analysis resources, which will help drive discoveries and new developments in all areas of science, including mathematics, computer sciences, medicine, and engineering, social sciences and digital humanities. The goal of these actions is to help create a fertile basis for research, technology development and industrial competitiveness in Europe.

In order to reach this goal, PRACE aisbl has set up the integrated PRACE 2 programme, relying on the contribution of all the PRACE partners, with the following mission:

- To provide a world-class HPC and data infrastructure to European researchers in science and industry comprised at any one time of leadership-class pan-European systems, interlinked with an underlying network of national and regional systems;
- To develop an architecturally diverse supercomputing infrastructure that no individual country could afford, in order to sustain European competitiveness;
- To foster international collaborations on the forefront of high-end computing in simulation and data science and to bring competence to the PRACE member states;
- To help develop Europe by promoting the European idea of bringing stability and peace through open scientific discourse between all members;

- To enhance the scientific output of the supercomputing systems through international Tier-0 allocations coupled with the assistance of the local High Level Support Teams (HLST);
- To foster healthy research competition through the unique and purely scientific review based process that pushes scientists to the top;
- To stimulate the deployment of HPC in the knowledge economy in Europe and help European industry to become more competitive.

2.2 PRACE 2 Project Access Calls

PRACE has opened eight Project Access calls within the PRACE 2 Programme, with an average offer of resources close to 4 billion core hours per year. This has represented a substantial increase as compared to the average 1.5 billion core hours awarded until 2016; even higher if one takes the results from the High-Performance Linpack (HPL) benchmark to compare the core hours across systems. Such an increase has been possible with the contributions of all PRACE Hosting Members and their periodically upgraded systems. PRACE calls follow a biannual schedule. Figure 1 shows the offer of resources per year based on the start of each call, both in absolute core hours and in using the HPL comparison factor.

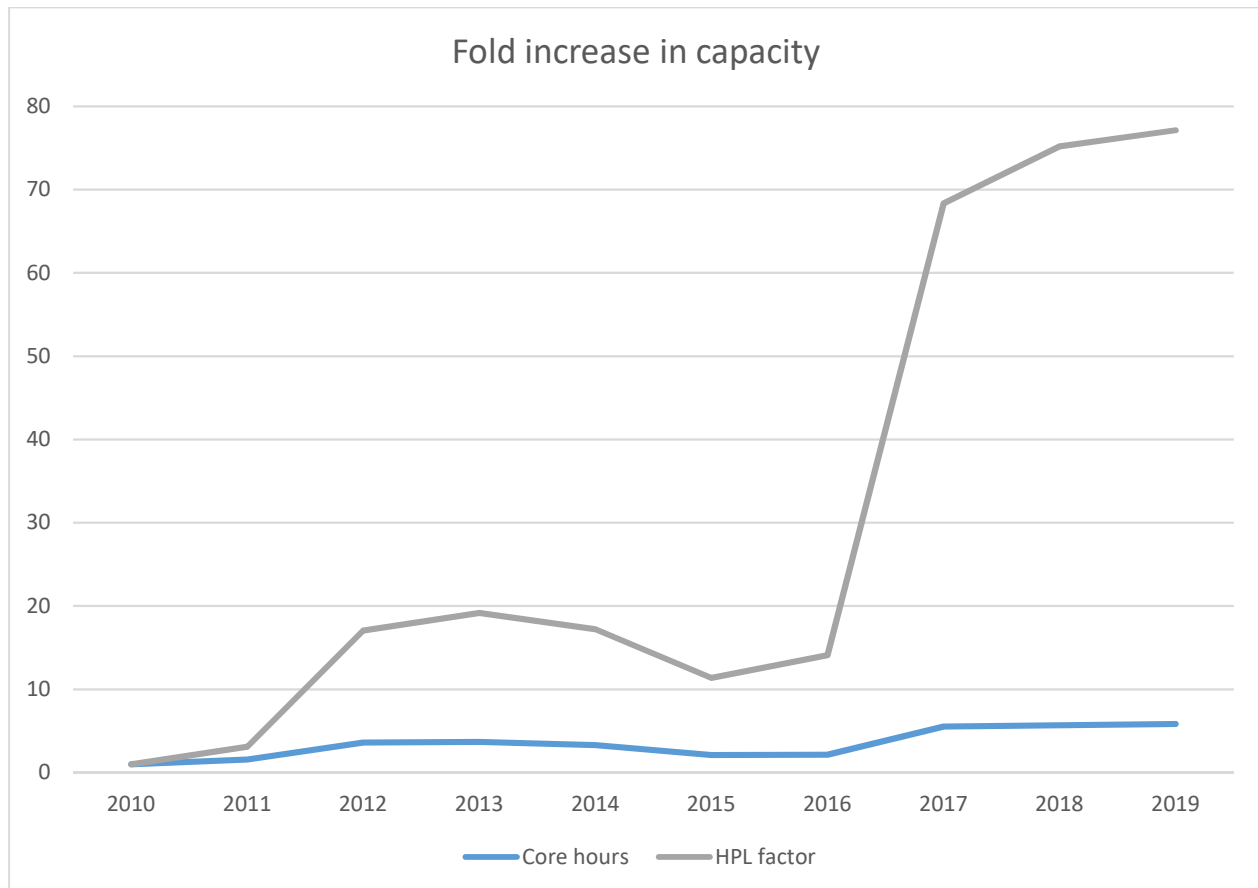


Figure 1: PRACE offer of core hours and increase of HPC computation capacity (compared to 2010), per year

One of the principles of the PRACE 2 programme is that all members have to contribute to the services of the infrastructure. An underlying consequence of such principle is the monitoring of the distribution of PRACE resources amongst PRACE members, in particular for General Partners (GPs), to show the benefits of contributing to the infrastructure. Figure 2 shows the evolution of a cumulative distribution of resources allocated to HMs and GPs, including resources allocated to third countries (TCs), while Table 1 tabulates data specifically for the PRACE 2 period.

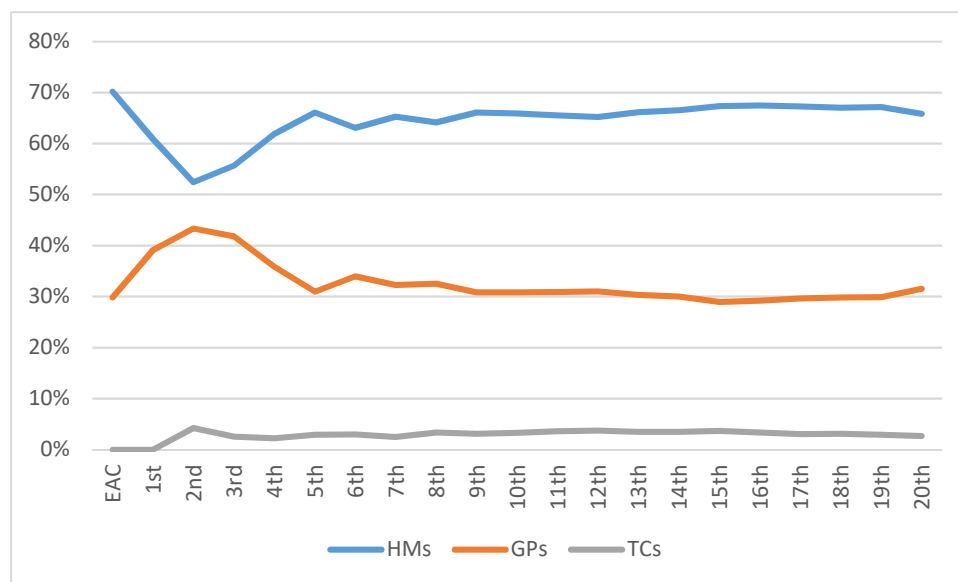


Figure 2: Cumulative distribution of PRACE allocations

	HMs	GPs	TCs
14 th Call	69%	28%	3%
15 th Call	74%	20%	5%
16 th Call	69%	31%	-
17 th Call	66%	34%	-
18 th Call	64%	32%	4%
19 th Call	68%	30%	1%
20 th Call	51%	49%	-
Average PRACE 2	66%	32%	3%

Table 1: Distribution of PRACE 2 resources

After three years of running and seven calls of the PRACE 2 Programme, the distribution of resources between Hosting Members, General Partners and Third Countries has practically converged to the PRACE 1 programme distribution. It is worth remembering that PRACE resources are allocated following the recommendations of its Access Committee, instructed to rank proposals based solely on their scientific excellence. The important variations observed from call to call, especially in Call 20, and the allocation of PRACE 2 resources to projects led by countries not contributing to the PRACE 2 programme show that there is no enforcement of quotas or shares

amongst applicants based on their country, scientific discipline, or any other criteria. Deliverable 2.2 of this project due in September 2020 will report on further allocation indicators related to this distribution of resources.

2.3 High Level Support Teams

The High Level Support Teams (HLSTs) programme started in April 2017 with the implementation of 24 FTEs devoted to Level-2 and Level-3 user support in BSC, CSCS, GCS and GENCI. This has recently been expanded with another 6 FTEs located in CINECA for a total of 30 FTEs. In this final full regime, the annual budget of the programme is 3.080.000 €, fully contributed by PRACE General Partners through their PRACE aisbl membership fees.

The Best Practice Guide ‘Application porting and code-optimisation activities for European HPC systems’ from PRACE-6IP WP7 reports on some of the HLSTs activities related to PRACE Calls 14 to 16 [4]. From Call 17 to Call 19, a total of 19 Tier-0 projects have been provided with Level-2 support. Additional level-2 support has been devoted to other 12 complementary activities, including mentoring of Project Access users. Finally, long-term, level-3 support has provided support to another 17 projects.

The programme has recently been extended until March 2021, in order to support PRACE Calls 20 and 21. Further extensions of the programme will be dependent upon the approval of the contributions plan and budget of PRACE for the following years and calls.

Additional work related to the HLSTs will be provided within PRACE-6IP, WP7 task 5. This task will provide additional and complementary effort to enhance the work of the PRACE HLSTs and extend this work with specific expertise from the other PRACE centres. This will ensure sharing of expertise across PRACE to maximise the benefits to users of the PRACE systems. Task 7.5 will work with the HLSTs to extend and enhance their activities, mainly by supporting Tier-1 intensive users targeting Tier-0, in order to maximise the scientific output of the Tier-0 systems. Only non-Hosting Members (HMs) can be part of this task, i.e. mainly Tier-1 centers experts are involved in this task.

In Task 7.5, a clear process is defined in order to assess the candidates for Tier-1 centers HLST support:

- Monthly telcons are organised
- Projects are selected during the telcons based on a set of criteria (scalability, targeted architecture, CPU hours volume, memory requirements)
- For accepted projects
 - Start project on local Tier-1 system
 - Apply for Preparatory Access on targeted Tier-0 system
 - Move to Tier-0 and validate the developments
 - Collaborate with target Tier-0 HLST to validate the developments

There is currently one ongoing project: Porting a Molecular Dynamics framework to hundreds of GPUs on Piz Daint. Most of the partners are waiting for upcoming architectures and local Tier-1

system enhancements in order to start their activities and benefit from the pre-exascale systems in order to help their local large users.

This task has the potential to reap huge benefits for the European HPC ecosystem by saving a huge amount of CPU hours for other Tier-1 users and Tier-0 systems. Even if some of the projects do not transition fully onto Tier-0 systems, the optimisation effort will not be in vain. Tier-1 centres will nevertheless save a substantial amount of CPU hours and project researchers will gain performance engineering knowledge and skills relevant to Tier-0 systems.

3 European HPC Ecosystem

The European Commission (EC), recognising the need for an EU-level policy on HPC, published the communication ‘High Performance Computing: Europe's place in a Global Race’ [5] on 15 February 2012. The communication stressed the importance of optimising national and European investments and of addressing the entire HPC ecosystem, and marked the beginning of its latest HPC Strategy. As part of the measures for Digitising European industry, the “European Cloud Initiative” [6] aims to strengthen Europe's position in data-driven innovation, improve its competitiveness and cohesion, and help create a Digital Single Market (DSM) [7] in Europe.

The European HPC ecosystem is one subpart of the European Data Infrastructure (EDI), which along with the European Open Science Cloud (EOSC). These two large initiatives are connected through common services and users (network, data and large instruments). These are presented in Figure 3.

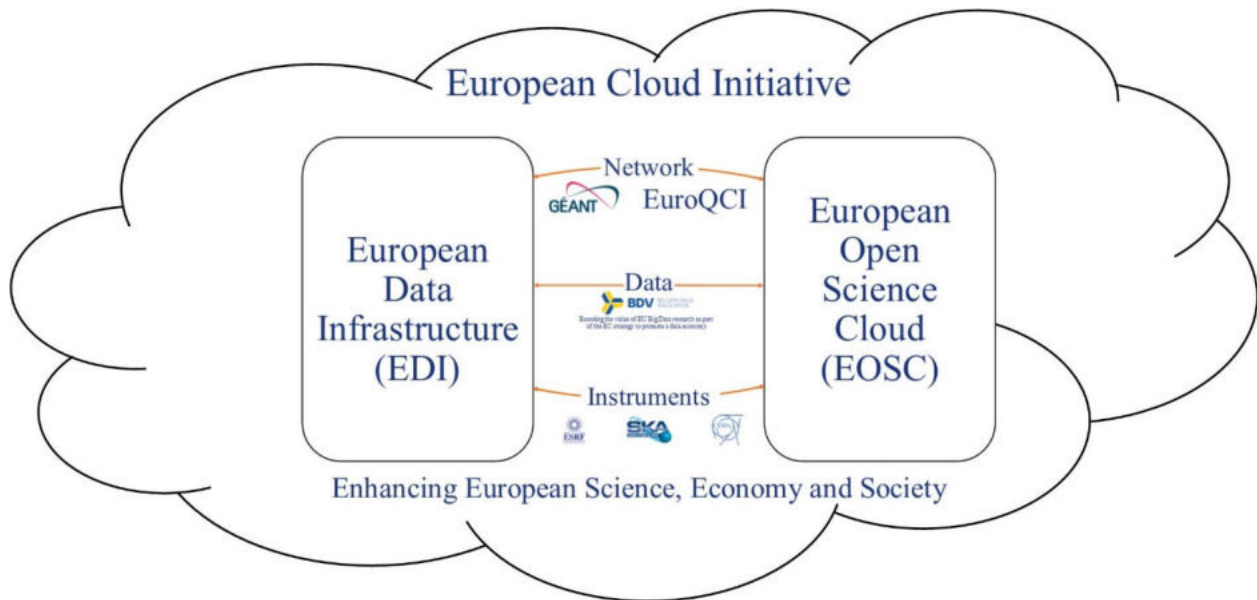


Figure 3: The European Cloud Initiative

The European HPC ecosystem itself is composed of three major pillars: Infrastructure, Applications and Technologies. These are now supported by the EuroHPC Joint Undertaking (JU) [8], which acts as a foundation and support mechanism to the ecosystem. The three pillars also operate within the European Open Science Cloud initiative to promote the FAIR (Findable, Accessible, Interoperable and Reusable) data principles for European research data, and provide resources and services for open science.

The European HPC ecosystem and its comprising projects is illustrated in Figure 4.

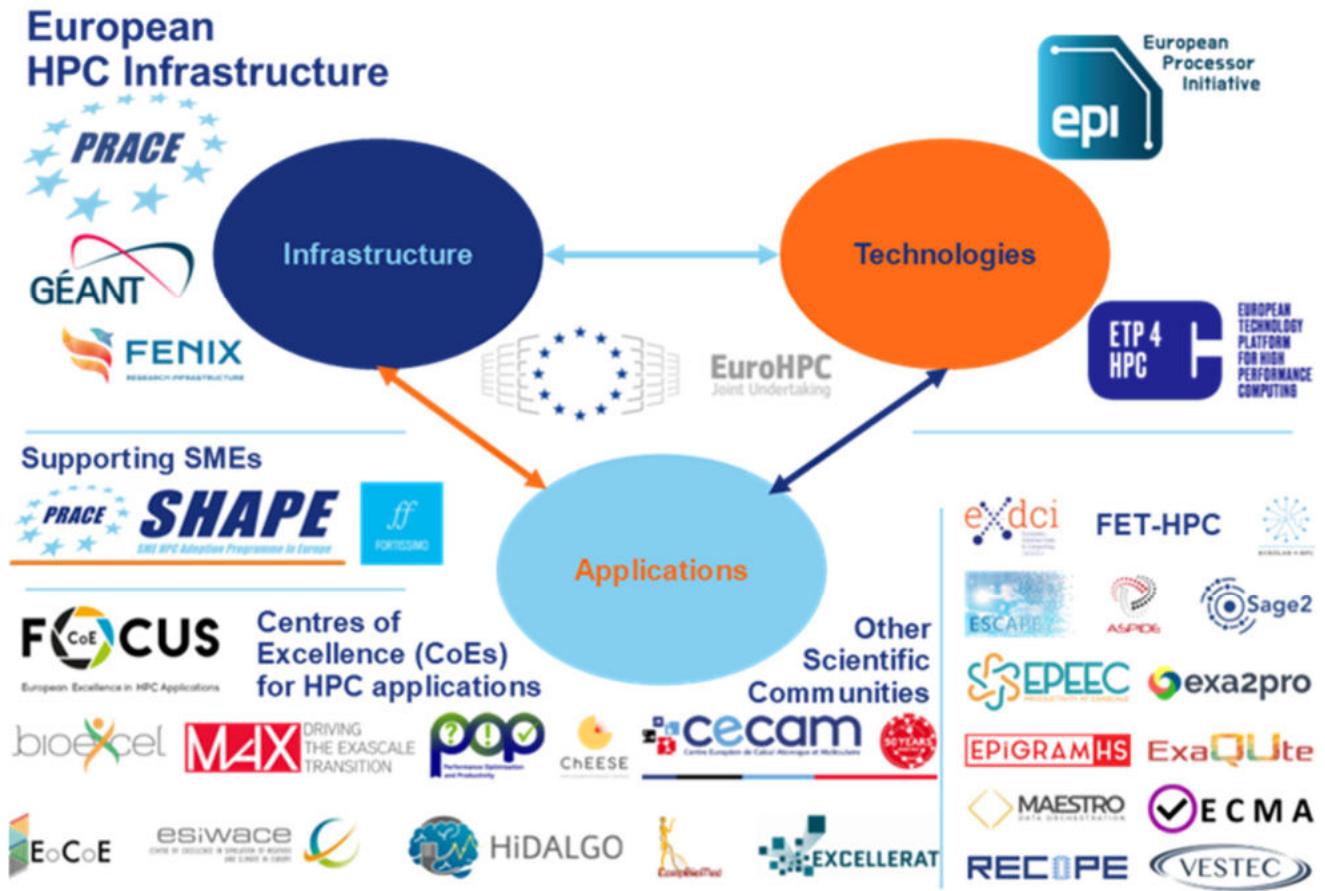


Figure 4: The European HPC ecosystem

3.1 European HPC Ecosystem Meetings organised by PRACE-6IP

In order for PRACE to better identify its role within the European HPC ecosystem in the EuroHPC era, PRACE organised a number of meetings with relevant stakeholders.

An HPC Ecosystem Summit was organised by PRACE on 14 May 2019 during the EuroHPC Summit Week 2019 in Poznań, Poland. The Summit was attended by more than 50 representatives from the EC, PRACE, GÉANT, Centres of Excellence (CoEs) and FETHPC projects, EXDCI and ETP4HPC, among others. The objective of this Summit was to present current activities and discuss future roles and responsibilities of the key European HPC stakeholders within the landscape. The discussion during this Summit helped to clarify the positions of various stakeholders and to define further stratification actions.

A follow-up session was organised by the PRACE-6IP project on 21 November 2019 during the SC19 conference in Denver, USA, in the form of a Birds of a Feather (BoF) session. The session was attended by more than 40 representatives from PRACE, GÉANT, CoEs and FETHPC projects, EXDCI, and ETP4HPC, among others. The objective of this follow-up session was to present an updated analysis of the European HPC landscape and a first insight into the new “HPC in Europe” portal that PRACE-6IP is developing based on all the inputs collected from the stakeholders.

mentioned above. The discussion during this session allowed improving the objectives of this service portal while clarifying the difference with other initiatives.

The outcomes of these meetings are summarised in the two documents entitled "Architecture and Integration of Services" and "HPC Ecosystem Summit Conclusion Report" which were submitted to the European Commission in July 2019, and which can be found in Section 8 (Annex 1) and Section 9 (Annex 2) respectively.

A further webinar was held on 24 March 2020, where the development of the HPC in Europe portal was presented to more than 40 participants representing stakeholders of the European HPC ecosystem. Input was received to further enhance the user experience of the portal, as described in the next subsection.

3.2 The HPC in Europe Portal

To prepare for the HPC Ecosystem Summit in Poznań, a dedicated survey with 10 questions was sent to 81 contacts (coordinators of CoEs, FETHPC projects, EuroHPC JU, ETP4HPC, BDVA, GÉANT, FocusCoE, EPI, EOSC, EUDAT, OpenAire, eInfraCentral, EXDCI). The contacts were asked in more detail to indicate which of the three pillars they are part of, and to indicate possible overlap and collaboration with other initiatives or organisations. The main part of the survey was the self-evaluation of the current actors concerning their role in the European HPC landscape provided through the answers to the matrix from Annex 2.

The conclusions of the survey and meetings held have been used to define the structure of a new platform to collect all the HPC services from European stakeholders, the “HPC in Europe” portal, following an inclusive and user-oriented approach. This structure has been documented in a follow-up document (“European HPC Ecosystem Follow-up Report”, that can be found in the Section 10 (Annex 3) and shared periodically, and the feedback received has been used to refine the sections of this portal.

The portal is structured around six main categories (HPC Access, Training and Events, Support, Applications, Technology, and Documentation) and five target audiences (Researchers, Industry, HPC beginners, HPC community, and General Public, stakeholders and policy makers). A neutral branding, inspired by EuroHPC has been applied in order to depict the neutrality and vast scope of the services broadcasted in the platform.

A complete description of the portal can be found in Annex 3.

4 PRACE in the EuroHPC Era

4.1 EuroHPC Joint Undertaking

The selected legal form to achieve the EuroHPC objectives is the Joint Undertaking (JU), as it was deemed to be the only instrument at the European Union level to effectively and efficiently combine joint procurement and ownership of supercomputers, as well as joint investment in the development of technology for the procured machines.

In June 2018, the Council endorsed the Commission's proposal to establish the EuroHPC JU and on 3 July 2018, the European Parliament voted in favour of the proposal. The proposal was formally adopted by the Council of the European Union on 18 October 2018. Located in Luxembourg, the JU started operating in November 2018 and will remain operational until the end of 2026. In the EuroHPC JU Regulation, PRACE is mentioned in the following two parts:

- a) In recital No 18 of the preamble where it is stated "[...] The Joint Undertaking may cooperate with PRACE for providing and managing access to a federated and interconnected supercomputing and data infrastructure and its services, as well as for training facilities and skills development opportunities", and
- b) In Article 3, par. 3 "The Joint Undertaking shall have the following specific objectives:" subparagraph (i), where it is stated "[...] to interconnect and federate regional, national and European High Performance Computing supercomputers and other computing systems, data centres and associated software and applications in cooperation with PRACE and GÉANT;"

4.1.1 Development of the EuroHPC JU Governance

A large part of the initial work of the EuroHPC JU has been to formalise and find the proper roles and working forms for the three governance bodies in the EuroHPC JU:

- The Governing Board (GB) is composed of representatives of the EU and Participating States. The Commission and each Participating State appoint one representative in the GB. Each representative may be accompanied by one expert.
- The Industrial and Scientific Advisory Board consists of the Research and Innovation Advisory Group (RIAG) and the Infrastructure Advisory Group (INFRAG) which provide independent advice to the Governing Board on the strategic research and innovation agenda and on the acquisition and operation of the supercomputers owned by the JU.
- The Executive Director is the chief executive responsible for day-to-day management of the JU.

The Industrial and Scientific Advisory Board

The Industrial and Scientific Advisory Board consists of two Advisory Groups – RIAG and INFRAG. The Research and Innovation Advisory Group (RIAG) is composed of no more than 12 members. This Advisory Group draws up and regularly updates the draft multiannual strategic research and innovation agenda. The research and innovation agenda shall identify research and innovation priorities for the development and adoption of technologies and key competences for

HPC across different application areas in order to support the development of an integrated HPC ecosystem in the EU, strengthen competitiveness and help create new markets and societal applications. The Infrastructure Advisory Group (INFRAG) is the second Advisory Group of the Industrial and Scientific Advisory Board. It is composed of no more than 12 members appointed by the Governing Board. This Advisory Group provides advice to the Governing Board for the acquisition and operation of the petascale and pre-exascale supercomputers, drawing up and regularly updating the draft multiannual strategic agenda for such acquisition. Both RIAG and INFRAG include a number of observers (with the possibility to join the meetings and to contribute to the policy documents, but with no voting rights).

4.1.2 Selection of Hosting Entities

The most significant activity of EuroHPC JU so far has been the process of selecting and signing hosting agreements with the entities in Europe that will be hosting the petascale and pre-exascale systems. In June 2019, EuroHPC JU selected eight hosting sites in eight different EU Member States, located in Sofia (Bulgaria), Ostrava (Czech Republic), Kajaani (Finland), Bologna (Italy), Bissen (Luxembourg), Minho (Portugal), Maribor (Slovenia), and Barcelona (Spain). In total, 19 of the 28 countries participating in the Joint Undertaking at the point of the selection are part of the consortia operating the centres. Together with EU funds, it represents a total budget of € 840 million. Contracts between EuroHPC JU and the eight hosts for European pre-exascale and petascale systems were signed on 26 November 2019, marking the start of the procurement process for the selected hosts – a process which is still ongoing. Petascale systems are supposed to go into production during 2021, and the pre-exascale systems half a year later.

4.2 PRACE-EuroHPC Relation

Since June 2019, high-level coordination meetings with members of PRACE (Council Chair, Vice-chair, Managing Director, Council Delegate – Thomas Lippert, Janne Ignatius, Serge Bogaerts and Philippe Lavocat) and EuroHPC (Governing Board Chair, Vice-chair, Executive Director – Herbert Zeisel, Thomas Skordas and Gustav Kalbe) were organised in order to align activities, discuss and define roles in the European HPC ecosystem. The meetings took place on 26 June 2019, 26 March 2020 and 5 May 2020. The future relation of PRACE with EuroHPC, the HPC service collaboration and the modes of collaboration were addressed in the first meeting. In the following meetings, access policies and additional services PRACE could provide were discussed in particular. A joint Working Group (WG) on access policies was established. This WG consists of experts from PRACE, EuroHPC and INFRAG. The objective of the WG is the preparation of an access policy document for the EuroHPC Governing Board (GB). A special meeting was reserved to elaborate the PRACE-EuroHPC governance. It was recognised that PRACE has to remain an independent organisation as long as national HPC resources will be distributed by the PRACE peer review process. The question of whether its members will directly fund PRACE in future or if EuroHPC JU will fund PRACE needs to be decided by the PRACE Members with the funding agencies and ministries in charge of PRACE.

5 PRACE Services for EuroHPC

PRACE can support EuroHPC JU by providing a number of services which are described in this section. These services are:

- HPC access policy and peer review
- Technology watch
- Coordination of HPC Ecosystem Training
- Supporting the operation of the European HPC Infrastructure
- Enhancing Open R&D services for Industry
- User support

5.1 PRACE Access Modes

5.1.1 *Current PRACE Access Modes*

Currently, PRACE provides the following access modes:

- Project Access (see Section 2)
- Preparatory Access
- SME HPC Adoption Programme in Europe (SHAPE)
- PRACE Distributed European Computing Initiative (DECI)

In the following sections the preparatory access programme, the SHAPE initiative, the DECI call activity are presented.

5.1.1.1 *Preparatory Access*

The purpose of the Preparatory Access call is to support researchers by providing the opportunity to test and optimise their applications on the envisaged Tier-0 system prior to applying for a regular production project, including the option to receive support from the PRACE experts. It is possible to choose between four different types of Preparatory Access, structured according to different user needs. Preparatory Access proposals have only a technical review under the responsibility of PRACE hosting sites; when expert support is requested, an additional review by WP7 is included. Detailed information about the four types of Preparatory Access and the review process can be found on [9].

5.1.1.2 *The SME HPC Adoption Programme in Europe (SHAPE)*

PRACE provides HPC support to Small and Medium Enterprises (SMEs) via the SME HPC Adoption Programme in Europe (SHAPE) [10]. Many SMEs face barriers when attempting to use HPC within their businesses. In many cases, they will have little or no previous HPC experience and often will not be large enough to take on the risk if HPC does not work out for them. SHAPE aims to overcome this by providing support to SMEs via short, 2-6 month projects where the SMEs

can try out HPC to see if or how HPC might improve their business models. SHAPE began with a pilot call in 2013 and was followed up with a second call in 2015. Then from 2016 calls have been issued twice a year. SHAPE has so far supported 55 SMEs across 15 countries within Europe and is presently managed via task 7.2 of PRACE-6IP (‘Applications Enabling Services for Industry’). Proposals are received from SMEs via email or the PRACE website and then reviewed by a panel consisting of PRACE-6IP WP7 representatives, BDOs (Business Development Officers) from around Europe, as well as PRACE Industrial Advisory Committee (IAC) and PRACE aisbl Peer Review Office representatives. Successful applicants each receive dedicated expert support from a nearby PRACE HPC centre along with access to appropriate HPC hardware. At the end of the project, a white paper is produced explaining the work that was carried out and the impact on the SME’s business. The review process, as well as results from a survey of SMEs who have benefited from SHAPE, are described in [11].

5.1.1.3 The PRACE Distributed European Computing Initiative (DECI)

The PRACE Distributed European Computing Initiative (DECI) programme provides access to Tier-1 level resources within Europe. Calls presently open annually with the most recent call, DECI-16, receiving 68 proposals from 21 different countries. Of the proposals received, 47 have been awarded resources from June 2020 to June 2021 on 14 systems in 12 different European countries. DECI is managed via task 7.3 of PRACE-6IP (‘DECI Management and Applications Porting’). The review process involves first a technical evaluation from the home site (usually the site closest to the PI’s institution), followed by a scientific review from a panel of experts who rank the proposals, with the final decisions being made based on the ranking and availability of resources. Resources are allocated according to the *juste retour* principle where each country receives a similar amount of resources relative to its contribution (minus 15% for proposals from countries that do not contribute); projects are then placed on systems that are most appropriate for their work. The mechanisms here have all been described in more detail in [2].

5.1.2 Future PRACE Access Modes

As mentioned in previous sections, EuroHPC JU will enable the EU and participating countries to coordinate their efforts and share resources with the objective of deploying in Europe a world-class supercomputing infrastructure and a competitive innovation ecosystem in supercomputing technologies, applications and skills. PRACE will be supporting these objectives by offering its services to EuroHPC for access to these resources.

The PRACE Scientific Steering Committee (SSC) has proposed to update PRACE access modes in light of expected future systems and an increased target userbase. Notably, this update enhances the current Project Access calls in conceiving the new Extreme Scale mode which is aimed at funding more ambitious projects while keeping the same high peer review quality. As a complement, the new Regular Access mode is proposed to bridge the gap to national HPC access programmes. Finally, fast-track access modes are proposed for industrial and academic users. The table below summarises the highlights of the access modes proposed by PRACE SSC:

Access Mode	Extreme Scale	Regular	Benchmark	Development	Academic Fast Track	Industry Fast Track
Duration	1y renewable	1y renewable	2 to 3 months	1y renewable	< 6 months	1y renewable
Periodicity of calls	1x / y	3x / y	Continuous call, weekly cut-offs	Continuous call, weekly cut-offs	Continuous call, cut-offs ev. 2w/1m	Continuous call, cut-offs ev. 2w/1m
Project size (core hours)	> 75 M	< 75 M	200 k to 500 k	1 M to 5 M Or 5M to 25M for CoEs and NCCs	Up to 75 M	Up to 75 M
Share of resources	50 to 70% Mostly pre-exascale	20 to 30% Mostly multi-petascale	Few % All systems	Few % All systems	~5% All systems	~5% All systems
Data storage needs	Large storage for medium to long term	Large storage for medium to long term	Limited	Data processing environment and platform		
Accessible to industry	Yes – Open R&D With specific track	Yes – Open R&D With specific track	Yes – Open R&D	Yes – Open R&D	Yes – Open R&D	Exclusively Open R&D
External sc. review	Yes	Yes	No	No	No / Pre-identified	No / Pre-identified
Tech. review	Yes	Yes	Yes	Yes	Yes	Yes
DMP required	Yes	Yes	No	No	Yes	Yes
Proposal type	Full proposal	Full proposal	Technical proposal	Technical proposal	Light request + support documents	Full proposal
Prerequisite	Benchmark	Benchmark	None	None	Previous allocation or Benchmark	Benchmark
Submission period	> 2 months	> 2 months	N/A	N/A	N/A	N/A
• Duration of evaluation process	5 months	2 months	≥1 week <2 weeks	≥1 week <2 weeks	≥2 weeks <1 month	≥2 weeks <1 month

Table 2: The future of PRACE access modes

PRACE has identified a group of seven experts from different PRACE centres to provide support on the development and refinement of the peer review processes for these access modes. The first task of this peer review group was to concentrate on preparing a detailed Peer Review process for the new Regular Access mode, based on the conditions set by the PRACE SSC. After finalisation of recommendation for the Regular access mode procedures and application form, this group will then carry on its activities and review the peer review process for other types of access modes within the PRACE catalogue of services.

5.1.2.1 Regular Access Mode

The aim of Regular access mode is to enable and maintain the outstanding progress of science in the domain through frequent open calls for compute resources with an agile review process. It

should facilitate an easy access for excellent science beyond national capacities. This access mode, open to all fields of science, will call for proposals with a case to enable progress of science in the domains covered. These proposals are expected to be able to justify the need for large allocations in terms of compute time, data storage and support resources because they contribute significantly to progress of their respective domain.

The preconditions of the Regular access mode are listed in the table below:

Access Mode	Regular	External sc. review	Yes
Duration	1y renewable	Tech. review	Yes
Periodicity	3x / y	DMP required	Yes
Project size (core hours)	< 75 M	Proposal type	Full proposal
Share of resources	20 to 30% Mostly multi-petascale	Prerequisite	Benchmark
Data storage needs	Large storage for medium to long term	Submission period	> 2 months
Accessible to industry	Yes – Open R&D With specific track	Duration of evaluation process	2 months

Table 3: Preconditions of the Regular access mode

Within three months, the peer review process group produced a document describing the proposal of peer review procedures for the Regular access mode programme which is based on discussions of the experiences from 10 EU countries, their peer review procedures and statistics of their large-scale allocations. The information has been gathered from Bulgaria, Cyprus, Finland, France, Germany, Italy, The Netherlands, Spain, Sweden, and Switzerland. Moreover, the same information has been also gathered from PRACE project calls and DECI calls. The information gathered is the following:

- Peer-review procedures of each country;
- Statistics on the number of applications per discipline per country for large scale applications;
- Feedback from several main applicants on the current PRACE peer review procedures;
- Peer review procedures and statistics of PRACE Project Access during 2010 – 2019 period;
- Procedures and statistics of DECI during 2006 – 2019 period.

The analysis and discussions of the information gathered resulted in the following recommendations:

- The Regular access mode should distribute the corresponding resources 3 times per year through a continuously open call for proposals associated with cut-offs;
- The allocations should be granted for one year with the option for projects to apply for an extension of their allocation going through an assessment of their ongoing awarded project. We recommend that applicants (Principal Investigators or Co-Investigators) can only have one Regular Access awarded at any given time;

- Regular access mode should distribute a limited share (typically 20 to 30%) of the available resources, mostly from the multi-petascale systems and to a lesser extend from pre-exascale systems;
- The administrative check of the applications should be done continuously;
- The technical review should be conducted by technical staff of resource providing centres and should not take more than two weeks. The technical evaluation should be finalised before the scientific review;
- The scientific review should be performed by six domain panels, under the lead of a panel chair appointing rapporteurs for each proposal. Rapporteurs should be selected within a pool of pre-identified domain experts. A ranking per domain should be produced by the domain panel and the global ranking by a prioritisation panel gathering the domain panels chairs and led by a neutral chair. The consolidation meetings for each global ranking should take place after each cut-off preferably through physical meetings. The optimal load of a reviewer should be four to five applications per reviewer. The length of the application should not be more than 10 pages. Each application should be reviewed by two reviewers: primary and secondary reviewer. The scientific review should not take more than three weeks. During the fourth week the applicant should have the chance to reply to the reviewer within three days;
- Based on the information gathered from 10 EU countries, PRACE project access mode and DECI, the following discipline categorisation is recommended:
 1. Biochemistry, Bioinformatics and Life sciences
 2. Chemical Sciences and Materials, Solid state physics
 3. Earth System Sciences & environmental studies
 4. Engineering, Mathematics and Computer Sciences
 5. Computational Physics: Universe Sciences, Fundamental Constituents of Matter
 6. Socio-Economic Sciences and Humanities: Economics, Finance and Management, Linguistics, Cognition and Culture, Physiology and Medicine

Thus, for these disciplines distributions and considering two reviewers per application as well as the fact that the average number of applications received by PRACE project access mode and DECI, the recommendation is to have six scientific panels with 10 reviewers per panel, considering that each reviewer can review up to four applications. This should also leave room for a back-up pool of reviewers for unexpected cancellations.

- Prior to the consolidation meeting, the projects should be classified into three categories and the lists should be made accordingly by the chair of the consolidation meeting and distributed to the meeting members:
 - a) *Definitely accepted with complete allocation*
 - b) *Possibly accepted or accepted with a cut*
 - c) *Rejected*
- The allocation should be done with the following three-grade system:
 1. *Grade 1* – Complete allocation
 2. *Grade 2* – Allocation with a cut in accordance with the indication in the application form or by the panel

3. *Grade 3* – Rejection of low score projects even if there are available resources.

The ranking, allocation, acknowledgement to the applicant of the decision and preparation of the system access accounts should take not more than three weeks, thus summing up the whole period between administrative check and system access of accepted application PIs to nine weeks.

More details as well as the application form of this access mode are given in the Section 11 (Annex 4).

5.2 Technology Watch

In WP5, task 5.1 (entitled “Europe-Centred View of the Worldwide HPC Technology and Market Landscape”) decided to publish two white papers on Technology Watch in 2020 and 2021 and to summarise the analysis in the final deliverable D5.2. The aim is to provide, in the general perspective of the evolving EU HPC landscape and EuroHPC, information and guidance which could be useful for decision makers at different levels. After the EC recommendations that were received in June 2019 following the PRACE-5IP Final Review, the scope of both white papers and the deliverable has changed and adapted to be more European centric, covering new, emergent and complementary paradigms to HPC, enhancing the quality of the reports. The scope and focus of the PRACE Technology Watch was also refined in collaboration with the INFRAG, the RIAG and EXDCI-2 project, to include topics of their interest and avoid overlaps.

Since PRACE is the largest independent European HPC community, it can provide a neutral vision for Technology Watch. PRACE has the expertise on how to introduce new technologies in advance. Early technology adoption ensures successful massive deployment and optimal exploitation of resources by user communities. As part of the new scope within the EuroHPC era, while PRACE-6IP WP5 is providing an exhaustive view on technologies that will be on the market over the future years, the new scope also focuses on worldwide market shares to understand how Europe is positioned globally in comparison to others, i.e. US, China, Japan at least. In a time of fierce competition to develop and provide access to Exascale technologies, when different technological solutions are emerging, it is more important than ever to make informed decisions at each level of the HPC pyramid (Tier-0, Tier-1 and Tier-2). Considerations must also be taken in assessing future technologies that could preserve a degree of sovereignty in Europe, concentrating on technologies that are positioned in both the European and international scenes.

These white papers could help EuroHPC to decide where to invest to build a viable, economic and long-term European ecosystem, including not only HPC but also other paradigms such as AI, Quantum Computing and Cloud Computing to go Exascale and beyond. It could also provide guidance to understand market influencers, technologies to focus on and support decision makers on where to invest in. In a period where many merge and acquisition are occurring, restraining the bargaining power of buyers, this is becoming more and more important.

Abbreviated in titles, for the first version of the white paper, HPC and Cloud Technologies, Edge Computing and HPC, Monitoring and Management Tools, Data Centres, Requirements Influencing New Technology and Business Analysis were chosen to be presented.

The white paper on Technology Watch:

1. Presents the most recent developments and improvements made by the main processor manufactures Intel, AMD and IBM;
2. Puts a spotlight on ARM based processors for HPC applications as the first generation of these processors has already been planned to be launched in late 2021 by the European Processor Initiative supported company;
3. Describes the recent progress on vital HPC system components, GPGPU, for artificial intelligence and machine learning applications;
4. Highlights analysis and benchmarking for HPC data centres' components to offer insights for HPC system designers and related scientific users;
5. Presents a thorough investigation of the global trends on all aspects of HPC hardware systems in the design of Exascale machines including cooling and building structure, etc;
6. Reviews recently emerged standardisation of uptime/downtime of data centres, which provides a perception to the relevant parties in Europe for future standardisation.

5.3 PRACE Training Strategy and beyond

5.3.1 PRACE Background in HPC Training

PRACE has developed a significant pan-European HPC training programme for the past 10 years. While a significant part of the programme still comprises of in-person training courses, this is increasingly supplemented by remote learning opportunities such as online courses and MOOCs (Massive Open Online Courses). PRACE courses are mainly focused on general (i.e. typically not domain specific) HPC skills and competences aimed at intermediate to advanced users; the rationale being that basic level, introductory HPC courses tend to be more localised. However, some introductory courses are still included in the PRACE training programme, e.g. to engage with new communities to HPC. PRACE training activities, including upcoming courses, can be found on the PRACE Training Portal [12].

PRACE organises over 100 courses annually via its 14 PRACE Training Centres, PTCs (in Austria, Belgium, Czechia, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, UK, Slovenia, Spain, Sweden). PTC courses are complemented by Seasonal Schools and special on-demand events run in collaboration with other projects and European Centres of Excellence (CoEs).

While in-person courses remain to be the most effective for teaching certain HPC skills, PRACE has been gaining considerable experience in the development and implementation of online courses, from “live” synchronous teaching sessions to asynchronous MOOCs. The COVID-19 pandemic has since added pressure to deliver more online courses. PRACE has responded well to the initial pressure, transforming approximately 50% of its in-person PTC courses to online implementations in Q2 2020, and the adaptation of its Summer of HPC mobility programme into a virtual mentoring programme. A level of preparedness is being developed within PRACE to deliver the majority of its annual training programme in an online setting.

5.3.2 Target Audience

PRACE Training focuses a significant proportion of its resources to provide advanced level training services to grow the community of users with the experience and know-how to exploit pre-

exascale and EuroHPC infrastructure. This community consists of a relatively small but important audience. PRACE also organises advanced training that no individual HPC centre can provide by pooling pan-European HPC expertise.

The remaining resources are used in a diverse range of intermediate level HPC courses across Europe, to be used as the stepping stones to more advanced courses. Without the investment of resources and coordination by PRACE for both advanced level and intermediate level courses, HPC training in Europe would be disjointed and fragmented.

There is a baseline effort that is invested towards basic level training, that brings new user groups (SMEs, new scientific disciplines) into HPC. It is a necessary and cost-effective effort by PRACE to ensure continued accessibility and dissemination of such courses to all European researchers. PRACE also has ongoing efforts in this area to assist with local efforts to conduct more basic level training, e.g. by making available material, running asynchronous online courses such as MOOCs.

5.3.3 *PRACE Collaborations*

PRACE collaborates with external projects and organisations to develop joint events. This includes joint courses with the European HPC CoEs – projects specialising in domains such as material science, climate, bio science etc. in a HPC context. PRACE is also a partner in the FocusCoE project which supports the CoEs. Other ongoing PRACE training collaborations include the International HPC Summer School, organised with international partners (e.g. XSEDE in the U.S.). PRACE has also carried out training with other European projects (e.g. EUDAT) and research infrastructures.

PRACE has steadily built robust relationships with various external parties from its collaborations. More recently, it has also been involved in setting up a pan-European training special interest group as well as participating in the inaugural European training stakeholder meeting. This has given PRACE the opportunity to share its expertise and to advise on future European training developments.

5.3.4 *Potential Future Role of PRACE Training*

As the EuroHPC Joint Undertaking takes Europe into the exascale era, developing skilled people will be a key objective. In the area of HPC training, PRACE is in an ideal position to contribute to this objective owing to its significant expertise and leadership role in pan-European activities and coordination. The roles and responsibilities that PRACE can take on include:

1. "Monitoring of training landscape, advice for strategic planning": PRACE has prior experience with leading the discussion on various training topics. In order to develop and implement a European HPC training strategy, some level of monitoring of the training landscape is needed. PRACE is in an ideal position to take the lead role in liaising discussion with different projects/infrastructures/institutions to monitor the needs of different communities and sectors that can be used to direct training developments.
2. "Setting the standards": PRACE can exploit the knowledge of its collective partners to improve the quality and standards of HPC courses, e.g. in defining more consistent learning outcomes and prerequisites for courses delivered all around Europe. This consistency will

not only benefit users who seek to find training but it will also aid strategic planning, e.g. are there gaps in the training programmes systematically or in certain areas?

3. "Pan-European access and collaboration": PRACE maintains to support a regular, joint training programme (e.g. PTCs, Seasonal Schools, etc.) that is accessible to all Europeans, and collaborates widely to organise “blockbuster” training events that makes use of pooled expertise from different partners. There is considerable merit to support these activities as otherwise a large proportion of intermediate to advanced HPC training in Europe will be carried out in a fragmented manner without coordination, in some cases not truly open to all Europeans.
4. “Driving the HPC curriculum”: PRACE can drive the dialogue with a variety of stakeholders - across academia, industry, application users/developers, technology providers - to develop fit-for-purpose HPC curricula for different audiences. More comprehensive HPC education will be vital to develop the next generation of talent equipped with skills in rapidly emerging fields such as HPDA & AI, GPU accelerators, quantum computing and neuromorphic computing, as well as machine and deep learning.

5.4 PRACE Operations and Services for the new Systems

PRACE is continuously working across the different Implementation Projects to the maintenance and support to operational services and to pilot new services. The operational services of the ecosystem of Tier-0 and Tier-1 HPC machines in Europe are maintained daily and updated regularly to provide the best solutions to scientific and industrial communities. The HPC ecosystem evolves continuously with the regular integration of new systems and the natural decommission of obsolete systems, to guarantee high-tech solutions to researchers. At present, PRACE-6IP provides day-to-day maintenance for eight Tier-0 and 18 Tier-1 systems with a helpdesk and persistent monitoring of resources and services.

The operational services offered by PRACE are divided into several categories:

- Network services;
- Data services;
- Compute services;
- AAA (authentication, authorisation, and accounting);
- Operational security services;
- User services;
- Monitoring services.

Since the end of September 2019, the effort was mostly spent on the review of Service Catalogue and the definition of a plan for the implementation of more user friendly and forward-looking services for the future considering also the incoming new EuroHPC pre-exascale systems.

A first step was the plan for four new services that have been tested already within PRACE-5IP and have been chosen for continuation within PRACE-6IP: urgent computing, *in situ* visualisation, light-weight virtualisation services, and prototypal services for data analytics. Concerning urgent computing, by the end of 2019 PRACE-6IP had started deploying a scientific code called Tsunami developed within CoE ChEESE to PRACE Tier-1 systems that have strong GPU sub-clusters.

Then, the new collaboration with FENIX-RI has led to the proposed development of a PRACE AAI (Authentication Authorisation Infrastructure) to allow easier access to resources and services. A plan for this will be ready before the end of PRACE-6IP.

The integration of new Tier-0 and Tier-1 was guaranteed during the previous phases, without an explicit definition in the Service Catalogue. Now, with the approval of the PRACE Service Catalogue 3.4, this service will officially be integrated in the offer of PRACE, in order to support those sites that need to integrate their systems into the infrastructure. The integration of new systems, will be used in particular by some sites updating their systems (e.g. CEA with Irene, CINECA with Marconi100, IT4I with Barbora), and other sites which are going to start the integration of a system into PRACE for the first time (e.g. UCLA with Navigator, UL with HPCFS-U2).

5.5 PRACE Open R&D Services for Industry

In this activity, PRACE assesses through pilot projects with European industry the technical, legal and financial requirements needed for a possible deployment of pre-competitive R&D (delayed or no publication of the results) and production activities beyond the current Open R&D offer. As this activity involves technical and administrative issues, it is handled by PRACE-6IP/WP2 and PRACE-6IP/WP6, with strong support from the PRACE Industry Liaison Officer. This activity is also linked to the PRACE SME HPC Adoption Programme in Europe (SHAPE) that provides support to SMEs through the complementary Open R&D offer (requiring publication of results). Most of the initial activity took place from Q2 2019 to Q1 2020. But with significant impact from COVID-19, higher priority was placed on COVID-19 related project from PRACE side, hence there was reduced availability to pilot projects on the industry side.

The first planned pilot involving French (TGCC@GENCI) and German (HLRS@GCS) Tier-0 sites in a joint collaboration with Airbus [13], assessing technical and administrative issues towards the deployment of cloud-based HPC-services for pre-competitive R&D, involving also external research entities like DLR (Germany) [14] and ONERA (France) [15] is under consideration. At this stage, the project received indications that Airbus may not be able to invest anymore in this pilot due to COVID-19 regulations. Further discussions are needed in order to clarify if this pilot will still be launched.

Besides that, further pilots are planned to be launched, addressing other industrial domains and interested PRACE partners. In this context, a project from KWR [16], the scientific R&D arm of the Dutch water industry, has been evaluated as a candidate to test this new offer with KWR expressing strong interest to use the expertise of PRACE. The organisation produced a project abstract and outlined in detail the project's computational needs and its anticipated business impact. Although the project found initial support from all main stakeholders of the respective work packages, it was decided that it will best fit the SHAPE Call 11, at least for a first project. After the cut-off date of the SHAPE Call on 1 June 2020, the project now awaits approval from the SHAPE panel.

In this same Call, CENTIMFE [17], an industry association from Portugal, proposed a project on airflow generation in automotive systems. Given the fact that the applicant is not a single SME as

required in the eligibility criteria of SHAPE, but rather a national technology cluster of various members from industry and universities, discussions are currently under way to direct the project based on its merits to WP6 for consideration as a further pilot.

5.6 User Support Services

5.6.1 Applications Enabling Services

Work Package 7 (WP7) of PRACE-6IP has the objective to deliver high-quality support to PRACE HPC users from academia and industry. This support is structured in layers that start at the Tier-1 level (Preparatory Access Type D), continue through the Tier-0 level (Preparatory Access Type C) and bridge the gap with the HLST programme (Task 5 of WP7). This includes the SHAPE programme, of specific support to SMEs. This comprehensive support provided by WP7 has proven highly useful so far, contributing to nearly 200 enabling projects, from which 55 of specific support to European SMEs.

5.6.2 Forward-looking Software Solutions Projects

Work Package 8 (WP8) of PRACE-6IP focuses on ‘Forward-looking Software Solutions’ and has the objective to deliver high quality, transversal software that addresses the challenge posed by the rapidly changing HPC pre-exascale landscape. These challenges include the diversity of hardware and software complexity. It will advance strategic and long-term projects, allowing for disruptive approaches to modernise HPC software. The main outcome is open source software in the form of libraries or significantly refactored codes. This investment in applications, by experienced and skilled software engineers, provides a necessary link between the computer infrastructure and the scientific results obtained with applications on these systems. All of the projects aim to provide software solutions that enable the use of modern HPC systems, such as the planned EuroHPC pre-exascale systems.

The 10 projects within WP8 have been selected based on competitive, peer reviewed calls, as reported on in deliverables D8.1, D8.2 and D8.3 of the PRACE-6IP project to be made available on the PRACE website [18]. This includes eight projects funded from the start of PRACE-6IP, and two projects funded via a second call, with a starting date of January 2020. These projects cover a wide range of scientific domains, from fundamental topics such as tasking runtimes, halo-exchange libraries, to mathematical libraries including sparse and dense linear algebra, to application domain related software targeted at science and engineering like plasma physics, biophysics, finite elements, and fluid dynamics, or emerging domains such as quantum computing.

The recent deliverable D8.3 has been used to report on the public release of prototype software by all projects. This early release of work-in-progress software guarantees software availability to the community, and provides the community with an opportunity to inspect, test, and provide feedback. All first phase projects have provided links to accessible code repositories such as GitHub, Bitbucket and similar. Projects typically use a modern development infrastructure, including version control, automated continuous integration (CI), and standard documentation formats. Testing includes correctness as well as performance. Whereas the readiness level of the projects

differs, integration in user codes has taken place, first performance results have been included in D8.3, and certain codes have already become part of the procurement benchmarks of the EuroHPC Joint Undertaking pre-exascale systems. No critical issues in the management of these projects emerged so far. The first phase of this work package can thus be considered successful.

6 Legal Support to PRACE Infrastructure and other WPs

In addition to the support mentioned in previous sections of this deliverable, the PRACE-6IP WP2 working group has provided direct legal support to PRACE aisbl on several topics of current relevance and to issues of a legal nature that arose in the different work packages of the PRACE-6IP project.

6.1 COVID-19 Outbreak

At the beginning of 2020, the COVID-19 outbreak had a significant impact on the project activities. On 2 March, the European Centre for Disease Prevention and Control (ECDC, [19]) assessed that “the risk of widespread sustained transmission of COVID-19 in EU/EEA and UK in the coming weeks is moderate to high, with more countries expected to report more cases and clusters.”

The first big impact was on the organisation of the EuroHPC Summit Week and PRACEdays2020 [20]. In order to avoid reputational damage, to reassure the participants and for the sake of public health, the EuroHPC Summit Week was cancelled at the beginning of March. By the end of March, all project events and internal meetings until beginning of September 2020 were cancelled, postponed or converted to online events/meetings.

6.1.1 Analysis COVID-19 Impact on the Project

The COVID-19 pandemic caused new and exceptional impact all over the world. In order to cope with the new circumstances and to assess the legal and financial implications of the COVID-19 pandemic on the project, WP2 and PMO consulted the National Contact Point (NCP) for Horizon 2020 and the legal advisor firm Bird & Bird LLP assisting PRACE at the beginning of March 2020.

The main questions to be clarified were if the clause on Force Majeure in the Horizon 2020 Model Grant Agreement (MGA) (Art. 51) could be invoked in relation to the COVID-19 outbreak, and in case Art. 51 should apply, will the project be entitled to claim the costs incurred as eligible to the EC. The advice of Bird&Bird and the NCP were inline:

- The definition of Force Majeure in Art. 51 of the MGA is a standard definition and relates to an extraordinary and unforeseeable event or situation that is beyond the beneficiaries control and that prevents them from fulfilling their obligations under the action. Therefore, the conclusion reached by Bird&Bird was that “the beneficiaries need to demonstrate that the COVID-19 outbreak and/or its consequences (such as governmental measures, temporary closures of certain locations, restrictions on event organisations, etc.) make it - at least reasonably - impossible to comply with the GA”. Moreover, Art. 49.1.1 of the MGA explicitly specifies that the beneficiaries may suspend implementation of the action or any part of it, if exceptional circumstances - in particular Force Majeure - make implementation impossible or excessively difficult.
- As for the possibility to claim the costs incurred as eligible to the EC, the NCP indicated that this would be possible if the costs fulfil the general eligibility conditions set out in Art. 6 H2020 MGA like any other costs incurred under the action.

- If such a situation occurs, beneficiaries must immediately inform the Project Officer, which will examine on a case-by-case basis the possible application of the rules on Force Majeure, in the meaning of Art. 51 of the H2020 MGA.

As to the organisation of the cancelled events at a later stage, Art. 51 of the MGA also requires that *"the parties must immediately take all the necessary steps to limit any damage due to force majeure and do their best to resume implementation of the action as soon as possible"*. In these cases, Bird&Bird indicated that "if it is possible to re-schedule the event without (considerable) extra costs, it could be argued that the beneficiaries indeed have the obligation to organise the event at a later date. If this would lead to considerable additional (and non-refundable) costs, the beneficiaries cannot be expected to organise the event at a later date, after they were prevented from doing so because of Force Majeure."

6.1.2 Practices related to the COVID-19 Outbreak from the Project Partners

This section reports on the internal measures/ regulations taken by some of the project partners' countries and organisations due to COVID-19:

- Already at the end of January 2020, the PRACE-6IP Coordinator organisation, Forschungszentrum Juelich imposed preventive safety precautions for its staff such as a ban on all business travels to China. In March 2020 the travel restrictions were extended to all international travels and Forschungszentrum Juelich switched to basic operations. The 16 March 2020 marked the beginning of the lockdown in Germany with schools and kindergarten closures and social distance measures introduced.
- CaSToRC followed the Cyprus Government's guidelines during the COVID-19 lockdown, with regards to working from home and when it was safe to return to the office.
- CINECA has from the very beginning adapted restrictions in line with the Italian regulations on the COVID-19 pandemic. From Feb 2020, business travels were discouraged and then forbidden from March 2020. At end of Feb the first lockdown phase started and all staff (who did not need physical presence in the centre) was mandated to work from home. From June, with the start of the second phase, staff is gradually returning at the office with specific safety regulations which includes: control of temperature at the entrance, mandatory use of face mask while in the premises, social distance to be maintained of 2 metres.
- Due to COVID 19, UHeM takes the following measures: staff is mostly working remotely; only limited number of people are allowed to be in the institute; wearing mask is mandatory in the institute; the centre is being cleaned periodically and hand sanitizer are dispensed in available places.
- Due to the coronavirus (COVID-19) spread and the recommendation of the Finnish institute for health and welfare (THL) and the Finnish Government (Valtioneuvosto), CSC is suspending all visits to CSC premises until further notice (announcement published on 12 March 2020). In addition, CSC employees will not travel or attend any external meetings for the foreseeable future. According to this decision, CSC is cancelling all customer and stakeholder meetings as well as customer trainings and events until further notice. CSC will make attempts to organise these meetings using virtual tools whenever feasible.

- The University of Coimbra ceased the delivery of on-site lectures at a very early stage of the outbreak in Portugal, on 10 March 2020, who then immediately switched to online delivery. Most of the administrative workers also stayed at home, working remotely whenever possible. Only very few had to come to the University to maintain basic operations of laboratories, computer facilities, etc. Exams are also being implemented remotely. It is believed that the lockdown at an early stage was crucial to keep the pandemic under reasonable control.

6.1.3 *PRACE versus COVID-19: Actions & Activities*

This section reports on several initiatives that PRACE or PRACE partners started or joined in order to support the fight against the COVID-19. Currently updated information can be found on the PRACE website [21]

6.1.3.1 *PRACE Fast Track*

PRACE gave support to mitigate the impact of COVID-19 pandemic via the Fast Track Call for Proposals [21] opened at the end of March 2020. By the end of June 2020, 27 projects were awarded via the Fast Track that will use PRACE supercomputers to contribute to the fight against COVID-19. For additional support to the applicants and the successful projects, the PRACE-6IP project identified the following services:

- Online training (WP4),
- Support to usage of services requested by users (WP6), and
- Support projects through Preparatory Access and provide additional resources through DECI (WP7).

6.1.3.2 *EUvsVirus Hackathon*

PRACE joined the initiative EUvsVirus Hackathon on 24-26 April 2020 [22]. The Task Force of the PRACE Strategy Working Group (SWG) recommended PRACE to join this initiative by providing access to large scale HPC and AI facilities for some of the projects, if needed. PRACE-6IP PMO forwarded this recommendation to the PRACE-6IP MB to which confirmed support was received from the following partners: GCS, GRNET, CCSAS, TU-Wien, Uni Antwerpen, PSNC, IT4I and GENCI.

6.1.3.3 *PRACE was mentioned in the G7 Science and Technology Ministers' Declaration on COVID-19*

In the G7 declaration from May 2020 [23], the G7 Science and Technology Ministers announced that they intend to work collaboratively, with other relevant Ministers to strengthen the use of high-performance computing for COVID-19 response, among others. In particular, the G7 Ministers aim to enhance cooperation between G7 partners and ongoing initiatives, such as the COVID-19 High Performance Computing Consortium, the Partnership for Advanced Computing in Europe, and the High Performance Computing Infrastructure in Japan.

6.1.3.4 COVID-19 High Performance Computing Consortium

This Consortium provides COVID-19 researchers worldwide with access to the world's most powerful HPC resources to help significantly advance the pace of scientific discovery in the fight to stop the virus. PRACE collaborates with this unique public-private consortium that includes government, industry, and academic leaders who have volunteered free compute time and resources to this important effort. Among the academic representative of this Consortium, two PRACE partners joined this initiative: CSCS – Swiss National Supercomputing Centre and SNIC PDC – Swedish National Infrastructure for Computing, Center for High Performance Computing [24].

6.1.3.5 The EXSCALATE4CoV (E4C) Project

Several PRACE partners such as CINECA, BSC and JUELICH joined along with other European institutions the E4C project. This project is a public-private consortium supported by the European Commission's Horizon 2020 tender for projects to counter the Coronavirus pandemic and improve the management and care of patients. At the core of E4C is Exscalate (EXaSCale smArt pLatform Against paThogEns), at present the most powerful and cost-efficient intelligent supercomputing platform in the world. Exscalate has a "chemical library" of 500 billion molecules and a processing capacity of more than 3 million molecules per second. The E4C consortium, coordinated by Dompé Farmaceutici, is composed of 18 institutions from seven European countries [25].

6.1.3.6 Vlaams Supercomputer Centrum (VSC), Belgium

The last weeks a number of research groups were actively working to fight the COVID-19 epidemic in different ways. Also, an important number of companies have developed ground-breaking ideas on this topic. VSC, the Flemish Supercomputer Center, as an HPC resource centre, supported these efforts by opening a special call for accessing computing resources on the VSC HPC infrastructure for Flemish research [26].

6.1.3.7 Association "National Center for Supercomputing Applications" (NCSA-BG), Bulgaria

NCSA has undertaken an initiative together with five other partners, including the second largest Pharmaceutical Company in the world Hoffmann La Roche, to create a Joint Pharmacology and Artificial Intelligence Platform for Predicting Drug and Polymorphic Side Effect.

This project consists of two phases running in parallel with the most immediate first 12 months focused on COVID-19. In that period a supercomputer platform will be built using artificial intelligence for virtual screening and identification of possible side effects of the molecules recommended for the treatment of COVID-19.

In the current SARS-CoV-2 rapidly evolving situation, the primary task becomes checking the mutual influence of the expected new 15-20 drugs used to combat SARS-CoV-2 with all drugs that are often prescribed to chronically ill patients, as well as the biological targets they can bind to.

For patients with underlying health conditions or otherwise compromised immune systems delayed detection or complete misrecognition of side effects can have serious consequences and in some cases fatal consequences.

The project aims to:

- a) Significantly reduce the time to discover such side effects
- b) Decrease the investment needed for screening several hundred times.

6.1.3.8 IT4Innovations National Supercomputing Center (IT4I), Czech Republic

The IT4Innovations National Supercomputing Center at VSB – Technical University of Ostrava offers its users from academic institutions priority access to its computational resources to solve problems regarding COVID-19 disease research [27].

6.1.3.9 CSC- IT Center for Science, Finland

In March, CSC opened a prioritised access to Puhti supercomputer for COVID-19 pandemic research. COVID-19 projects have used about a third of Puhti's capacity.

One of these groups in the “fast track” is professor Ilpo Vattulainen's group in Department of Physics, University of Helsinki. The objective of their project is to use atomistic molecular dynamics simulations and machine learning techniques to unveil the mechanism of action of the main protease (mPro) of the SARS-COV-2 virus.

Another example of the prioritised access projects is a multidisciplinary collaboration project between several Finnish researchers who joined forces to investigate the airborne transmission of coronavirus.

CSC also offered resources for a global virtual bio-hackathon helping to develop new tools for COVID-19 analysis. [29]

More information about CSC's COVID-19 activities [28].

6.1.3.10 Grand équipement national de calcul intensif (GENCI), France

As part of the research efforts conducted at national level to contain the COVID-19 pandemic, GENCI provides French academic and industrial researchers with its computing and storage resources for their work in modelling / simulation, data processing, and the use of artificial intelligence [30].

6.1.3.11 Gauss Centre for Supercomputing e.V. (GCS), Germany

Recognising the urgency of the need for new strategies to contain the global pandemic, the three GCS centres have committed to fast-tracking applications for COVID-19 related computing time, minimising any hurdles during the application process. This applies to research at the molecular level to understand the virus and develop vaccines and therapeutics, epidemiological research to understand and forecast disease spread, and other related approaches aimed at understanding and halting the pandemic [31].

6.1.3.12 Irish Centre for High-End Computing (ICHEC), Ireland

ICHEC has been expediting access for all scientific and academic research relating to COVID-19 on the national high-performance computer “KAY”. Researchers with approved projects will be given fast-track access to HPC [32].

6.1.3.13 *Computing Center of the Slovak Academy of Sciences (CCSAS), Slovakia*

The scientific community worldwide is currently focused on solving problems related to the spread of the COVID-19 disease. SAS Center of Operations – Computing Center is planning to join this effort by providing priority machine time and premium technical support for scientific projects linked to this subject [33].

6.1.3.14 *Barcelona Supercomputing Center (BSC), Spain*

The Spanish Supercomputing Network (RES, from its Spanish name “Red Española de Supercomputación), coordinated by BSC has dedicated 50% of the resources of its latest call to research on covid-19. Given the effective review period of three months and standard allocation times of four months, this is expected to provide significant advances in a useful timeframe [34].

6.1.3.15 *Swedish National Infrastructure for Computing (SNIC), Sweden*

SNIC KTH is participating in the efforts of researchers against the COVID-19 pandemic and gives access to its resources for activities that support this work.

SNIC KTH together with BioExcel Center of Excellence has launched a series of activities to support research on the SARS-CoV-2 virus to assist with the global fight against COVID-19 [36].

SNIC PDC is also a member of the COVID-19 High Performance Computing (HPC) Consortium [24].

6.1.3.16 *Swiss National Supercomputing Centre (CSCS), Switzerland*

CSCS supports special national and international calls to study COVID-19. Together with its team and the supercomputer “Piz Daint”, CSCS will contribute to research in the fight against COVID-19 [35].

6.1.3.17 *National Center for High Performance Computing (UHeM), Turkey*

In March 2020, UHeM opened a call for the researchers conducting research related to COVID-19 with proposals being swiftly reviewed within one week. Two proposals were awarded for 3 million core hours of computational resource. The researchers run and completed their test before May 2020.

6.2 PRACE Collaborations

PRACE has three different levels of collaborations. At the 6th Council, Copenhagen, 24 January 2012, the following classification and decision was approved.

Council-2012-06-05: *The Council agrees on the rationale for collaborations presented above and approves the methodology presented. BoD shall apply this process to the pending requests from SPECS, IGE and HP-SEE.*

And the referenced methodology is:

1. *If the collaborators are PRACE users, seek advice of the Scientific Steering Committee on the pertinence and suitability of pursuing this collaboration or of expressing PRACE*

- support to the project proposal. If the answer is affirmative, BoD makes a proposal to Council voting via e-mail and acts based on the Council decision.*
2. *If the collaboration is technology oriented, set-up an evaluation committee composed of the PRACE Association and the PRACE project to assess the interest of PRACE to engage in such collaboration and identify who would be the PRACE contact person. The contact person is the person in charge of proposing collaboration work plan and presented to the BoD for approval. After approving it, the BoD makes a proposal to Council voting via e-mail and acts based on the Council decision.*
 3. *If the collaboration is related to strategic issues (e.g. international collaborations with peer actors, investments on HPC at national or international level, access programme design), then the Board of Directors makes a proposal in the subsequent Council (including contact person, work plan and draft MoU, if applicable) and a voting decision will take place at that time.*

In the reporting period, the following collaboration agreement was prepared:

6.2.1 Collaboration Agreement PRACE-GEANT-CERN-SKA

A new Collaboration Agreement (CA) between PRACE-GEANT-CERN-SKA was prepared and approved by all parties, and will be signed soon. This Collaboration Agreement will address the transition to exascale computing. The first systems with such capabilities are slated for the early 2020s with numerous development efforts underway in Europe, the United States, China and Japan. In anticipation of the delivery of these systems, the global HPC community is broadening its horizons, as well as providing a step change in capability for its traditional user base (computational fluid dynamics, quantum chemistry etc.). The exascale systems will need to provide the e-Infrastructure required by large experimental facilities that are due to generate unprecedented volumes of data as new capabilities come on line in the next decade. In addition, exascale platforms will be required to run artificial intelligence/machine learning (AI/ML)-related workloads as the fields of HPC and machine/deep learning continue to converge. ML/DL techniques will be widely adopted to enhance both scientific analysis and improve the performance, usability and reliability of the underlying platforms. Ensuring effective collaboration between HPC experts, scientists and engineers working on world leading ‘big science’ experiments, and the national and international bodies that facilitate the underlying e-Infrastructure to move data across the world is therefore critical for the successful delivery of projects such as the SKA and HL-LHC (High Luminosity LHC). The challenges and opportunities of the exascale computing era and its convergence with AI/ML are the motivation for this CA between CERN, SKA, PRACE and GEANT.

In the Collaboration Agreement, a work plan is included in Annex I which describes in more detail the collaboration activities. This includes, but is not limited to training support, work on a common set of demonstrators (Benchmarking proof-of-concept, Data Access, Authenticated Workflow) and the capability by providing training & centre of expertise.

6.3 Support to WP3

6.3.1 New PRACE website compliance with GDPR

The PRACE website was re-designed with the aim to give a cleaner and more intuitive experience to the visitor looking for PRACE related content such as Calls for Proposals, events, and support documentation. With WP2 support, this has resulted in updated versions of the Legal and Corporate sections of the new website.

The Legal Notice and Terms of Use document is now available on the PRACE website under the following link:

- <https://prace-ri.eu/legal-corporate/legal-notice-terms-of-use/>

The PRACE Web Team also carried out an analysis of the cookies used by the PRACE website. The PRACE Cookie Policy was then updated, listing of all of these cookies, their category, a short description of each and their duration. The new Cookie Policy can be found at the following link:

- <https://prace-ri.eu/legal-corporate/cookies-policy/>

It clearly explains to users of the PRACE website, why cookies are used, and how they can disable these should they wish to do so.

7 Summary

During the second period of the PRACE-5IP project a new key stakeholder has appeared in the HPC ecosystem, namely the EuroHPC JU. In this deliverable, we have reported on the current relationship of PRACE with this new high-level funding programme and clarified the roles of different stakeholders in the European HPC ecosystem. The developments in the PRACE 2 Programme are also reported as a demonstration of the current PRACE services and support the offer of PRACE to EuroHPC.

In this deliverable we have reported extensively on the PRACE offer to EuroHPC that are concretised in services such as the peer review process, training, technology watch, user support, PRACE operations and open R&D services for industry.

Moreover, we have reported on the development of the new HPC in Europe web platform established by the project that intends to offer an overview of the most important HPC services in Europe of the major actors in this ecosystem.

COVID-19 has emphasised the important role of HPC in fighting the disease. This deliverable reports on several initiatives that PRACE or PRACE partners started or joined to support the fight against COVID-19.

Annex 1 - Architecture and Integration of Services



E-Infrastructures H2020- INFRAEDI-2018-2020

INFRAEDI-01-2018: Pan-European High Performance Computing infrastructure and services (PRACE)

PRACE-6IP

PRACE Sixth Implementation Phase Project

Grant Agreement Number: INFRAEDI-823767

Architecture and Integration of Services *Draft*

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Author(s): Stelios Erotokritou, CaSToRC; Oriol Pineda, BSC; Veronica Teodor,
JUELICH; Florian Berberich JUELICH
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- [2] High Performance Computing: Europe's place in a Global Race ‘ [COM(2012) 45 final]

List of Acronyms and Abbreviations.

aisbl	Association International Sans But Lucratif (legal form of the PRACE-RI)
BDVA	Big Data Value Association
CoE	Centre of Excellence
DECI	DEISA Extreme Computing Initiative
DEISA	Distributed European Infrastructure for Supercomputing Applications EU project by leading national HPC centres
DSM	Digital Single Market
EC	European Commission
EDI	European Data Initiative
EOSC	European Open Science Cloud
ESFRI	European Strategy Forum on Research Infrastructures
ETP4HPC	European Technology Platform for High Performance Computing
EUDAT	European Collaborative Data Infrastructure
EXDCI	European Extreme Data & Computing Initiative
FET	Future and Emerging Technologies
FENIX	Fusion Engineering International Experiments
GÉANT	Collaboration between National Research and Education Networks to build a multi-gigabit pan-European network. The current EC-funded project as of 2015 is GN4.
HLST	High-Level Support Teams
JU	Joint Undertaking
PRACE	Partnership for Advanced Computing in Europe; Project Acronym

PRACE 2	The upcoming next phase of the PRACE Research Infrastructure following the initial five year period.
RI	Research Infrastructure
Tier-0	Denotes the apex of a conceptual pyramid of HPC systems. In this context the Supercomputing Research Infrastructure would host the Tier-0 systems; national or topical HPC centres would constitute Tier-1

List of Project Partner Acronyms

BADW-LRZ	Leibniz-Rechenzentrum der Bayerischen Akademie der Wissenschaften, Germany (3 rd Party to GCS)
BILKENT	Bilkent University, Turkey (3 rd Party to UHEM)
BSC	Barcelona Supercomputing Center - Centro Nacional de Supercomputación, Spain
CaSToRC	The Computation-based Science and Technology Research Center (CaSToRC), The Cyprus Institute, Cyprus
CCSAS	Computing Centre of the Slovak Academy of Sciences, Slovakia
CEA	Commissariat à l'Energie Atomique et aux Energies Alternatives, France (3 rd Party to GENCI)
CENAERO	Centre de Recherche en Aéronautique ASBL, Belgium (3 rd Party to UANTWERPEN)
CESGA	Fundacion Pública Gallega Centro Tecnológico de Supercomputación de Galicia, Spain, (3 rd Party to BSC)
CINECA	CINECA Consorzio Interuniversitario, Italy
CINES	Centre Informatique National de l'Enseignement Supérieur, France (3 rd Party to GENCI)
CNRS	Centre National de la Recherche Scientifique, France (3 rd Party to GENCI)
CSC	CSC Scientific Computing Ltd., Finland
CSIC	Spanish Council for Scientific Research (3 rd Party to BSC)
CYFRONET	Academic Computing Centre CYFRONET AGH, Poland (3 rd Party to PNSC)
DTU	Technical University of Denmark (3 rd Party of UCPH)
EPCC	EPCC at The University of Edinburgh, UK
EUDAT	EUDAT OY
ETH Zurich (CSCS)	Eidgenössische Technische Hochschule Zürich – CSCS, Switzerland
GCS	Gauss Centre for Supercomputing e.V., Germany
GÉANT	GÉANT Vereniging
GENCI	Grand Equipement National de Calcul Intensif, France
GRNET	Greek Research and Technology Network S.A., Greece
ICREA	Catalan Institution for Research and Advanced Studies (3 rd Party to BSC)

Architecture and Integration of Services

INRIA	Institut National de Recherche en Informatique et Automatique, France (3 rd Party to GENCI)
IST-ID	Instituto Superior Técnico for Research and Development, Portugal (3 rd Party to UC-LCA)
IT4I	Vysoka Skola Banská - Technická Univerzita Ostrava, Czech Republic
IUCC	Machba - Inter University Computation Centre, Israel
JUELICH	Forschungszentrum Juelich GmbH, Germany
KIFÜ (NIIFI)	Governmental Information Technology Development Agency, Hungary
KTH	Royal Institute of Technology, Sweden (3 rd Party to SNIC-UU)
KULEUVEN	Katholieke Universiteit Leuven, Belgium (3 rd Party to UANTWERPEN)
LiU	Linköping University, Sweden (3 rd Party to SNIC-UU)
MPCDF	Max Planck Gesellschaft zur Förderung der Wissenschaften e.V., Germany (3 rd Party to GCS)
NCSA	NATIONAL CENTRE FOR SUPERCOMPUTING APPLICATIONS, Bulgaria
NTNU	The Norwegian University of Science and Technology, Norway (3 rd Party to SIGMA2)
NUI-Galway	National University of Ireland Galway, Ireland
PRACE	Partnership for Advanced Computing in Europe asbl, Belgium
PSNC	Poznań Supercomputing and Networking Center, Poland
SDU	University of Southern Denmark (3 rd Party to UCPH)
SIGMA2	UNINETT Sigma2 AS, Norway
SNIC-UU	Uppsala Universitet, Sweden
STFC	Science and Technology Facilities Council, UK (3 rd Party to UEDIN)
SURFsara	Dutch national high-performance computing and e-Science support center, part of the SURF cooperative, Netherlands
TASK	Politechnika Gdańska (3 rd Party to PNC)
TU Wien	Technische Universität Wien, Austria
UANTWERPEN	Universiteit Antwerpen, Belgium
UC-LCA	Universidade de Coimbra, Laboratório de Computação Avançada, Portugal
UCPH	Københavns Universitet, Denmark
UEDIN	The University of Edinburgh
UHEM	Istanbul Technical University, Ayazaga Campus, Turkey
UIBK	Universität Innsbruck, Austria (3 rd Party to TU Wien)
UiO	University of Oslo, Norway (3 rd Party to SIGMA2)
UL	UNIVERZA V LJUBLJANI, Slovenia
ULIEGE	Université de Liège; Belgium (3 rd Party to UANTWERPEN)
U Luxembourg	University of Luxembourg
UM	Universidade do Minho, Portugal, (3 rd Party to UC-LCA)
Umeå	Umeå University, Sweden (3 rd Party to SNIC-UU)
UnivEvora	Universidade de Évora, Portugal (3 rd Party to UC-LCA)
UnivPorto	Universidade do Porto, Portugal (3 rd Party to UC-LCA)

Architecture and Integration of Services

UPC	Universitat Politècnica de Catalunya, Spain (3 rd Party to BSC)
USTUTT-HLRS	Universitaet Stuttgart – HLRS, Germany (3 rd Party to GCS)
WCSS	Politechnika Wroclawska, Poland (3 rd Party to PNSC)

1 Introduction

The European Data Infrastructure (EDI) aims to combine world-class supercomputing facilities – to be funded through EuroHPC – with high-speed connectivity and leading-edge data and software services for science, industry and the public sector. The EDI helps enable the European Open Science Cloud (EOSC) which aims to give the Union a global lead in research data management and ensure that European scientists reap the full benefits of data-driven science, by offering services for storage, management, analysis and re-use of research data. This document describes the European HPC Ecosystem, and the EOSC and EDI architecture and outlines how PRACE uniquely adds value to them, through its services and activities.

2 The European e-Infrastructures architecture

The e-Infrastructures Reflection Group (e-IRG) considers the European e-Infrastructure architecture to be structured around the following layers [1]:

- Network
- Computing
- Middleware
- Data
- Functionalities
- Users
- Communities

It is understood that some of these layers may be served by a single infrastructure, e.g. Network by GÉANT and (High-Performance) Computing by PRACE, while other layers may need domain-specific facilities, such as Centres of Excellence (CoE). Additionally, certain communities may prefer to design integrated infrastructures capable of serving all of their needs, e.g. CERN. The competitive advantage of PRACE, and other horizontal infrastructures, is the ability to deploy a European-wide service that no single country or community could afford or justify individually.

Following this architecture, the EC is developing the EOSC as a mechanism to collect all European research services in an integrated platform, facilitating interoperability and also promoting best practices, especially regarding the use of open data. After a thorough analysis of the e-Infrastructure ecosystem, EOSC defined its core services around data, in order to consolidate the offer of services of this layer. The first layers are already well established with existing infrastructures like GÉANT and PRACE, and the later layers are well-organised in specific user communities.

Complementary to this initiative, the EC has also promoted the EDI, in order to strengthen the network and computing layer and their interface with the data layer. To complete the landscape, the EC has funded the organisation of user communities and research communities around the Centres of Excellence and FETHPC projects.

2.1 The European HPC Ecosystem

The European HPC ecosystem is composed of three major pillars: Infrastructure, Applications and Technologies. These are now supported by the EuroHPC Joint Undertaking (JU), which acts as a foundation and support mechanism to the ecosystem. The three pillars also operate within the European Open Science Cloud initiative to promote the FAIR (Findable, Accessible, Interoperable and Reusable) data principles for European research data, and provide resources and services for open science.

The European HPC ecosystem is illustrated in Figure 1, with details on each entity following in the relevant sections:

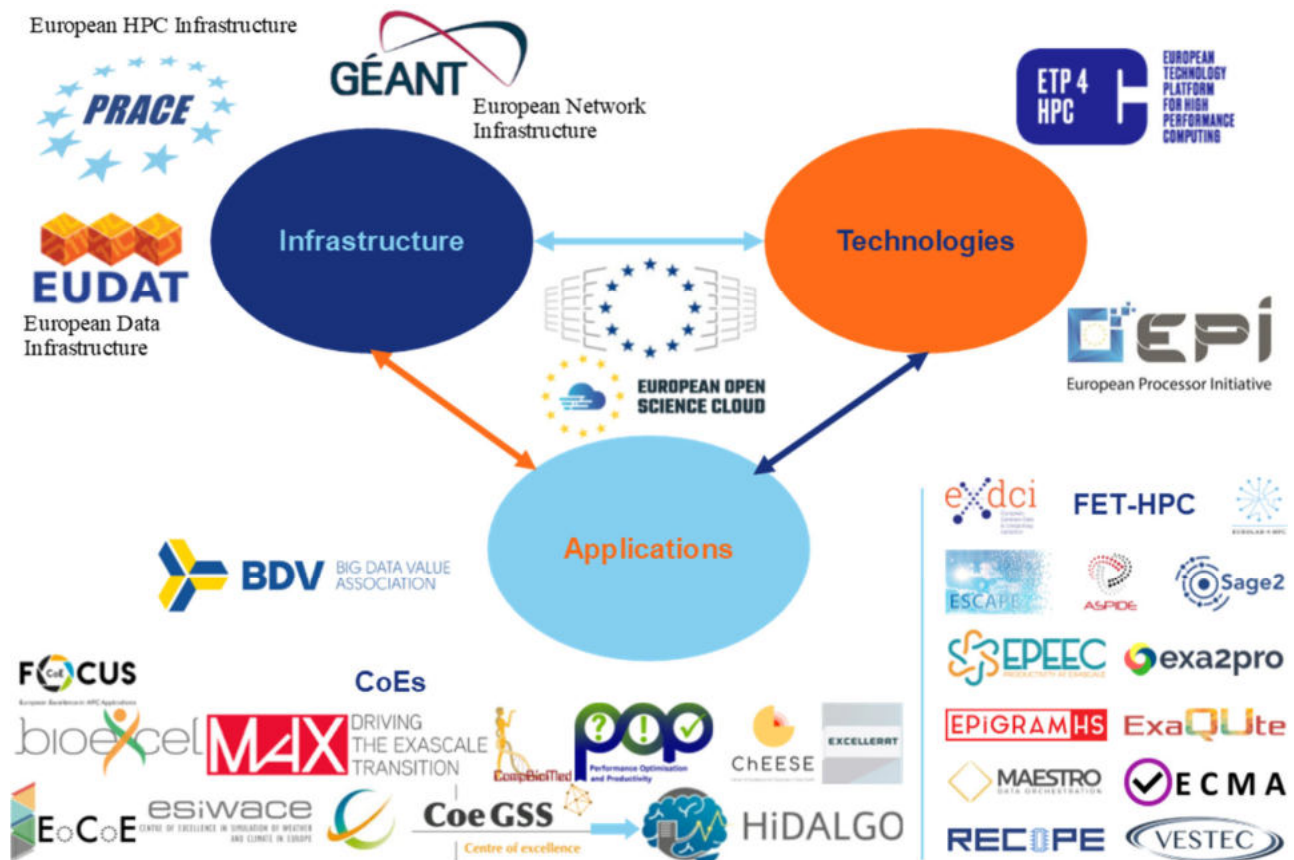


Figure 1: European HPC ecosystem

2.1.1 The Infrastructure Pillar

The Infrastructure pillar is composed of three necessary technologies: compute, data and network, which are required by a world-class HPC infrastructure to best support its users.

a) The HPC Infrastructure.

The first of these is the HPC Infrastructure, which is composed of a pool of High Performance Supercomputing systems. In the European HPC ecosystem, this infrastructure is provided by

PRACE and is composed of seven Tier-0 European systems hosted by the five PRACE Hosting Members (France, Germany, Italy, Spain and Switzerland) and multiple Tier-1 national system hosted by other PRACE members. Together with other smaller local Tier-2 systems, these systems provide the “pyramid” of available systems upon which European researchers can begin their journey into HPC (upon Tier-2 systems), advance their expertise (using Tier-1 systems) and become proficient users of the most powerful European HPC systems (on Tier-0 systems).

PRACE provides access to Tier-0 systems free of charge at the point of usage, under a peer review system based on scientific excellence. Furthermore, under the infrastructure pillar, PRACE provides other services to users, such as training (which is relevant to all users and not just a specific scientific field), general user support and optimisation and prototyping activities.

Within 2020, this European HPC Infrastructure will be complemented by five EuroHPC Petascale systems and three EuroHPC Pre-Exascale systems.

b) The Data Infrastructure

A Data Infrastructure is necessary and closely coupled with an HPC Infrastructure. HPC simulations and computational research rely heavily on observations, processed data and computed data. It is therefore important for a reliable, survivable and readily available European data infrastructure to co-exist with the HPC Infrastructure. Upon this data infrastructure, researchers can store their data for various retention periods, as well as making it available for use by other researchers for verification and expansion of research purposes through the FAIR Data Principles.

The Data Infrastructure is provided by EUDAT, which shares and preserves data across borders and disciplines, through a common model and service infrastructure for managing data. European researchers and practitioners from any research discipline can in this way preserve, find, access, and process data in a trusted environment, as part of the EUDAT Collaborative Data Infrastructure.

c) Network Infrastructure

For this data to be available, survivable, easily, and quickly accessible within Europe, and for all supercomputing systems to be virtually connected to each other for the transfer and use of this data by computational scientists throughout Europe, it is necessary to have a reliable, fast, survivable and secure network infrastructure through which this data can be transferred within the European HPC ecosystem.

This European Network Infrastructure is provided by GÉANT - interconnecting 38 national research and education network (NREN) partners, and connecting over 50 million users from all scientific disciplines at 10 000 institutions across Europe.

2.1.2 The Applications Pillar

The Applications pillar encompasses various projects focusing on specific HPC applications for various computing domains, namely “Centres of Excellence in HPC Applications” and “Big Data

and AI”. The “Future and Emerging Technologies in HPC” also contribute to this pillar, though their main objective is technology development.

a) Centres of Excellence (CoEs) in HPC Applications

In 2015 nine Centres of Excellence (CoEs) for computing applications were selected, following an H2020 e-Infrastructures call, meant to help strengthen Europe's existing leadership in HPC applications, and to cover important areas. In 2018, the second generation of CoEs was selected. This includes continuation of most of the previous CoEs, as well as two new centres, and FocusCoE as a coordination project for all nine CoEs.

The role of the CoEs is to promote within their scientific field the use of upcoming exascale and extreme performance computing capabilities, and to scale up existing parallel codes towards exascale scaling performance. In addition, CoEs address the skills gap in computational science in the targeted domains by specialised trainings for increased adoption of advanced HPC in industry and academia.

The current CoEs are:

- [EoCoE-II](#) – Energy Oriented Centre of Excellence for computer applications
- [BioExcel-2](#) – Centre of Excellence for Biomolecular Research
- [MaX](#) – Materials design at the eXascale
- [ESiWACE2](#) – Excellence in Simulation of Weather and Climate in Europe
- [POP2](#) – Performance Optimisation and Productivity
- [CompBioMed2](#) – Computational Biomedicine
- [HiDALGO](#) – HPC and Big Data Technologies for Global Systems
- [EXCELLERAT](#) – The European Centre of Excellence for Engineering Applications
- [ChESEE](#) – Centre of Excellence for Exascale in Solid Earth

and [FocusCoE](#), the project to coordinate their activities.

b) Big Data and AI (BDVA)

The Big Data Value Association (BDVA) aims to develop the Innovation Ecosystem that will enable the data and Artificial Intelligence (AI) driven digital transformation in Europe delivering maximum economic and societal benefit, achieving and sustaining Europe’s leadership on Big Data Value creation and AI.

BDVA aims at strengthening competitiveness and ensuring industrial leadership of providers and end users of BDVA technology-based systems and services and at promoting the widest and best uptake of BDVA technologies and services for professional and private use.

2.1.3 The Technologies Pillar

The ETP4HPC association and EPI (European Processor Initiative) share the aim of achieving European independence for HPC technologies. While EPI focusses on creating EU-owned processor technology, ETP4HPC aims to build a fully indigenous HPC supply chain in Europe.

a) ETP4HPC

ETP4HPC is an industry-led think tank composed of European HPC technology stakeholders: technology suppliers, vendors, research centres, independent software vendors (ISVs) and end users. Formally incorporated as an association at the end of 2012, ETP4HPC was meant to answer the EC Communication: 'High Performance Computing: Europe's place in a Global Race' [2], and act as the “one voice” of the European HPC industry.

ETP4HPC became the European Commission's partner in the contractual Public-Private Partnership (cPPP) for High-Performance Computing at the end of 2013. The objectives of this cPPP were:

- Develop next generation of HPC technologies, applications and systems towards exascale;
- Achieve excellence in HPC applications delivery and use.

The build-up and creation of the Partnership gave new momentum to European HPC. This is reflected in the growing number of organisations joining the ETP4HPC (more than 90 end of 2018), as well as through the response to the Calls for Proposals that were closed between 2014 and 2017. During this period 230 million euros in funding were allocated to 43 technical projects targeting technological blocks related to the exascale goal – hardware, system software, middleware and applications, with the selected FETHPC projects mostly covering the ETP4HPC Strategic Research Agenda topics and vision, whereas the Centres of Excellence covered the excellence in HPC applications goal.

The cPPP has thus been a productive collaboration with the EC between 2014 and 2018, with ETP4HPC and the CoEs providing input to the Work Programmes, in particular via ETP4HPC Strategic Research Agendas. This cPPP will come to an end soon as the EuroHPC Research and Innovation Pillar will take over. All HPC cPPP related H2020 calls for projects have been cancelled, and were redefined early 2019, under the umbrella of the EuroHPC JU. ETP4HPC already worked on revised input for this purpose, and delivered it to the DG CONNECT in September 2018 (this R&I input for Work Programme 2019-2020 is a joint effort with BDVA, the private side association for Big Data cPPP). Together, the two private associations were invited to provide six experts for the EuroHPC Research and Innovation Advisory Group (RIAG); the six other experts were appointed by the JU Governing Board. The RIAG:

- Will be responsible for elaborating the Strategic Research and Innovation Agenda (SRIA) on technology, applications, and skills development
- Will submit the SRIA to the Governing Board
- Will participate in the Work Programmes' definition
- Will provide feedback on achievements and global consistency of programme and schedules

The current agreed setup is that four RIAG seats will be assigned to ETP4HPC representatives and two to BDVA representatives. The experts will represent the associations as a whole through a clear mandate. The role of ETP4HPC, as a voice for HPC ecosystem including, but not limited to, technologies, will thus be continued with a strengthened role with respect to the cPPP, inside the more global coordination ensured by EuroHPC.

b) EPI

The European Processor Initiative (EPI) is an ambitious programme to develop chips integrating off-the-shelf 64-bit architecture CPU cores with Vector Extension and RISC-V based heterogeneous accelerator cores. The overall aim of EPI is to develop IP (intellectual property) owned in Europe for low-power microprocessors for the global market. Even though focus is on delivering chips for HPC, and in particular for Exascale supercomputers, the automotive industry for edge-HPC and broader data-centre market will also be targeted. The rationale is to reach higher-volume markets that can compensate the considerable R&D costs involved in chip development and go-to-market. For the implementation of this vision, the 26 European partners of the EPI consortium have signed a Framework Partnership Agreement (FPA). This FPA is currently planned to cover two Specific Grant Agreements (SGAs) with a total budget of 120 million euros. These two SGAs will span a total period of four years, with SGA1 running from December 2018 to November 2021, and SGA2 from November 2020 to April 2022, and will allow the consortium to develop the technologies and tap out two revisions of the EPI 1st generation processor. Under SGA2 the initial technologies will be optimised and performances increased, and revision 2 of the EPI 1st generation processor will be taped out. This chip will benefit from the experience gathered during SGA1, both in the development and usage of the EPI technology. Following this, EPI expects to develop the 2nd generation of the processor and the related technologies in subsequent SGAs, which will target Exascale level systems and enable the derivation of chips for large-volume markets.

c) Future and Emerging Technologies in HPC

The aim for the call for proposals "Towards exascale high performance computing" was to attract projects that can achieve world-class extreme scale computing capabilities in platforms, technologies and applications. In total, 21 projects were selected and began in 2015. These included 19 Research and Innovation Actions (RIA) and 2 Coordination and Support Actions (CSA).

Under the FET Proactive programme, 13 FETHPC-02-2017 – Transition to Exascale Computing projects were selected and began in 2018. These included 11 Technology Projects and 2 CSAs.

The 11 Technology Projects are:

- [ASPIDe](#) – exAScale ProgramIng models for extreme Data processing
- [EPEEC](#) – European joint Effort toward a Highly Productive Programming Environment for Heterogeneous Exascale Computing
- [EPiGRAM-HS](#) – Exascale Programming Models for Heterogeneous Systems
- [ESCAPE-2](#) – Energy-efficient SCalable Algorithms for weather and climate Prediction at Exascale
- [EXA2PRO](#) – Enhancing Programmability and boosting Performance Portability for Exascale
- [ExaQUte](#) – EXAscale Quantification of Uncertainties for Technology and Science Simulation
- [MAESTRO](#) – Middleware for memory and data-awareness in workflows
- [RECIPE](#) – REliable power and time-ConstraInts-aware Predictive management of heterogeneous Exascale systems
- [Sage2](#) – Percipient Storage for Exascale Data Centric Computing2;
- [VECMA](#) – Verified Exascale Computing for Multiscale Applications;

- [VESTEC](#) – Visual Exploration and Sampling Toolkit for Extreme Computing.

The 2 CSA are:

- [EXDCI-2](#) – European eXtreme Data and Computing Initiative;
- [Eurolab-4-HPC](#) – Foundations of a European Research Center of Excellence in High Performance Computing Systems.

2.1.4 The participation of PRACE in the European HPC Ecosystem

PRACE participates and/or contributes to all the HPC ecosystem pillars, either directly or through the HPC services provided:

- In the infrastructure pillar, PRACE coordinates the access to the top layer of European HPC systems and the interface with national HPC systems. PRACE is also coordinating with the European network and data services providers, in order to guarantee interoperability and promote joint services.
- In the applications pillar, the training and support services of PRACE complement the activities of European communities towards excellence in research and exascale applications. In addition, PRACE policies for access to HPC systems, based on scientific excellence and efficient use of the supercomputers, promote the technical and scientific competitiveness of European researchers.
- The role of PRACE in the technology pillar is not always evident or even visible. Even if PRACE is not directly involved in the associations driving this pillar, the objectives of PRACE are taken into account by them, and are included in their roadmaps. In addition, PRACE coordinates an annual forum for HPC sites and vendors to share future developments, positions and requirements under the necessary confidentiality environment.

3 The position of PRACE in the e-Infrastructure landscape

The main services of PRACE within the infrastructure pillar of the European HPC ecosystem are:

- HPC Access Provision
- Support to HPC Users
- Training in HPC

These are all well-established services that are already compatible with EOSC rules of participation, meaning that they could be incorporated into the EOSC marketplace and other service catalogues without any adaptation required. In this sense, EOSC is seen by PRACE as an excellent opportunity to increase the user community of PRACE and to facilitate interoperability with other e-Infrastructures.

The objective of PRACE is to deliver general HPC services that a priori can be used by any user and scientific community, including industry. This applies to access provision, user support and

training. This generalist role allows communities with large needs or strong requirements to develop services tailored to their specific needs. In order to promote an integrated offer of services, PRACE has worked with the major actors in the field in order to define the boundaries of the services provided.

In addition to these core services, PRACE is also involved directly or indirectly in other HPC ecosystem activities, namely:

- HPC Policy
- HPC Technology
- HPC Research
- HPC Operations
- HPC Dissemination

The role of PRACE in these services and activities is summarised in the following sections.

3.1 HPC Access Provision

The European HPC systems are classified according to their performance and scope. The first level of systems, so called Tier-0, integrates those supercomputers with a performance beyond any national needs. The second layer (Tier-1) is composed of supercomputers oriented to satisfy the domestic needs of each country, and the third layer (Tier-2) is formed by regional and domain-specific systems. PRACE is currently coordinating the complete European Tier-0 layer and the interface with the Tier-1 layer (through the DECI programme). The EuroHPC JU will contribute to this provision with the acquisition of three pre-exascale systems and five petascale systems.

The strategic importance of PRACE is to make sure that there is no gap between the national HPC capacities and PRACE minimum access requirements. In this way, it is ensured that most of the computing user needs across Europe are satisfied by one or another European HPC programme.

In this context, the role of PRACE is to provide a world-class Peer Review to distribute European Tier-0 computing resources based on the scientific excellence of the awarded projects. Over the past ten years, this has proven to be a robust and well-recognised process that has allowed the distribution of more than 21 billion core hours to nearly 700 international research computing projects. The future of PRACE is to continue operating this Peer Review process for access to EuroHPC JU computing systems based on scientific excellence. PRACE is also prepared to provide support to complementary access mechanisms that EuroHPC may envisage.

3.2 Support to HPC users

User support is structured in four levels, according to the scope and duration of the support provided:

- Level 1, so-called helpdesk support, refers to small requests that can normally be solved in one day or at most in one week

- Level 2 refers to application analysis and simple modifications, which can range from three to six months of required effort
- Level 3 refers to wider support requests for code porting or enabling, up to twelve months of required effort
- Level 4 refers to large code re-factorisation initiatives that can imply a few years of effort

The main role of PRACE is to provide Level 2 general user support, through the Preparatory Access mechanisms and with a maximum duration of 6 months of effort; this includes the SHAPE programme, aimed at promoting the adoption of HPC by European SMEs. As part of the PRACE 2 programme, the High-Level Support Teams (HLST) programme started recently with the objective to enhance the efficiency of PRACE Tier-0 awarded projects; this programme provides Level 2 support and short-term Level 3 support to projects identified by system administrators and PRACE Access Committee as susceptible to be technically improved. More recently, WP8 of PRACE-6IP has engaged into general-interest Level 4 activities, based on an internal selection of codes and libraries with a potential to be widely used in HPC simulations. The support provided by PRACE is complemented by the collaboration with the POP CoE in the usage of tools to audit and optimise the performance of applications running in Tier-0 systems.

Level 1 support is provided by the local HPC system administrators. When the requests relate to project allocation or duration of Tier-0 projects, PRACE is consulted and informed about the outcome.

Some communities and notably the Centres of Excellence also provide Level 2 and Level 3 support. Nevertheless, the boundaries of PRACE support are set in the objectives and availability of the support. While PRACE is providing a general support to any European HPC user, limited only by the availability of the required knowledge, these communities provide specific support to selected application codes and, in some cases, only the members of the community are eligible to benefit from this support. The major difference here is the horizontal support provided by the POP CoE to any European HPC user in the audit and optimisation of application codes.

Level 4 activities are also conducted by the Centres of Excellence as part of their mission to enable applications towards exascale. Again, these activities are compatible with and complementary to the objectives of PRACE in Level 4 activities.

3.3 Training in HPC

Training in HPC, and in many cases encompassing computational science topics, is typically offered via a combination of national and European training programmes. While national training programmes vary widely in scope and extent between countries, European training programmes play a complementary role by making use of synergistic resources that offers European researchers access to a large repertoire of training opportunities.

PRACE typically offers training on transversal HPC subjects across all levels of HPC users from different domains (i.e. from basic to advanced training, on e.g. general parallel programming techniques) but primarily with a focus on intermediate and advanced levels in order to complement

national programmes that typically cater for more basic training for local users. The European CoEs play a complementary role by offering training that is more focused on specific disciplines and communities, e.g. simulation and modelling HPC applications, algorithms and techniques. Some training courses are jointly organised by PRACE and the CoEs that encompass both types of skills, while some CoEs utilise PRACE (e.g. via the PRACE Training Centres) as a vehicle to deliver more domain-specific training. Similarly, some of the technology projects also conduct training on emerging and cutting-edge technologies, tools and techniques; in some cases in collaboration with PRACE and/or the CoEs.

While face-to-face courses/workshops represent the main type of training offered by PRACE, the CoEs and the technology projects, other types of training are also made available to researchers:

- Massive Open Online Courses (MOOCs)
- Online webinars
- Synchronous online courses (online participation in courses at set times)
- Student placement programmes (e.g. PRACE Summer of HPC)
- International HPC Summer School (PRACE, RIKEN, XSEDE, SciNet)

3.4 Other activities in the HPC ecosystem

As mentioned above, PRACE is also involved directly or indirectly in other activities related to the European HPC ecosystem. The current and proposed future role of PRACE in these activities is summarised below:

3.4.1 HPC Policy

The European Commission is the institution coordinating and financing the European policy in HPC, based on inputs from ETP4HPC and more recently from the INFRAG and RIAG advisory groups of EuroHPC JU. Even though PRACE has never directly been involved in HPC Policy, PRACE national members are active contributors of ETP4HPC and its Strategic Research Agenda. This situation is expected to continue with EuroHPC, with PRACE national members represented in the Governing Board, and in the INFRAG and RIAG advisory groups. Nevertheless, in order to further enhance the role of PRACE in this activity, a dedicated position for PRACE should be established in these bodies.

3.4.2 HPC Technology

As explained in section 2.1.3.a), ETP4HPC has been collecting the trends and positions of HPC technology stakeholders since its establishment in 2012. This has been transposed into the periodic Strategic Research Agenda editions elaborated since then, with the objective to establish the future objectives in HPC technology.

Complementary to this, PRACE organises the annual “European Workshops on HPC Centre Infrastructures”, where HPC sites and vendors can interact in an appropriate environment to share future developments, positions and requirements. Unfortunately, the high confidentiality required for a fruitful exchange with vendors is in contraposition with a wide dissemination and use of the results of the workshop. This should be further explored to match both positions.

3.4.3 HPC Research and Innovation

The strategy of PRACE related to research and innovation has always been to promote scientific excellence in academia and industry, across all computational research domains. This is the strategy that the Scientific Steering Committee has established for PRACE, and has been the central element of PRACE services, especially the PRACE Peer Review Process, but also of the training and support services of PRACE.

In the next months, the computational capacity of Europe will highly increase after the deployment of the new EuroHPC supercomputers. This will open a plethora of new opportunities and services that PRACE will be able to support. The INFRAG and RIAG advisory groups will be the ones proposing the research priorities to the EuroHPC Governing Board for this new era of HPC in Europe. The proposal of PRACE is to maintain scientific and innovation excellence as the driver of HPC access allocation.

3.4.4 HPC Operations

PRACE operations work has allowed PRACE to provide a pan-European HPC Infrastructure offering services to user communities as a single coordinated research infrastructure. Through a common service catalogue, a federated network and common security features implemented by all PRACE sites, researchers can access and use HPC resources and services as seamlessly as possible. PRACE offers compute services, (both Tier-0 and Tier-1), and middleware services that support users in their workflows. All these resources are tightly integrated in the PRACE ecosystem and they require a strong effort to be coordinated and operational.

This operation has required years of effort to coordinate and successfully realise. In the future, the new EuroHPC systems can be integrated into the PRACE HPC network and available to users in the same way as other PRACE systems (Tier-0 and Tier-1) upon which European researchers can refine their skills and carry out their research.

In addition to the maintenance of the operational services, PRACE operations continuously develop new services to satisfy the needs of the European user community addressing the challenges of convergence between HPC and HPDA as stated by the EDI vision. PRACE operations thus has developed and in the future will continue to explore new services for users. Such services include urgent computing, in-situ visualisation, lightweight virtualisation services and prototypal services for data analytics. PRACE operations also explores new services targeted at industrial users through the adoption of pilot cases based on innovative technologies and the technological evolution of existing PRACE operational services.

Further to the above activities, PRACE operations aims and is leading the way to integrate the PRACE European HPC infrastructure with other European infrastructures – such as EUDAT. These efforts will federate the various EDI infrastructures, allowing European users to seamlessly access interoperable services across different infrastructures to better and more efficiently execute their research.

3.4.5 HPC Dissemination

The PRACE communication strategy has always sought to disseminate and communicate to various target audiences – both at European and global level - the variety of services and resources PRACE provides, the high-level achievements of PRACE, and the excellent scientific and industrial results that can be achieved through PRACE HPC access.

PRACE dissemination has established the right connections, tools, activities, events, publications, tone of voice, and level of detail to reach the existing pool of researchers and related players of the current HPC landscape, but also aims to reach out to, attract, and inspire future generations of HPC users among various scientific disciplines and target groups (ranging from the general public to political and governmental audiences).

PRACE dissemination can continue to expand its activities and assume a stronger leadership role with regards to dissemination within the European HPC ecosystem –coordinating and cooperating with various actors so dissemination and outreach of European HPC activities attracts a wider and more diverse audience.

4 Summary and conclusions

This document has presented the position of PRACE in the European e-Infrastructure landscape and the added value of PRACE services and activities for the European HPC ecosystem. PRACE services and activities contribute directly to the objectives of EOSC and EDI, where PRACE is already properly positioned.

The PRACE brand is well established and well recognised as the major provider of access to the largest European HPC systems, support to all European researchers using HPC and training of the European computational community. In this regard, PRACE is already coordinating with other HPC service providers in Europe (e.g.; FocusCOE), in order to define the roles of each actor in each service, identify potential synergies and optimise the European capacity in HPC.

The role of PRACE in other HPC activities – like HPC policy, technology, research and innovation, operations and dissemination – has also been discussed, and a first proposal of PRACE strategy and integration of activities is presented in this document.

Annex 2 - HPC Ecosystem Summit Conclusion Report



E-Infrastructures H2020- INFRAEDI-2018-2020

**INFRAEDI-01-2018: Pan-European High Performance Computing
infrastructure and services (PRACE)**

PRACE-6IP

PRACE Sixth Implementation Phase Project

Grant Agreement Number: INFRAEDI-823767

HPC Ecosystem Summit Conclusion Report *Final*

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References and Applicable Documents

- [1] High Performance Computing: Europe's place in a Global Race ‘ [COM(2012) 45 final]
- [2] COM (2016) 178 final
- [3] COUNCIL REGULATION (EU) 2018/1488; <https://eurohpc-ju.europa.eu/>

List of Acronyms and Abbreviations.

aisbl	Association International Sans But Lucratif (legal form of the PRACE-RI)
BDVA	Big Data Value Association
CoE	Center of Excellence
DECI	DEISA Extreme Computing Initiative
DEISA	Distributed European Infrastructure for Supercomputing Applications EU project by leading national HPC centres
DSM	Digital Single Market
EC	European Commission
EDI	European Data Initiative
EOSC	European Open Science Cloud
ESFRI	European Strategy Forum on Research Infrastructures
ETP4HPC	European Technology Platform for High Performance Computing
EUDAT	European Collaborative Data Infrastructure
EXDCI	European Extreme Data & Computing Initiative
FET	Future and Emerging Technologies
FENIX	Fusion Engineering International Experiments
GÉANT	Collaboration between National Research and Education Networks to build a multi-gigabit pan-European network. The current EC-funded project as of 2015 is GN4.
HLST	High-Level Support Teams
JU	Joint Undertaking
PRACE	Partnership for Advanced Computing in Europe; Project Acronym
PRACE 2	The upcoming next phase of the PRACE Research Infrastructure following the initial five year period.
RI	Research Infrastructure
Tier-0	Denotes the apex of a conceptual pyramid of HPC systems. In this context the Supercomputing Research Infrastructure would host the Tier-0 systems; national or topical HPC centres would constitute Tier-1

List of Project Partner Acronyms

BADW-LRZ	Leibniz-Rechenzentrum der Bayerischen Akademie der Wissenschaften, Germany (3 rd Party to GCS)
BILKENT	Bilkent University, Turkey (3 rd Party to UHEM)
BSC	Barcelona Supercomputing Center - Centro Nacional de Supercomputacion, Spain
CaSToRC	The Computation-based Science and Technology Research Center (CaSToRC), The Cyprus Institute, Cyprus
CCSAS	Computing Centre of the Slovak Academy of Sciences, Slovakia
CEA	Commissariat à l’Energie Atomique et aux Energies Alternatives, France (3 rd Party to GENCI)
CENAERO	Centre de Recherche en Aéronautique ASBL, Belgium (3 rd Party to UANTWERPEN)

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CESGA	Fundacion Publica Gallega Centro Tecnológico de Supercomputación de Galicia, Spain, (3 rd Party to BSC)
CINECA	CINECA Consorzio Interuniversitario, Italy
CINES	Centre Informatique National de l'Enseignement Supérieur, France (3 rd Party to GENCI)
CNRS	Centre National de la Recherche Scientifique, France (3 rd Party to GENCI)
CSC	CSC Scientific Computing Ltd., Finland
CSIC	Spanish Council for Scientific Research (3 rd Party to BSC)
CYFRONET	Academic Computing Centre CYFRONET AGH, Poland (3 rd Party to PNSC)
DTU	Technical University of Denmark (3 rd Party of UCPH)
EPCC	EPCC at The University of Edinburgh, UK
EUDAT	EUDAT OY
ETH Zurich (CSCS)	Eidgenössische Technische Hochschule Zürich – CSCS, Switzerland
GCS	Gauss Centre for Supercomputing e.V., Germany
GÉANT	GÉANT Vereniging
GENCI	Grand Equipement National de Calcul Intensif, France
GRNET	Greek Research and Technology Network S.A., Greece
ICREA	Catalan Institution for Research and Advanced Studies (3 rd Party to BSC)
INRIA	Institut National de Recherche en Informatique et Automatique, France (3 rd Party to GENCI)
IST-ID	Instituto Superior Técnico for Research and Development, Portugal (3 rd Party to UC-LCA)
IT4I	Vysoka Skola Banska - Technicka Univerzita Ostrava, Czech Republic
IUCC	Machba - Inter University Computation Centre, Israel
JUELICH	Forschungszentrum Juelich GmbH, Germany
KIFÜ (NIIFI)	Governmental Information Technology Development Agency, Hungary
KTH	Royal Institute of Technology, Sweden (3 rd Party to SNIC-UU)
KULEUVEN	Katholieke Universiteit Leuven, Belgium (3 rd Party to UANTWERPEN)
LiU	Linköping University, Sweden (3 rd Party to SNIC-UU)
MPCDF	Max Planck Gesellschaft zur Förderung der Wissenschaften e.V., Germany (3 rd Party to GCS)
NCSA	NATIONAL CENTRE FOR SUPERCOMPUTING APPLICATIONS, Bulgaria
NTNU	The Norwegian University of Science and Technology, Norway (3 rd Party to SIGMA2)
NUI-Galway	National University of Ireland Galway, Ireland
PRACE	Partnership for Advanced Computing in Europe aisbl, Belgium
PSNC	Poznan Supercomputing and Networking Center, Poland
SDU	University of Southern Denmark (3 rd Party to UCPH)
SIGMA2	UNINETT Sigma2 AS, Norway
SNIC-UU	Uppsala Universitet, Sweden
STFC	Science and Technology Facilities Council, UK (3 rd Party to UEDIN)
SURFsara	Dutch national high-performance computing and e-Science support center, part of the SURF cooperative, Netherlands
TASK	Politechnika Gdańska (3 rd Party to PNSC)
TU Wien	Technische Universität Wien, Austria

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UANTWERPEN	Universiteit Antwerpen, Belgium
UC-LCA	Universidade de Coimbra, Laboratório de Computação Avançada, Portugal
UCPH	Københavns Universitet, Denmark
UEDIN	The University of Edinburgh
UHEM	Istanbul Technical University, Ayazaga Campus, Turkey
UIBK	Universität Innsbruck, Austria (3 rd Party to TU Wien)
UiO	University of Oslo, Norway (3 rd Party to SIGMA2)
UL	UNIVERZA V LJUBLJANI, Slovenia
ULIEGE	Université de Liège; Belgium (3 rd Party to UANTWERPEN)
U Luxembourg	University of Luxembourg
UM	Universidade do Minho, Portugal, (3 rd Party to UC-LCA)
UmU	Umea University, Sweden (3 rd Party to SNIC-UU)
UnivEvora	Universidade de Évora, Portugal (3 rd Party to UC-LCA)
UnivPorto	Universidade do Porto, Portugal (3 rd Party to UC-LCA)
UPC	Universitat Politècnica de Catalunya, Spain (3 rd Party to BSC)
USTUTT-HLRS	Universitaet Stuttgart – HLRS, Germany (3 rd Party to GCS)
WCSS	Politechnika Wroclawska, Poland (3 rd Party to PNSC)

1 Introduction

The European Commission (EC), recognising the need for an EU-level policy on HPC, published the communication ‘High Performance Computing: Europe's place in a Global Race’ [1] on 15 February 2012. The communication stressed the importance of optimising national and European investments and of addressing the entire HPC ecosystem and marked the beginning of its latest HPC Strategy. Since then, within Digital Single Market (DSM) strategy [2] subpart European Data Initiative (EDI), the EC has significantly increased investment in HPC, through various projects and initiatives in three pillars, as shown in Figure 1: Technology, Infrastructure and Applications.

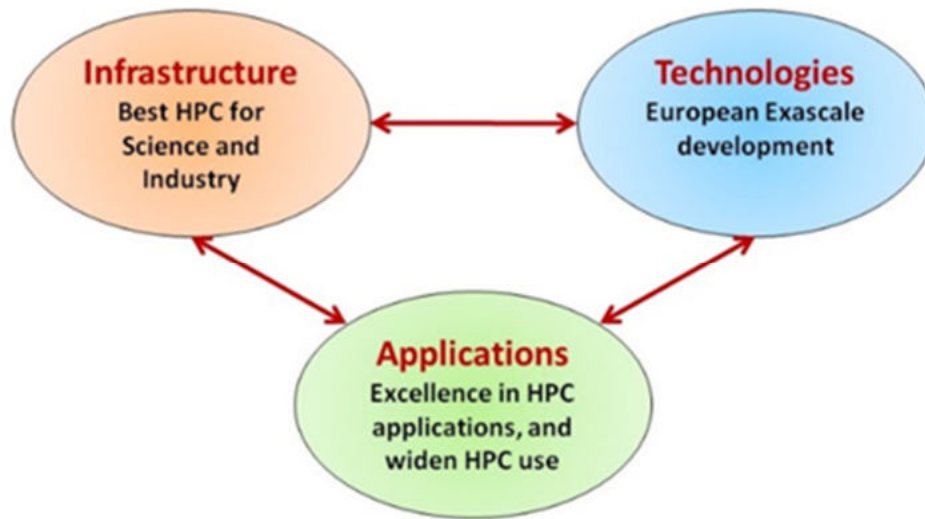


Figure 1: HPC ecosystem Pillars

The EuroHPC Joint Undertaking (JU) [3] began operation on 1 January 2019. EuroHPC will allow the EU and participating countries to coordinate their efforts and share resources with the objective of deploying a world-class supercomputing infrastructure and a competitive innovation ecosystem in supercomputing technologies, applications and skills.

Based on the EC recommendation received during the Interim Review from 17 December 2018, PRACE-5IP project prepared the organisation of a summit in order to sort out and fix roles (who does what in the future), with the participation of all relevant players affected (e.g. EOSC, EuroHPC, CoEs, Other Support actions for the HPC ecosystem like EXDCI-2, HPC-GIG, FocusCoE).

This document presents the actions undertaken by PRACE to coordinate the activities of European HPC stakeholders, the conclusions achieved and next steps for harmonised provision of European HPC services and activities.

2 The Analysis of the HPC Landscape

2.1 The HPC Ecosystem Summit, Poznań, 14 May 2019

An HPC Ecosystem Summit was organised by the PRACE-6IP project on 14 May 2019 during the EuroHPC Summit Week 2019 in Poznań, Poland. The Summit was attended by more than 50 representatives from the European Commission, PRACE, GÉANT, CoE and FETHPC projects, EXDCI-2 and ETP4HPC, among others. The objective of this Summit was to present current activities and discuss future roles and responsibilities of the key HPC stakeholders within the landscape. The discussion during this Summit allowed to clarify the positions and to define further stratification actions.

2.2 The HPC Ecosystem Survey

To prepare for the HPC Ecosystem Summit, a dedicated survey with 10 questions was sent to 81 contacts (coordinators of CoEs, FETHPC projects, EuroHPC JU, ETP4HPC, BDVA, GÉANT, FocusCoE, EPI, EOSC, EUDAT, OpenAire, eInfraCentral, EXDCI-2) before the meeting. The contacts were asked in more detail to indicate which of the three pillars they were part of, if they would be able to attend the HPC Ecosystem Summit in order to take part in the discussions, to indicate their specific domain and include a list of their services. Moreover, they were asked to indicate possible overlap and collaboration with other initiatives or organisations. The main part of the survey was a self-evaluation on each contact's role in the European HPC landscape provided through the answers to the following matrix as shown in Figure 2.

	Developer	Coordinator	Provider	User/Beneficiary	Enabler
HPC Policy					
HPC Technology (industry, hard & soft)	<ul style="list-style-type: none"> <i>Developer: institution in charge of preparing materials for the development activity</i> <i>Coordinator: institution in charge of collecting materials from developers and of coordinating their implementation</i> <i>Provider: institution in charge of providing the services to execute the activity</i> <i>User/beneficiary: institution that benefits from the activity</i> <i>Enabler: institution that enables the activity by providing the necessary services that are not part of the core of the activity</i> 				
HPC Computing Services					
HPC Training					
HPC Application Enabling and User Support					
HPC Research					

Figure 2: Matrix self-evaluation role in the European HPC landscape

2.3 Agenda and Minutes of the HPC Ecosystem Summit

2.3.1 Agenda

For this meeting, the following agenda was sent in advance with the invitation e-mail:

Programme:

14:30 Welcome (EC/PRACE) – Setting the scene

14:40 HPC Ecosystem

14:50 Results from the Survey

15:00 Panel Discussion

- Participants: all involved stakeholders
- Topics: **Training, Support, Services, Research, Technology, Policy**
- Questions: Where are overlapping tasks? Where is potential for cooperation?

16:30 Conclusion

16:50 Next Steps

17:00 End of Meeting

2.3.2 Minutes

The following part of this section reports the discussions that took place during this HPC Ecosystem Summit in Poznań, 14 May 2019:

14:30 Welcome (EC/PRACE) – Setting the scene

Florian Berberich (FB), PRACE-6IP and Leonardo Flores (LF), EC open the meeting and thank the participants for helping to define the roles in the HPC ecosystem.

14:40 HPC Ecosystem

FB's presentation (see attachment):

Objectives of the HPC Ecosystem Summit:

- Set the roles (who does what in the future)
- Involve all relevant HPC players
- Publish a vision of the architecture and integration of the services with EOSC, EDI, data services, etc. for the communities

14:50 Results from the Survey

FB informs that the survey was sent to 81 contacts (coordinators of CoE, FETHPC projects, EuroHPC, ETP4HPC, BDVA, GÉANT, FocusCoE, EPI, EOSC, EUDAT, OpenAire, eInfraCentral, EXDCI). Almost 50% received feedback, but no reply from EuroHPC.

The received answers were from: 10 CoEs, 15 FETHPC projects, EOSC, EPI, HBP, FocusCoE, GÉANT, ETP4HPC, and PRACE.

Analysis of the survey results: focus on the provider aspect.

- HPC policy provider:
 - Assumed role of EuroHPC.
 - Answers received – indicate to provide HPC policy: CoEs (2/10), ETP4HPC (1/1), EXDCI (1/1), FETHPC (1/15) and PRACE (1/1).
 - The definitions are explained in this first category with examples

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- The *developer* is the institution in charge of preparing materials for the development activity, in this case ETP4HPC.
- The *coordinator* is the institution in charge of collecting materials from developers and of coordinating their implementation, in this case EuroHPC.
- The *provider* is the institution in charge of providing the services to execute the activity, in this case it is still to be clarified if this will be the EC or EuroHPC.
- The *enabler* is the institution that enables the activity by providing the necessary services that are not part of the core of the activity, like GÉANT for HPC compute services, or the HPC-GIG and EXDCI-2 CSAs.
- The survey is still open and answers can still be provided – EuroLab did not fill in the survey
- HPC Technology provider:
 - Answers received - indicate to provide HPC technology: CoEs (4/10), eInfraCentral (2/5), EPI (1/1), FETHPC (5/15), GÉANT (1/1), EOSC (1/1)
 - The answers indicate a provider role for ETP4HPC and CoEs → The questions were not clear enough. Some of the CoEs do co-design which can be interpreted as technology provision as well.
 - Serge Bogaerts (SB), PRACE aisbl, indicates that PRACE as coordinator of the EXDCI-2 CSA, answered for HPC Technology, but expecting to see ETP4HPC there as well. [After checking with ETP4HPC, it became clear that the first answers received were not on behalf of ETP4HPC but rather on behalf of the members of ETP4HPC, e.g. CEA. New answers were given by the ETP4HPC office which reflect the role of ETP4HPC]
- HPC Computing Service provider:
 - Answers received - indicate to provide HPC services (provide access to HPC compute resources): CoE (5/10), eInfraCentral (2/5), FETHPC (5/15), PRACE (1/1), EOSC (1/1), HPB (1/1)
 - Guy Lonsdale (GL), FocusCoE, comments that the CoEs should have been providing this. Interesting that ETP4HPC is the provider of this, meaning of HPC compute services. To be clarified with ETP4HPC: why did they indicate to be the provider of this service. [see comment concerning Technology provider]
- HPC training provider:
 - Answer received – indicate to provide HPC training: CoE (8/10), eInfraCentral (2/5), FETHPC (6/15), PRACE (1/1), EOSC (1/1), HPB (1/1)
 - Further discussions with EOSC are needed in order to clarify what type of training they are providing. For now, we have the CoEs-PRACE training collaboration.
 - GL indicates that ETP4HPC must have been answering about training for its members, for their organisation, not for the users. GL enquires about EXDCI-2's role. [See comment concerning Technology provider]

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- SB indicates that EXDCI-2 appears under PRACE. It was not clear in the survey if one should answer as representative of the organisation or of the project in which the organisation is involved.
- Per Öster (PÖ), CSC, comments that EOSC provides training for HPC technology, data management or tools like notebooks, there is an overlap.
- FB asks about the EOSC training portal.
- Tiziana Ferrari (TF), EOSC, confirms that EOSC provides training coordination with the clusters, as joint events; it delivers training as EOSC hub. She adds that there is no overlap with the PRACE training, maybe one small overlap on accelerators. One of the reviewers' recommendations – deliver training, they see positive points because of the calendar, the need for coordination.
- Annabel Grant (AG), GÉANT, enquires if a single portal is being planned.
- FB confirms - the *HPC in Europe* portal linked to the Training Portal. Moreover, he adds that this portal could be linked this to EOSC training portal - this could be helpful for people looking for training information and find all relevant information in one place.
- HPC Application Enabling and User Support provider:
 - Answer received – indicate to provide HPC Application Enabling and User Support: CoE (9/10), eInfraCentral (2/5), FETHPC (7/15), PRACE (1/1), EOSC (1/1), HPB (1/1)
 - FB mentions that looking into detail, an overlap between the involved actors could be identified. PRACE is providing application and user support via the PRACE-IP projects and via its members via the High-Level Support Team (HLST) programme. Clarification with the PRACE partners is still needed. FB asks about CoEs' position for the application and user support and how are the CoEs supporting the users in this topic.
 - A representative from BioExcel answers that the applications are developed beforehand, BioExcel has four core applications. FB comments that if a code is not supported by BioExcel, the user can come to PRACE. The representative of BioExcel indicates that BioExcel works closely with the developer.
 - Dirk Pleiter (DP), CoE MaX, indicates that CoE MaX has a set of predefined codes and service framework supported.
 - FB underlines that each CoE will be asked for a list of codes and services to make available in the portal.
 - DP comments that important is to identify the gaps.
 - SB draws the attention to the fact that application and user support is very wide. Need to take this into account, distinguish the overlap.
 - FB comments that his understanding is that the CoEs are working more on the in-depth services. Are the CoEs available for a short time like 2-3 months support? The representative of BioExcel comments that the support is limited only if unique for the whole community. FB asks into which extend are the CoEs ready to provide user support. The representative of BioExcel replies that for big projects, for example for user with 50 million core hours, support is being provided.
 - FB asks if the codes are supported by the CoEs, how the funding is being provided, and are the codes of general purpose or not.

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- BioExcel replies that for training: a collection of these promoting events would be appreciated as well as a common scheme. Oriol Pineda (OP), BSC adds that this is being prepared for the HPC in Europe portal, therefore a common action on this topic is needed.
- TF replies that relating to the EOSC applications, the competence centres are meant to complete the ESFRI, to target the big projects. This is an opportunity to collaborate with the centres, to redirect the users to the right provider. FB confirms, adding that at least this can ease the collaboration between each other. The Centres of Competence mentioned, are not the same as those of the EuroHPC. PÖ comments that the same applications can be used in different environments, on the large scale HPC. FB indicates that the idea of a joint training database could be a good solution to get an overview.
- HPC Research provider:
 - Answer received – indicate to provide HPC Research: CoE (6/10), eInfraCentral (1/5), FETHPC (6/15)
 - Developer role is clear.
 - Provider role – FETHPC, ETP4HPC and CoEs interpreted this as software research, then it makes sense.
 - DP adds that CoE MaX does co-design, so it explains their answer.
 - GL indicates that no research at all is being done by ETP4HPC, apart from SRA. [see comment concerning Technology provider ETP4HPC]

15:00 Panel Discussion

- Participants: all involved stakeholders
- Topics: **Training, Support, Services, Research, Technology, Policy**
- Questions: Where are overlapping tasks? Where is potential for cooperation?

HPC Policy:

LF enquires who provides the vision. The EC have provided input to RIAG and INFRAG. EuroHPC will do the policy in terms of funding and the main guidelines, and it is up to the stakeholders where to put the effort, where to engage. We need a conceptual framework. Operational infrastructure is the role of EuroHPC. The Infrastructure and Technologies Pillars still need to be clarified. We need the framework for discussion. Application can be also a part of the service.

FB comments that EuroHPC defines the policy, no overlapping.

LF confirms - the HPC policy is a clear case. But the members of the association are not clear, so when we speak about ETP4HPC, we talk about the association.

PÖ adds that the Member States are part of EuroHPC, and this is an opportunity to put the policy in place.

HPC Technology:

FB asks if any overlapping at technology level could be reported. PRACE is not involved in this pillar. ETP4HPC and the FETHPC projects develop the technology.

HPC Ecosystem Summit Conclusion Report

There is an overlap, not much, but the gaps need to be clarified between the stakeholders. What is coming in the next years and who is going to provide that? The microprocessor, so many things come additionally.

DP comments that PRACE could help FETHPC projects in the selection of the co-design projects. They can also help bring new users in prototype-based services. PRACE could play an important role to fill in the gap.

LF adds that EXDCI is doing the mapping. Jean Francois Lavignon started that. With whom are you collaborating to do that?

FB indicates that also cooperation at this level is needed. ETP4HPC is doing this and is being involved in the SRA preparation groups.

Eugene Griffiths (EG), BSC comments that SRA needs to fit in EuroHPC.

HPC Computing Service:

FB indicates that the feedback received is misunderstanding and this will be double checked [done]. EOSC access to computer resources, but no overlap between EOSC and PRACE, we need to facilitate the user to find the right offer.

Certain categories of users are looking for services that the academic sector cannot offer.

FB comments that example of use cases between EGI and PRACE need to be identified.

TF adds that the community has a composite need and does not go to more providers. This means besides having different providers in Europe, coordinated application enabling, coordinated capacity management is needed.

FB adds that cloud approach with invisible provider might work for some demands. But PRACE users need to know where they can run their codes. So this contradicts with the cloud idea.

HPC Training:

FB comments that it is planned that training from other providers should be made available via the planned portal HPC in Europe.

TF enquires about SME specific support from PRACE side.

FB indicates SHAPE, the SME HPC Adoption Programme in Europe. Now discussions are ongoing on how to improve inside PRACE. The resources are available based on open R&D, results have to be published. How is it in EOSC?

TF replies that in EOSC there is no scientific evaluation and programme for offering vouchers for a given time and capacity.

FB suggests to compare these two initiatives and promote both of them together.

GL underlines the clear interest to collaborate from FocusCoE, but he points out to the label issue.

FB confirms, indicating that first it was proposed the PRACE portal as a joint platform, but the CoEs did not agree with this proposal. Now, we suggest a joint data base, with no logo. I could be also linked to the PRACE Training Portal which provides further material.

HPC Ecosystem Summit Conclusion Report

LF indicates that he understands the struggle with this label, but the users need to be considered – they need a single entry point with an explanation of what is being provided. He encourages all the stakeholders to collaborate. A common understanding of the services that are out there needs to be defined.

Mark Asch (MA), EXDCI-2, comments that in EXDCI a specific task was supposed to do this portal and enquires about the outcome.

FB indicates that EXDCI was supposed to do a job portal, which does not exist anymore. There was no training portal to be done by EXDCI. The job portal is now included in HiPEAC.

HPC Application Enabling and User Support:

FB indicates that PRACE will try to collect the codes which the CoEs are working with, as well as their capability to give other support to the user support. The difference between the short-term user support – just porting the code - and long-term support should be kept in mind.

LF enquires why the EC is paying the CoEs to develop their codes.

FB comments that in PRACE different support levels are defined: level 1 – basic support, such as password; level 2 – short-term support; level 3 - long-term support, and level 4 - refactoring a code. High-Level Support Teams are between level 3 and 4.

LF points out to a typical example: POP can analyse my code, but the user does not know when to go to PRACE or not.

FB indicates that PRACE agreed to collaborate closer with POP to do this profiling of the code.

HPC research:

FB comments that for soft- and hardware, ETP4HPC and CoEs were identified; Software is being provided only by the CoEs.

16:00 Conclusion

FB concludes the discussions and enquires how to proceed with this exercise. PRACE-6IP will provide a summary of the discussion, how we can see the ecosystem, with the possible collaboration with the different stakeholders. He enquires the need of a follow-up meeting.

OP, BSC comments that training and support still need to be clarified and further questionnaires on these topics might be needed.

One attendee comments that common services are visible and asks how all the stakeholders can manage this coordination.

FB indicates that this can be reflected in the document as well – PRACE can provide a solution for today's HPC ecosystem and at the same time a future vision with more integrated services. PRACE will write such a document and all other stakeholders will be asked to comment and depending on the topic, more specific meetings in order to refine this exercise will be organised.

FB adds that additional answers to the survey are expected. These will be taken into account for the conclusions. [done]

16:30 End of Meeting

2.4 PRACE view on the HPC Ecosystem

The view of PRACE regarding the HPC ecosystem is structured in the following tracks:

- HPC Policy
- HPC Technology
- HPC Access
- HPC Training
- HPC Support
- HPC Research

These tracks were reflected in the self-evaluation matrix used for the questionnaire distributed to the European HPC contacts. The results obtained have been processed in order to identify the most relevant actors and their roles for each track. It is worth mentioning that the HPC Ecosystem Summit in Poznań evidenced some confusion on a few contacts, especially regarding the affiliation reported. This has been later clarified and taken into account in the summary results presented here:

- **HPC Policy:** this was coordinated and developed by the European Commission, based on inputs from the member states and from the SRA elaborated by ETP4HPC. Recently, this coordination was transferred to EuroHPC JU, under the guidance of the RIAG and INFRA advisory groups.
- **HPC Technology:** ETP4HPC has been coordinating the European HPC technology providers, in order to identify and guide the future European investments in HPC.

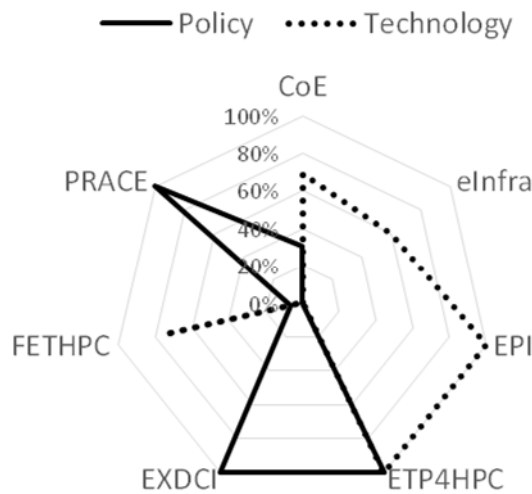


Figure 3: Provision HPC Policy and Technology in % of positive responses in the respective stakeholder groups.

- **HPC Access:** PRACE is the access provider of the most powerful European HPC systems through the Tier-0 (Project Access) and Tier-1 (DECI) programmes. The role of PRACE is to provide Europe-wide general-purpose HPC access. More specific HPC access (post-

HPC Ecosystem Summit Conclusion Report

processing and interactive services) is under development by the complementary FENIX infrastructure. The HPC access provision is complemented by national HPC programmes, available in most European countries.

- **HPC Training:** PRACE is the main provider of general HPC training in Europe through the PRACE Training Centres (PTCs). Domain-specific training is provided by the European HPC communities supported by Centres of Excellence, under the coordination of the FocusCoE CSA.
- **HPC Support:** PRACE is the main provider of general HPC support in Europe through the Preparatory Access mechanism. This mechanism offers support for general code porting and development, including Tier-1 to Tier-0 upgrade, up to a maximum of 12 months of support. Additionally, the horizontal POP Centre of Excellence provides tools to audit and optimise the performance of applications. Domain-specific support activities are carried out by the corresponding European HPC communities supported by Centres of Excellence. Additional user support is provided for awarded PRACE users through the HLST programme, in order to improve the performance of their projects and optimise the use of PRACE allocations.

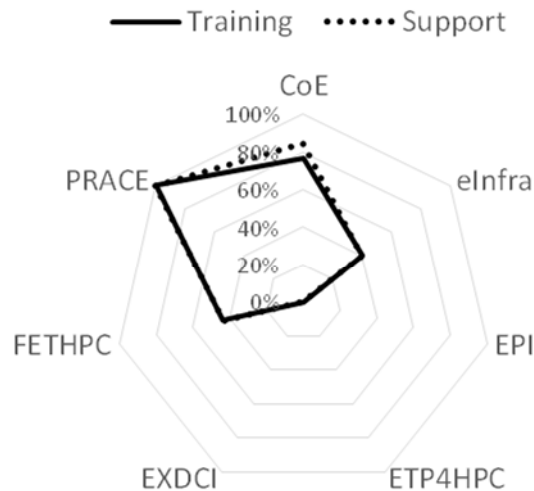


Figure 4: Provision HPC Training and Support in % of positive responses in the respective stakeholder groups

- **HPC Research:** European Centres of Excellence and FETHPC projects are the main initiatives that conduct research in HPC in Europe, under the coordination of initiatives like EXDCI and FocusCoE.

3 Conclusions and Next Steps

This document presents the roles and activities of the major European HPC stakeholders, based on the results of a survey distributed to them and the follow-up discussions of the summit organised during the EuroHPC Summit Week 2019.

This summit showed that there is a need to collect and present the complete offer of European HPC services in an organised manner. The PRACE-5IP project started to develop the framework “HPC in Europe” portal to serve as a central point of access to all these services. This work will be finalised by the PRACE-6IP project by the end of 2019.

The view of PRACE is that, at this stage, the HPC stakeholders and their activities are well self-organised, as a result of the recent coordination activities undertaken. The main role of PRACE is to manage the scientific excellence-based Peer Review process for the access to the most powerful European HPC systems, complemented with general training and support programmes to European HPC users. The training and support offer is completed by the services provided by Centres of Excellence and other domain-specific initiatives.

Special emphasis needs to be put on training and support activities, in order to clarify them to the European users of these services. In this context, PRACE is already working with the FocusCoE project, and the training activities offer has already been structured to avoid duplication between different contributors (PRACE and CoEs). The boundaries between support provided by PRACE, CoEs and HLST programme are well-established, but further coordination work needs to be done between the parties involved in order to integrate the offer of support services into a Europe-wide support programme. Training and support integration need to be properly consolidated through the “Europe in HPC” portal in order to provide a clear offer of services to European HPC users.

The results from these future activities will be collected in a common paper on the future European landscape, to be discussed and elaborated by all stakeholders. A follow-up of the European HPC Summit will be prepared before the end of the year, in order to collect the feedback of all involved players. It is very important to get all stakeholders actively involved to prepare a joint vision. This vision will be also reflected in the new HPC in Europe portal.

4 Annex

Slides presented at the European HPC Summit: *European-HPC-Summit-20190514.pdf*.



HPC Ecosystem Summit

Florian Berberich

Forschungszentrum Juelich GmbH



Agenda

14:30 Welcome (EC/PRACE) – Setting the scene

14:40 HPC Ecosystem

14:50 Results from the Survey

15:00 Panel Discussion

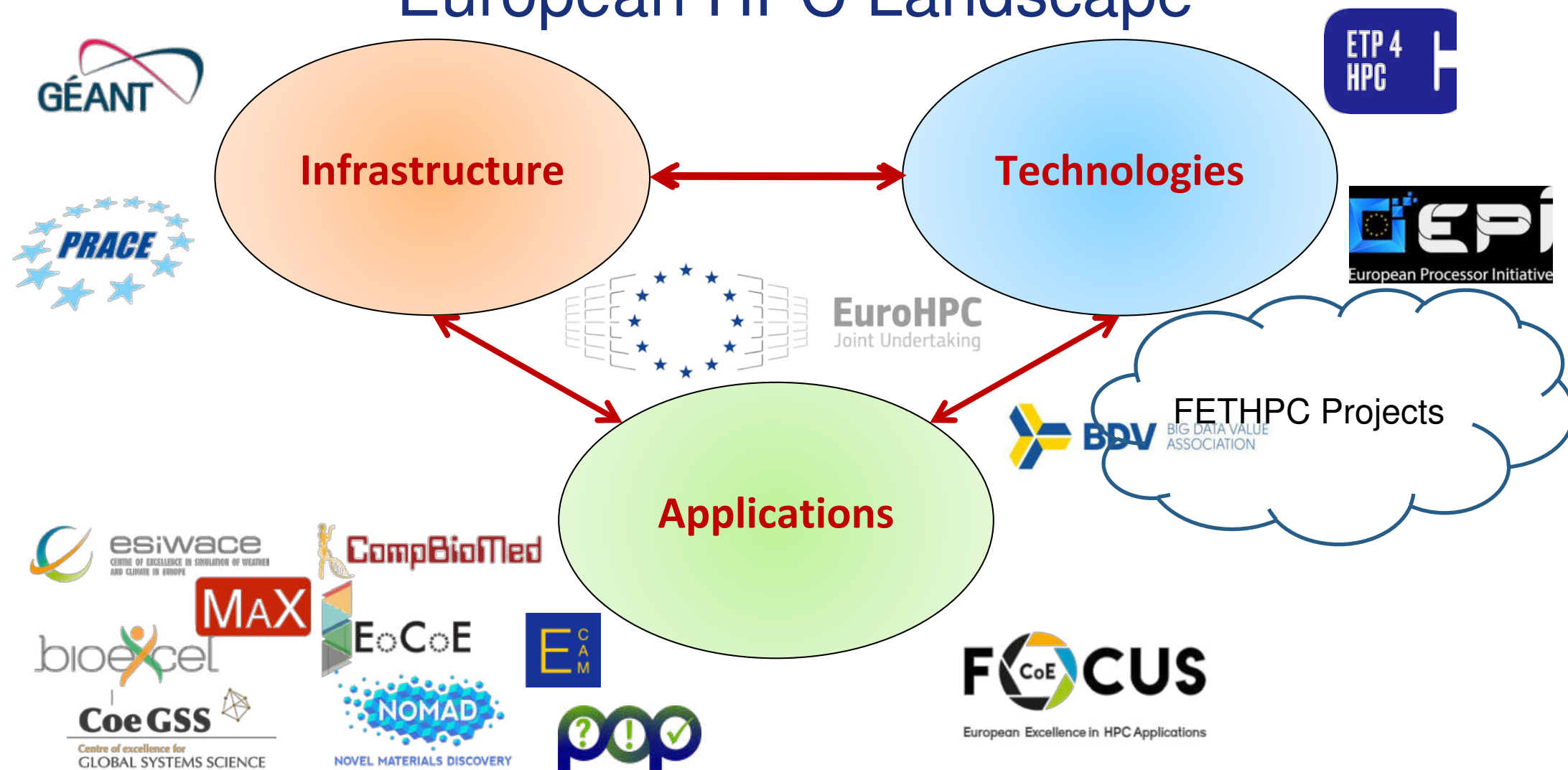
Participants: EuroHPC, PRACE, GEANT, CoE – Focus CoE,
FETHPC – ETP4HPC, EOSC, BDVA

Questions: Where are overlapping tasks? Where is potential for
cooperation?

16:00 Conclusion

17:00 Next steps and end of meeting

European HPC Landscape



Objective of HPC Summit

- ▶ Sort out and fix roles (who does what in the future)
- ▶ Participation of all relevant players affected (e.g. EOSC, EuroHPC, CoEs, other support actions for the HPC ecosystem like EXDCI, HPC-GIG, FocusCoE)
- ▶ Prepare and publish a vision of architecture and integration of services with EOSC, EDI, data services, etc. for the communities

Survey

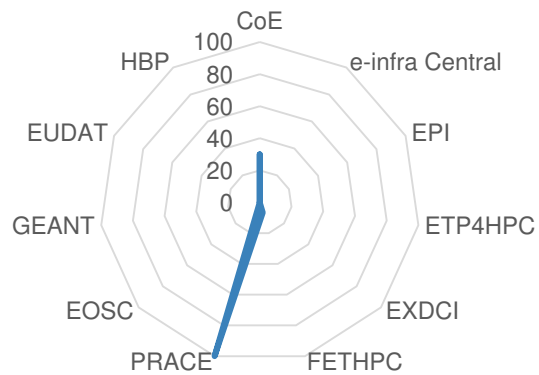
- ▶ Survey was sent to 81 contacts (coordinators of CoE, FETHPC projects, EuroHPC, ETP4HPC, BDVA, GÉANT, FocusCoE, EPI, EOSC, EUDAT, OpenAire, eInfraCentral, EXDCI)
- ▶ 39 answers were received by yesterday
 - ▶ 10 from CoE
 - ▶ 15 FETHPC
 - ▶ EOSC, EPI, HBP, FocusCoE, GÉANT, ETP4PC, PRACE aisbl, PRACE-IP,
 - ▶ EuroHPC missing
- ▶ High response rate of nearly 50%

The HPC Ecosystem Matrix

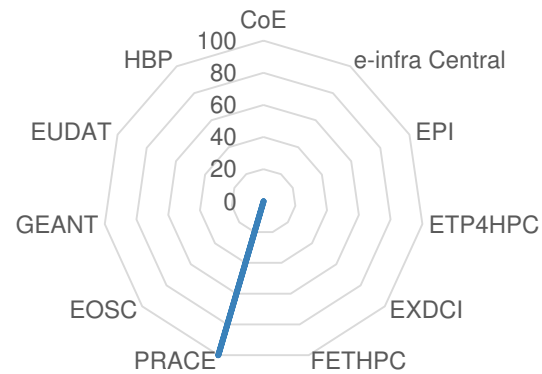
	Developer	Coordinator	Provider	User/Beneficiary	Enabler
HPC Policy					
HPC Technology (industry, hard & soft)	<ul style="list-style-type: none"> Developer: institution in charge of preparing materials for the development activity Coordinator: institution in charge of collecting materials from developers and of coordinating their implementation Provider: institution in charge of providing the services to execute the activity User/beneficiary: institution that benefits from the activity Enabler: institution that enables the activity by providing the necessary services that are not part of the core of the activity 				
HPC Computing Services					
HPC Training					
HPC Application Enabling and User Support					
HPC Research					

HPC Policy

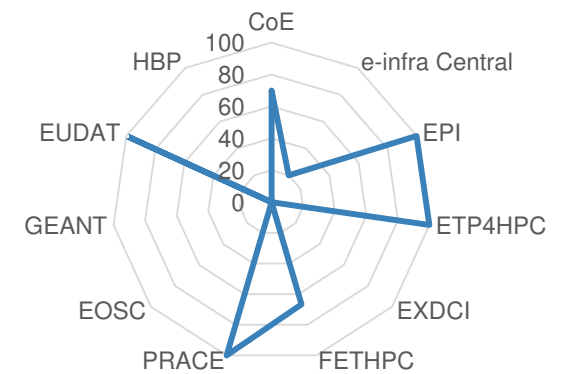
Developer



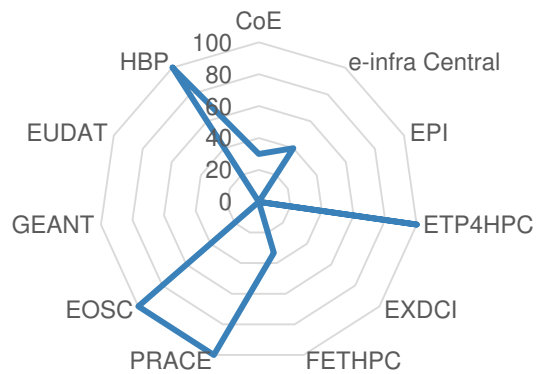
Coordinator



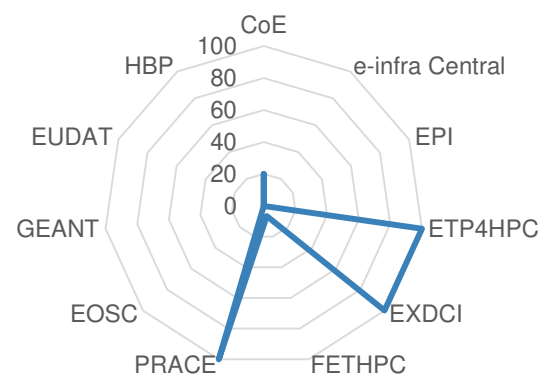
User/Beneficiary



Enabler

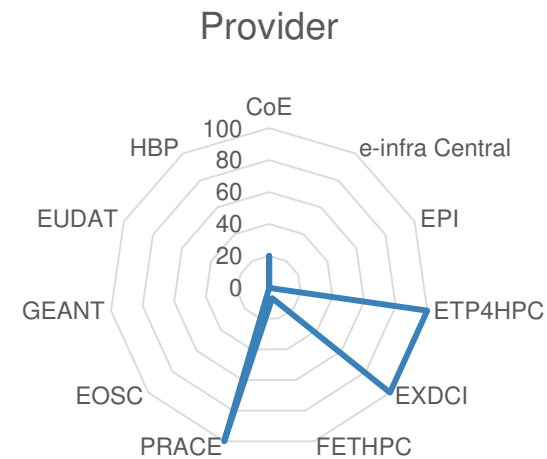


Provider



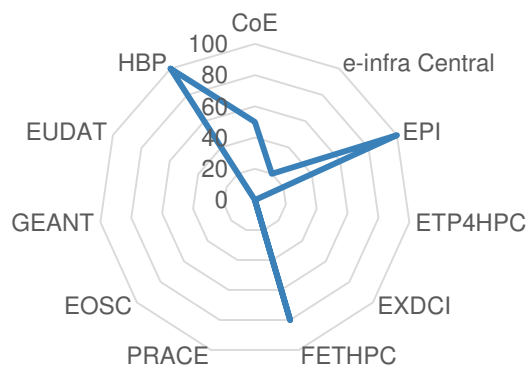
HPC Policy

- ▶ No input from EuroHPC
- ▶ Indicate to provide HPC policy
 - ▶ *CoE (2/10)*
 - ▶ *ETP4HPC (1/1)*
 - ▶ *FETHPC (1/15)*
 - ▶ *EXDCI (1/1)*

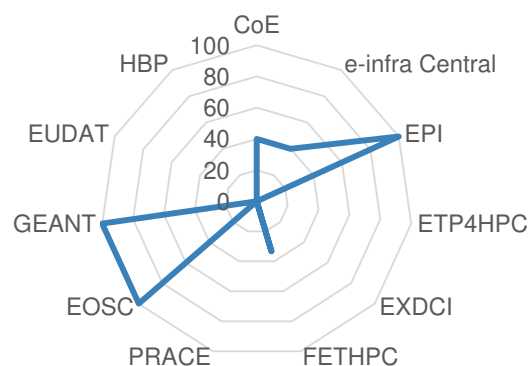


HPC Technology

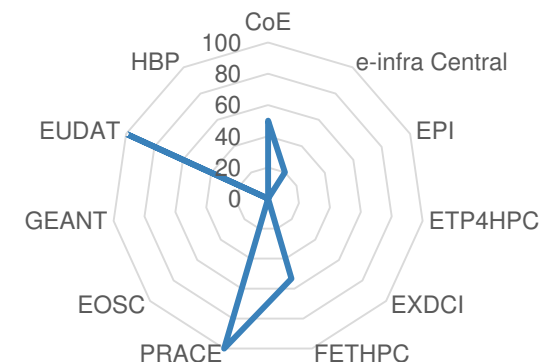
Developer



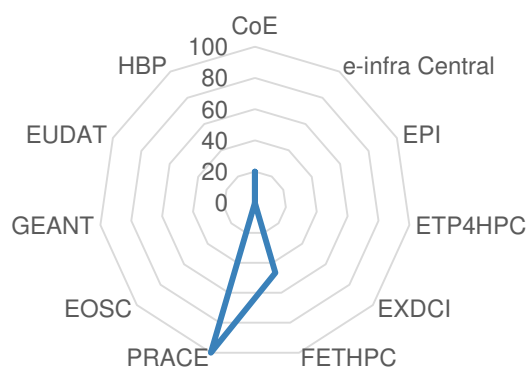
Provider



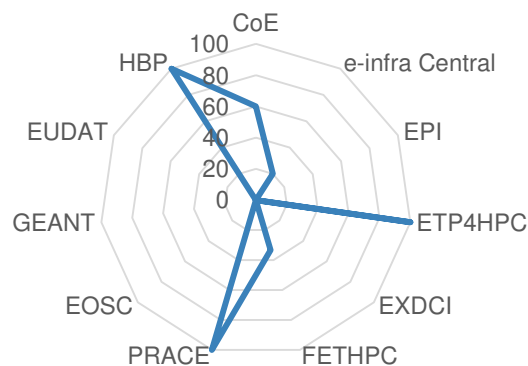
User/Beneficiary



Coordinator

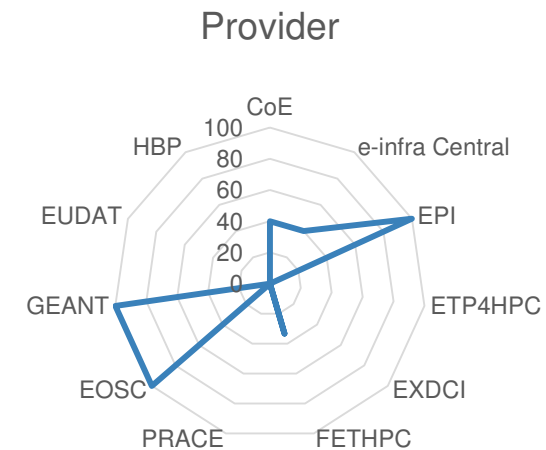


Enabler

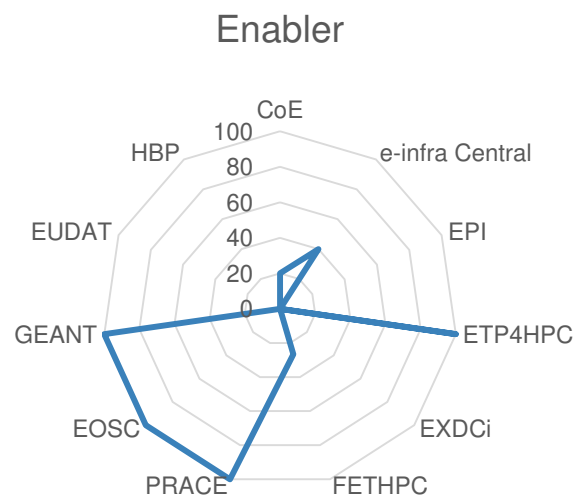
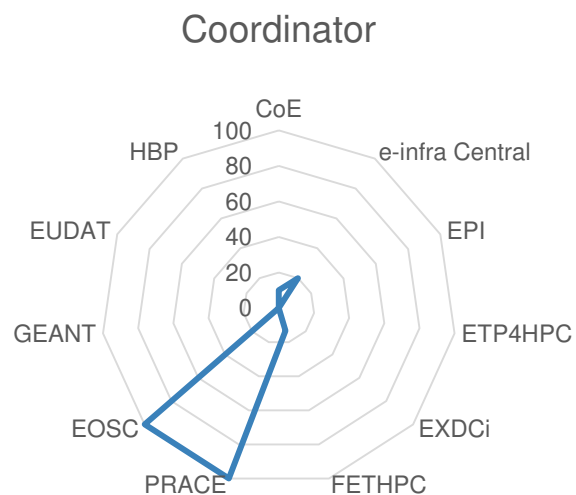
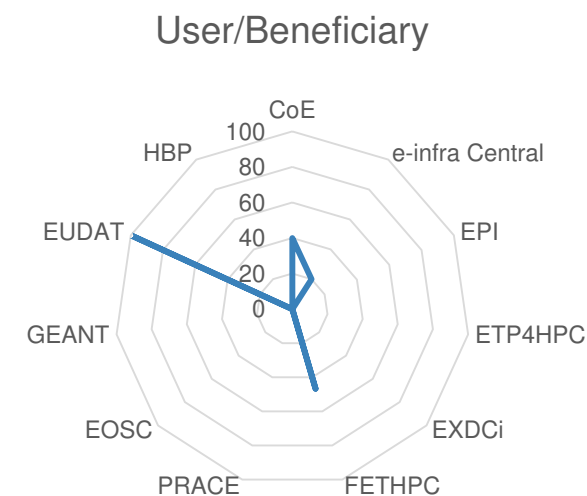
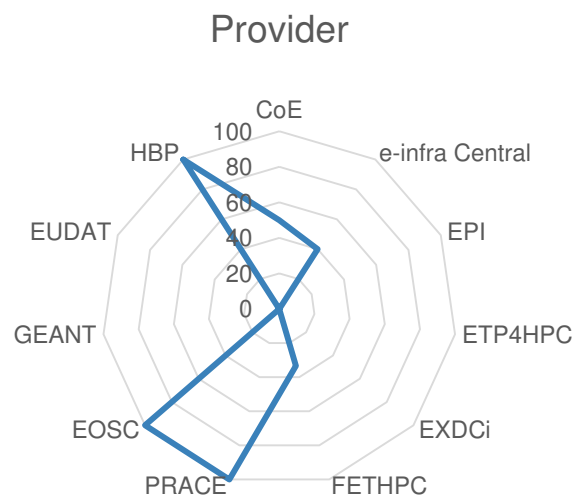
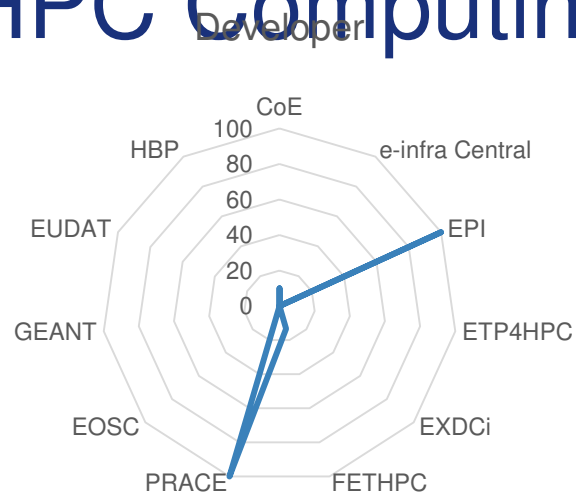


HPC Technology

- ▶ Indicate to provide HPC technology
 - ▶ *CoE* (4/10)
 - ▶ *eInfraCentral* (2/5)
 - ▶ *EPI* (1/1)
 - ▶ *FETHPC* (5/15)
 - ▶ *GÉANT* (1/1)
 - ▶ *EOSC* (1/1)



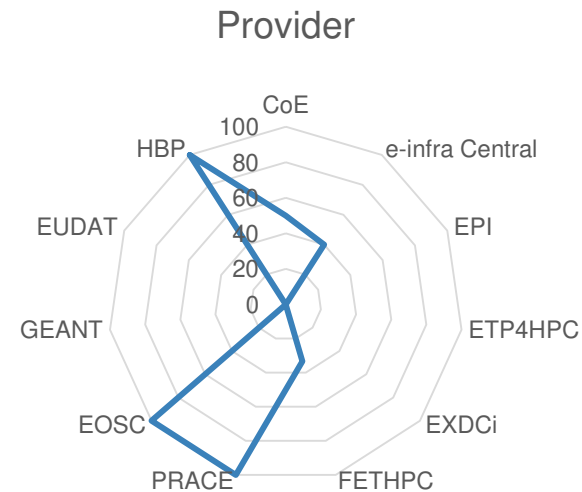
HPC Computing Services



HPC Computing Services

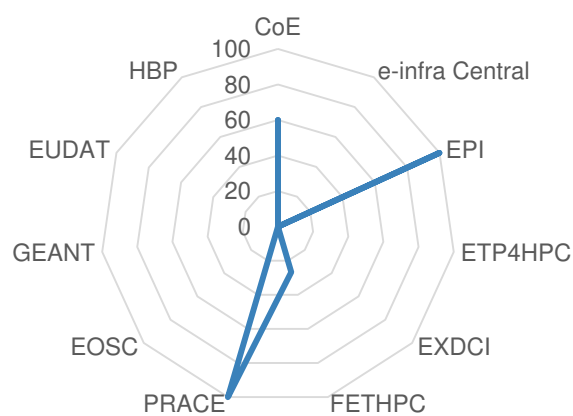
- ▶ Indicate to provide HPC services*
 - ▶ *PRACE* (1/1)
 - ▶ *eInfraCentral* (2/5)
 - ▶ *CoE* (5/10)
 - ▶ *FETHPC* (5/15)
 - ▶ *EOSC* (1/1)
 - ▶ *HPB* (1/1)

** provide access to HPC compute resources*

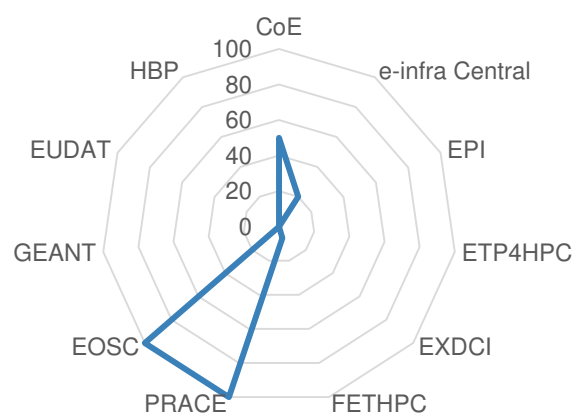


HPC Training

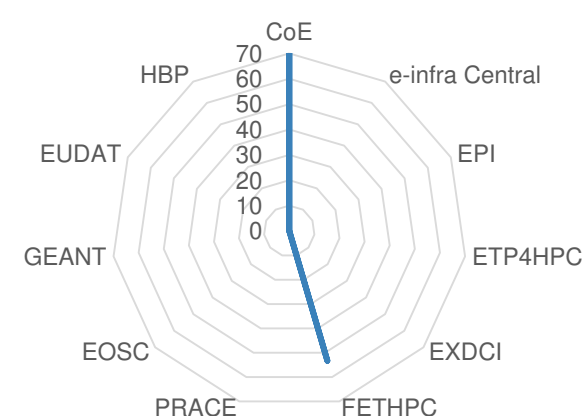
Developer



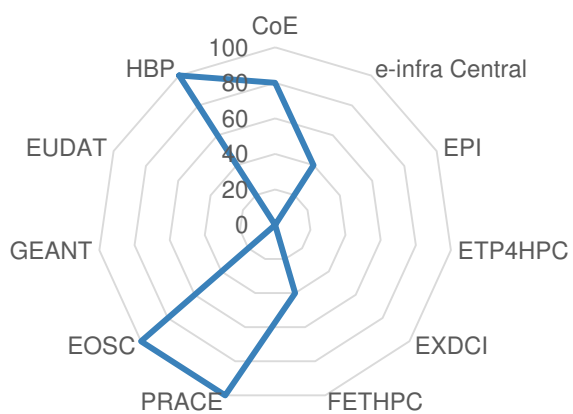
Coordinator



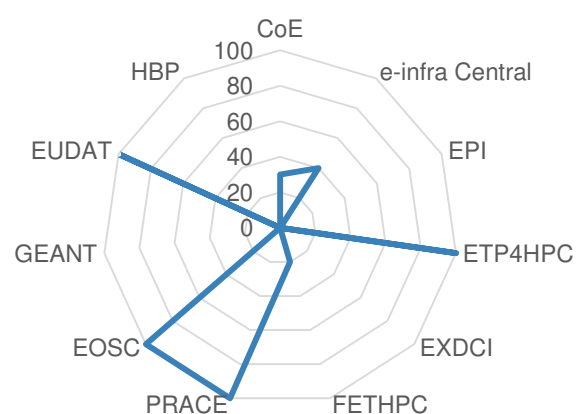
User/Beneficiary



Provider

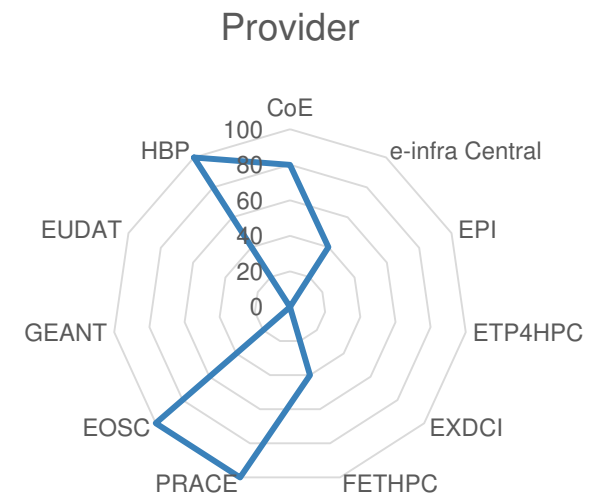


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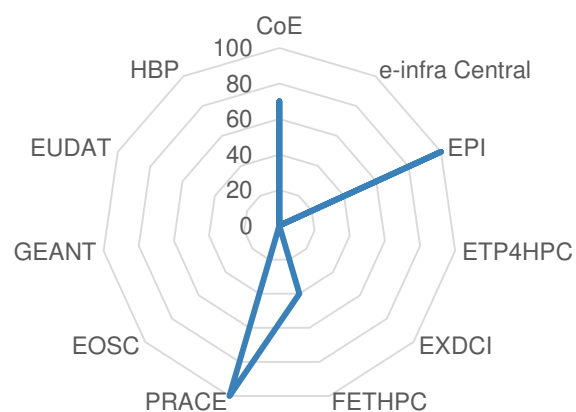
HPC Training

- ▶ Indicate to provide HPC Training
 - ▶ PRACE (1/2)
 - ▶ eInfraCentral (2/5)
 - ▶ *CoE* (8/10)
 - ▶ *FETHPC* (6/15)
 - ▶ *EOSC* (1/1)
 - ▶ *HPB* (1/1)
- ▶ Example CoE – PRACE
 - ▶ Cross disciplinary training: PRACE
 - ▶ Domain specific: CoE
 - ▶ Collaborations possible
 - ▶ Creation of a European training portal linking all training offers

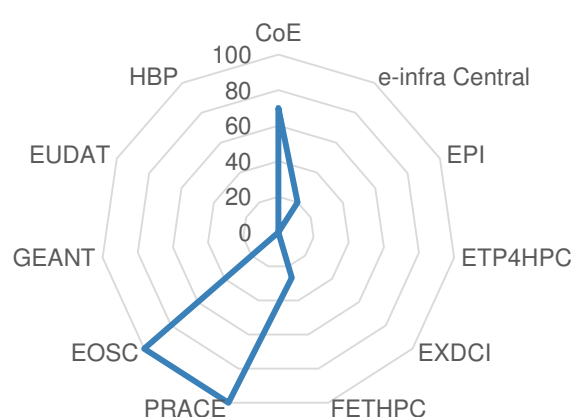


HPC Application Enabling and User Support

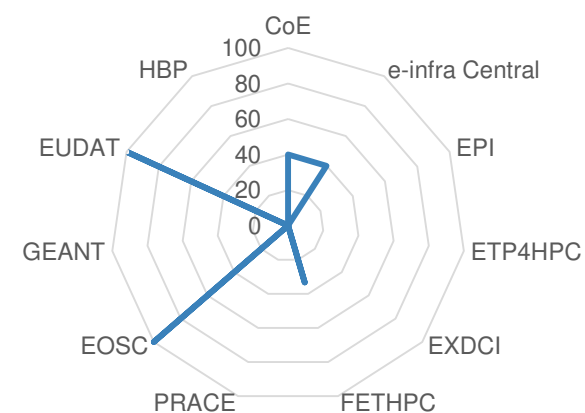
Developer



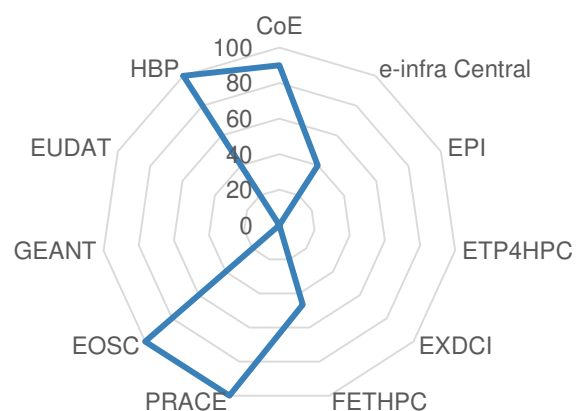
Coordinator



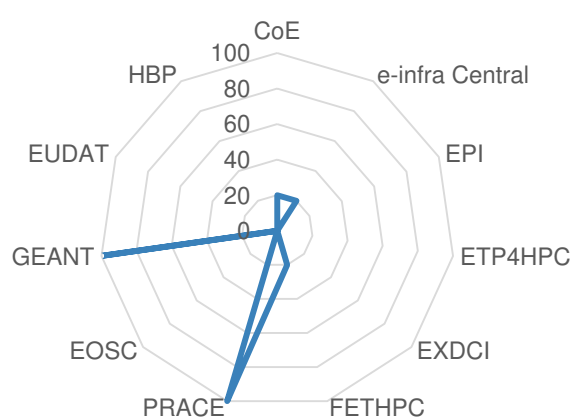
User/Beneficiary



Provider



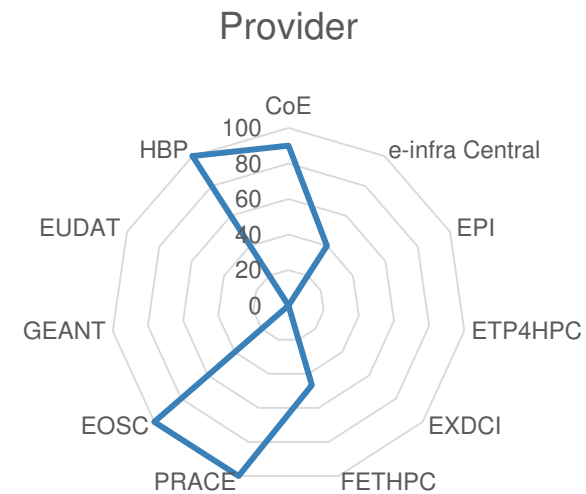
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HPC Application Enabling and User Support

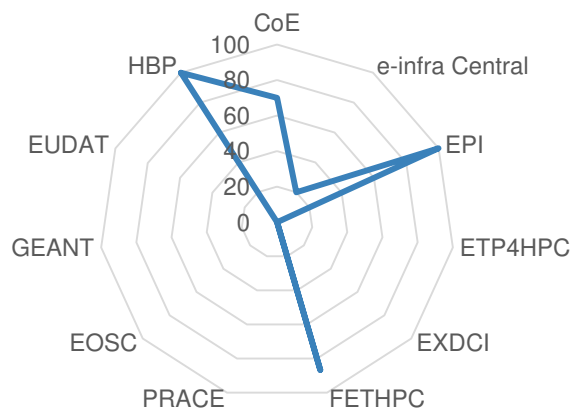
- ▶ Indicate to provide HPC application enabling

- ▶ *PRACE* (1/2)
- ▶ *einfraCentral* (2/5)
- ▶ *CoE* (9/10)
- ▶ *FETHPC* (7/15)
- ▶ *EOSC* (1/1)
- ▶ *HPB* (1/1)

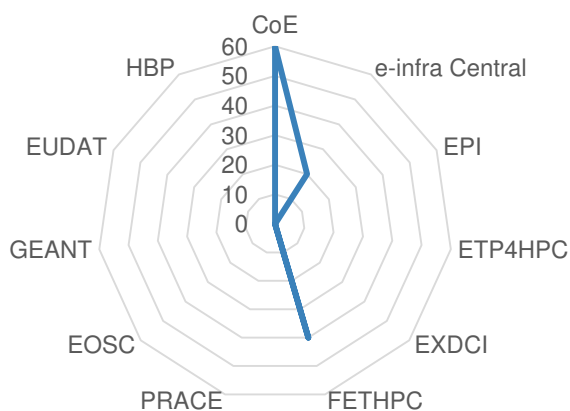


HPC Research

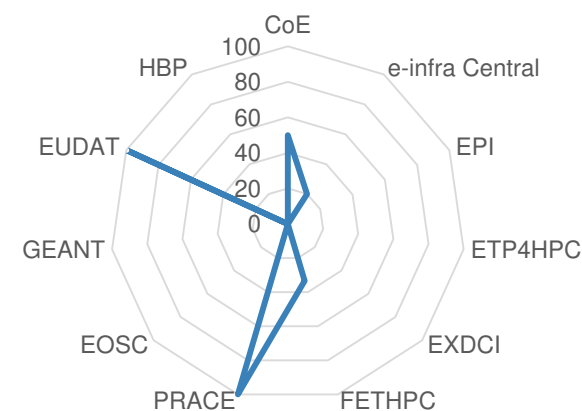
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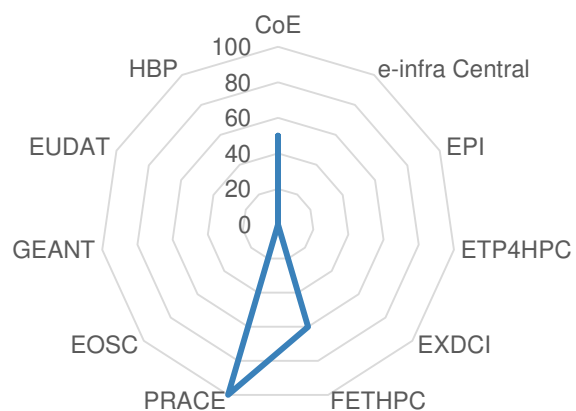
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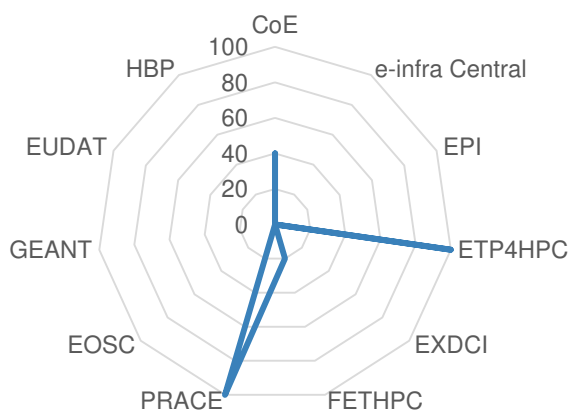
User/Beneficiary



Coordinator

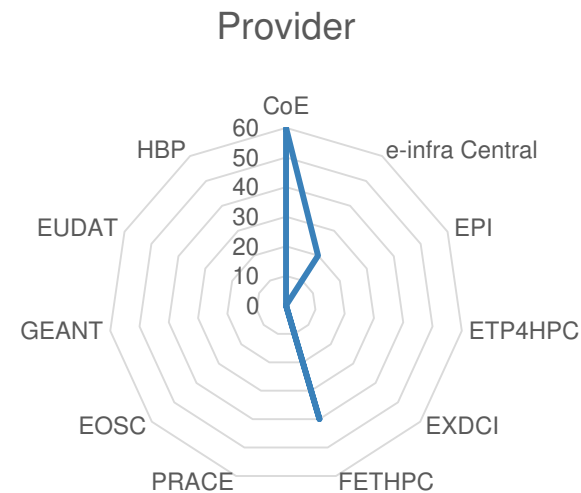


Enabler



HPC Research

- ▶ Indicate to provide HPC research
 - ▶ *CoE* (6/10)
 - ▶ *eInfraCentral* (1/5)
 - ▶ *FETHPC* (6/15)





Discussion: Overlapping Activities (1/3)

- ▶ HPC Policy
 - EuroHPC defining HPC policy?
- ▶ HPC Technology
- ▶ HPC Computing Services
 - Access to Tier-0 and Tier-1 systems via PRACE partners



Discussion: Overlapping Activities (2/3)

- ▶ HPC Training
 - ▶ Many actors provide training
 - ▶ PRACE Training is integral part of the European HPC ecosystem
 - ▶ Collaboration with CoEs and other European projects
 - ▶ Training provided:
 - ▶ *Regular Courses – PRACE Training Centers (PTCs)*
 - ▶ *Workshops: Seasonal Schools, on demand events, Int. HPC Summer School*
 - ▶ *Online Training: Training Portal, MOOCs, CodeVault*
 - ▶ *PRACE Summer of HPC*



Discussion: Overlapping Activities (3/3)

- ▶ HPC Application Enabling and User Support
 - ▶ WP7 (PRACE-5IP & 6IP): Applications Enabling and Support
 - ▶ WP8 (PRACE-6IP): Forward-looking Software Solutions
 - ▶ (PRACE 2) High Level *Application* Support Teams (HLST)
- ▶ HPC Research

Discussion

- ▶ Define the complementarities
 - ▶ User should easily understand where to go
 - ▶ Where are overlapping tasks?
 - ▶ Where is potential for cooperation?
- ▶ How we can interact / collaborate?
 - ▶ Follow-up meeting?



THANK YOU FOR YOUR ATTENTION

www.prace-ri.eu

Annex 3- European HPC Ecosystem Report

European HPC Ecosystem Report

Draft

Version: 0.11
Author(s): Florian Berberich, JUELICH; Oriol Pineda, BSC; Philippe Segers, GENCI;
Jean-Philippe Nominé, CEA; Veronica Teodor, JUELICH
Date: 24.07.2020

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Authorship	Written by:	Florian Berberich, JUELICH; Oriol Pineda, BSC; Philippe Segers, GENCI; Jean-Philippe Nominé, CEA; Veronica Teodor, JUELICH
	Contributors:	Tiziana Ferrari, EOSC; Serge Bogaerts, PRACE aisbl; Vincenzo Capone, GEANT; Dirk Pleiter, MAESTRO; Evangelos Floros, EuroHPC
	Reviewed by:	Simon Wong, ICHEC
	Approved by:	PRACE-6IP MB

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European HPC Ecosystem Report

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List of Acronyms and Abbreviations

AI	Artificial Intelligence
aisbl	Association International Sans But Lucratif (legal form of the PRACE-RI)

BDVA	Big Data Value Association
CoE	Center of Excellence, H2020 projects aiming communities to prepare for Exascale
DECI	DEISA Extreme Computing Initiative
DEISA	Distributed European Infrastructure for Supercomputing Applications EU project by leading national HPC centres
DSM	Digital Single Market
EC	European Commission
EDI	European Data Initiative
EOSC	European Open Science Cloud
EPI	European Processor Initiative
ESFRI	European Strategy Forum on Research Infrastructures
ETP4HPC	European Technology Platform for High Performance Computing
EUDAT	European Collaborative Data Infrastructure
Exascale	HPC systems at the scale of 10^{18} floating-point operation per second (ExaFlops)
EXDCI	European Extreme Data & Computing Initiative
FET	Future and Emerging Technologies
FENIX	Fusion Engineering International Experiments
FETHPC	Future and Emerging Technologies in HPC, H2020 funded projects.
GÉANT	Collaboration between National Research and Education Networks to build a multi-gigabit pan-European network. The current EC-funded project as of 2015 is GN4.
H2020	Horizon 2020 EC Framework Programme
HPC	High Performance Computing, usage of Supercomputer
HLST	PRACE High-Level Support Teams
HPB	H2020 Human Brain Project
IAC	PRACE Industrial Advisory Committee
IoT	Internet of Things
INFRAG	EuroHPC Infrastructure Advisory Group
JU	Joint Undertaking
NREN	European National Research and Education Network
Petascale	current systems at the scale of 10^{15} floating-point operation per second (PFlops)
PRACE	Partnership for Advanced Computing in Europe; Project Acronym
PRACE 2	The upcoming next phase of the PRACE Research Infrastructure following the initial five years period.
PRACE RI	PRACE Research Infrastructure, with a legal form PRACE aisbl
PRACE-nIP	PRACE n th Implementation Phase, EC funded projects
RI	Research Infrastructure
RIAG	EuroHPC Research and Innovation Advisory Group
SSC	PRACE Scientific Steering Committee
Tier-0	Denotes the apex of a conceptual pyramid of HPC systems. In this context the Supercomputing Research Infrastructure would host the Tier-0 systems; national or topical HPC centres would constitute Tier-1

1 Introduction

The European Commission (EC) recognised the need for an EU-level policy in High-Performance Computing (HPC) to optimise the national and European investments in the field and to coordinate the entire HPC ecosystem. To this end, on 15 February 2012 the EC strategy on HPC was published in the communication ‘High Performance Computing: Europe's place in a Global Race’ [1]. Acknowledging the importance of HPC for society, science and industry the communication announced a joint European effort in order to increase the investments in HPC and promoting European HPC technology.

As no single Member State alone has the financial, and human, resources to develop a sustainable Exascale HPC ecosystem (systems at the scale of 10^{18} floating-point operation per second), within the European Data Initiative (EDI) subpart of the Digital Single Market (DSM) strategy [2], the EC has step by step increased the investment in HPC significantly, supporting with various projects and initiatives the three HPC pillars as shown in Figure 1: Technology, Infrastructure and Applications. Moreover, a strong HPC ecosystem was identified as mandatory to leverage the full potential of data in Europe, along with the need for providing more open data, coping with interoperability issues and fragmentation of access to data and digital services.

This document analyses the current situation of the European HPC landscape, presents the three pillars of the HPC ecosystem, their services, with their overlaps and gaps, complementarity and opportunities for collaborations, and proposes a high-level service architecture.

2 Three Pillars of the HPC Ecosystem

The European HPC Strategy is based on three pillars: Technologies, Infrastructure and Applications. Each organisation, project or initiative is linked to at least one of those pillars. These three pillars have the objective to serve the European HPC user community through a user-driven approach, with the relevant European HPC communities and user groups adequately represented in each of the pillars. The individual actors are described briefly in this section.

The EuroHPC Joint Undertaking (JU) [3] was founded on 28 October 2018. EuroHPC JU will permit the EU and participating countries to coordinate their efforts and share resources with the objective of deploying in Europe a world-class supercomputing infrastructure and a competitive innovation ecosystem in supercomputing technologies, applications and skills. A good overview on the European Exascale Projects, (FETHPC and Centres of Excellence (CoE)) is provided by the European High-Performance Computing Handbook 2018 [4] and 2019 [26].

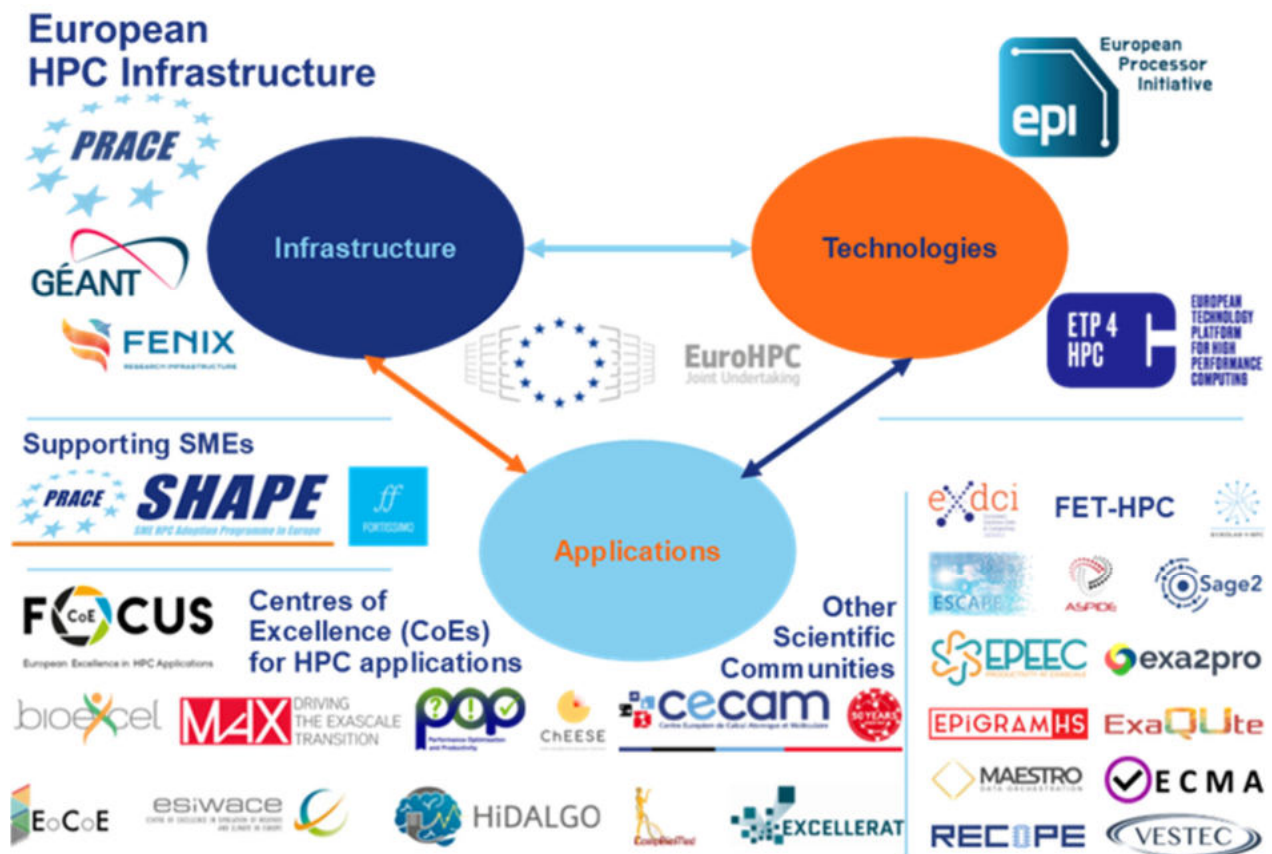


Figure 1: HPC ecosystem Pillars

This schematic view of a complex ecosystem of stakeholders should not be seen as something static, with homogeneous pillars and some formally established relation between them, but more like dynamic “n-body” interactions, with constantly evolving needs and offers of these pillars. Actors are constantly interacting between these pillars, with some of them playing active roles on more than one pillars. To provide one short example, Technologies are evaluated through

benchmarks of Applications, representative of typical workloads of HPC Infrastructure, and co-design is part of the HPC culture, with overlaps and complementarity among the pillars.

In addition to the three classical pillars, the convergence of simulation and big data workloads is becoming more and more important due to the deluge of data coming from next generation scientific instruments (satellites, (radio)telescopes e.g. SKA (Square Kilometre Array), accelerators, microscopes, sequencers, etc.) but also Internet of Things (IoT), social media and from large scale simulations (massive 3D simulations, multi-scale and multi-physics coupled simulations, ensemble/optimisation/scenario studies, uncertainties quantification, etc.).

An HPC infrastructure tailored to treat these large amounts of data will be also indispensable for Machine Learning or Artificial Intelligence (AI). Data are involved in all three pillars. The Technologies pillar will develop systems designed especially for I/O or AI, the Infrastructure will provide access to systems suitable for AI, and in the Applications pillar machine learning and AI algorithms will be implemented in codes [5][6][7][8][9]. HPC, Big Data and AI are converging.

2.1 Infrastructure

2.1.1 *Partnership for Advanced Computing in Europe (PRACE)*

The development of the European HPC ecosystem was initiated and pursued by the Partnership for Advanced Computing in Europe (PRACE) and its 26 member countries in the past ten years. PRACE is supported by the PRACE Member States and through the EU by a series of Implementation Phase (IP) projects [10]. Over the last decade, PRACE and its members have given national HPC ecosystems a common European umbrella which is recognised as an ESFRI Landmark since 2016. PRACE was founded in 2010 as the European HPC infrastructure, with an investment above € 400 million from four Hosting Members (BSC representing Spain, CINECA representing Italy, GCS representing Germany and GENCI representing France) for its initial phase until 2015, with the objective of developing a persistent and pan-European HPC facility. In 2016 a fifth Hosting Member, ETH Zurich/CSCS (Switzerland) opened its system via the PRACE Peer Review Process to researchers from academia and industry. Subsequent investments from all PRACE members and contributions from the EC have allowed the infrastructure to provide a continuous set of services, based on a peer-review process of assessment of scientific excellence, awarding more than 25 billion core hours to over 775 research projects led by investigators from 40 different countries, from academia and industry. This large computing capacity has been complemented by high-level quality training and strong user support programmes (including support to SMEs), to foster the development of a solid HPC community in Europe.

PRACE, with a governance structure that includes a Scientific Steering Committee (SSC) and an Industrial Advisory Committee (IAC), underlined the urgent need for more compute cycles, and huge demands in terms of memory / storage capacities and performance in the recent Scientific Case 2018-2026 [11]. In addition, the need for new approaches, i.e. scaling via ensembles, deep learning, and statistical models are expressed.

In relation to the newly created EuroHPC JU, PRACE published its Position Paper: PRACE in the EuroHPC era [12], which defines its current and proposed future services for the European HPC ecosystem. The following services encompass the PRACE offer:

- 1) Peer Review Access to HPC systems
- 2) Support for industry (including SMEs)
- 3) Enabling of HPC applications
- 4) Services for universities and user communities
- 5) HPC training
- 6) Promotion of HPC careers - gender balance
- 7) Operational HPC services
- 8) HPC procurement and prototyping support (including Technology Watch)
- 9) Dissemination and documentation for HPC services

Only Policy and Technology are not directly included in the PRACE Position Paper, since PRACE is not providing HPC Policy and directly HPC Technology, even if assessment of technologies and guidance is provided through a series of white papers and best practice guides [13][14], illustrating the strong interaction already in place between the three ecosystem pillars.

2.1.2 GÉANT

GÉANT develops, delivers and promotes advanced network and associated e-Infrastructure services for research and education, supporting open collaboration and knowledge-sharing amongst its members and the wider research and education community. The GÉANT Association BV [15] is owned by its core membership of the European National Research and Education Network (NREN) organisations. Since coordinating pan-European research and education (R&E) networking on behalf of Europe's NRENs, GÉANT's role has evolved to that of a true services innovator, incorporating network planning, procurement, building and operation, as well as coordination of research programmes and development of innovative services.

GÉANT is also at the forefront of trust, identity and security services for research and education, promoting and supporting eduGAIN, the global service for interconnecting federations of identity and service providers. Research collaborations that span multiple organisations and countries can be easily established using the eduTEAMS collaboration suite, built upon eduGAIN, which enables seamless interaction with HPC and network resources as well as with EOSC resources.

Working with NREN partners and the EC, the high-speed networks that they build and operate connect NRENs to each other and to the rest of the world, enabling scientists, academics, innovators and students to collaborate, regardless of their location. HPC current and future exascale usages highly depend on the integration of core HPC services with data and network services. GÉANT is a partner of PRACE and joined the PRACE-6IP project in May 2019; additional MoUs have been established between GÉANT and PRACE to cooperate on the aspects mentioned above.

2.1.3 FENIX

Fenix is an emerging infrastructure that is based on an MoU between five European supercomputing centres, namely BSC (Spain), CEA (France), CINECA (Italy), CSCS (Switzerland), and JSC (Germany), that agreed to align the way of provisioning computing and storage services to facilitate a federation of distributed e-infrastructure services.

The Fenix architecture foresees different compute and data services in combination with a thin layer of federation services. The latter include federated identity and access services, as well as

resource management services. This includes a central proxy Identity Provider (IdP) that is operated by GÉANT. The computing and data services fall into two broad categories, those that are operated in a restricted HPC environment and those that are operated in a more open, Cloud-like environment.

Fenix e-infrastructure services are generic and can be exploited by different research and engineering communities. These services can be flexibly composed and used by the latter to deploy and operate community-specific platform services.

The initial focus community is the community of brain researchers that are organised in the Human Brain Project (HBP) as Fenix is currently realised through the Interactive Computing E-Infrastructure (ICEI) project, which is part of the HBP. 25% of the ICEI resources are made available to the HBP through programmatic access, another 15% of the resources are provided to European researchers at larger through PRACE.

Fenix is set up as a framework organisation that can encompass multiple projects and will in future be expanded and involve more partners.

2.1.4 EOSC

The objective for the European Open Science Cloud (EOSC) is for it to be a fundamental enabler of Open Science and of the digital transformation of science, offering every European researcher the possibility to access and reuse all publicly funded research data in Europe, across disciplines and borders, leveraging past investment in research data infrastructures to add value in terms of scale, interdisciplinarity, and faster innovation.

The EOSC is being developed to provide all researchers, innovators, companies and citizens with seamless access to an open-by-default, efficient and cross-disciplinary environment for storing, accessing, reusing data, tools, publications and any EOSC resource for research, innovation and educational purposes¹. A family of EC-funded implementation projects are currently active to: address the issues of delivering the tools and processes that will deliver the federating structure of EOSC and its compute and data manage platform (EOSC-hub, OCRE), to develop policies and best practices for FAIR data (FAIRsFAIR and 5 thematic clusters of ESFRI research infrastructures), tools and policies for open scholarship (OpenAIRE-Advance) and permanent identifiers (FREYA), and to connect national data and compute infrastructures of pan-European relevance.

It is envisaged that EOSC will operate a European distributed platform (the EOSC “Shared Resources”) including a resource tier providing a federated data and computing facility with storage and compute to deposit and process research data. This platform will also include a portfolio of data analytics offering that integrates easy to use, community-specific tools used for simulation, data processing and data produces as a service. Through EOSC-hub, the pan-European e-Infrastructures EGI² and EUDAT CDI³ are pillars of EOSC resource tier by delivering petabyte-

¹ <https://eoscpilot.eu/eosc-glossary#overlay-context=eosc-glossary>

² <https://www.egi.eu/>

³ <https://www.eudat.eu/eudat-collaborative-data-infrastructure-cdi>

scale data life cycle management services for data discovery, access, processing and analytics, data curation and deposition.

Data Management is one of the key services that EOSC provides to European researchers to promote open, free and online access to research data and scientific publications. EOSC aims to provide a European storage and data management infrastructure, providing generic services and building blocks to store, find, access, and process data in a consistent and persistent way.

As HPC and data are converging and becoming more closely coupled, it is important for EOSC and EDI much work together to plan on how best to serve the future needs of European users.

In this regard, building upon the increasing interest surrounding the connections linking HPC initiatives and the EOSC, EOSCsecretariat.eu has investigated the current landscape of European CoEs for HPC in relation to the EOSC, for the benefit of the EOSC Governance and other stakeholders. The results of the EOSCsecretariat.eu online survey on the ten HPC CoEs were collected [28]. The main outcome of this survey is that although there is not yet a structured and all-encompassing cooperation between the HPC CoEs and the EOSC communities, the CoEs encourage engagement of their communities in EOSC, and *vice versa*. This can be done by providing training materials and platforms, organising workshops and other relevant activities that build on successful mutual participation at events that have taken place in the past and should be a priority as the EOSC is implemented in 2020.

2.1.5 EuroHPC

The EuroHPC Joint Undertaking (JU) will contribute to the ambition of value creation in the Union with the overall mission to develop, deploy, extend and maintain in the Union an integrated world class supercomputing and data infrastructure and to develop and support a highly competitive and innovative High Performance Computing (HPC) ecosystem. The overall objectives of the JU can be summarised as follows:

- To provide the research and scientific community, as well as the industry including SMEs, and the public sector from the Union or countries associated to Horizon 2020 with the best available and competitive High Performance Computing and data infrastructure and to support the development of its technologies and its applications across a wide range of fields;
- To provide a framework for the acquisition of an integrated, demand-oriented and user-driven world-class petascale and pre-exascale supercomputing and data infrastructure in the Union;
- To provide Union-level coordination and adequate financial resources to support the development and acquisition of such infrastructure, which will be accessible to users from the public and private sector primarily for research and innovation purposes;
- To support an ambitious research and innovation agenda to develop and maintain in the Union a world-class High Performance Computing ecosystem, exascale and beyond, covering all scientific and industrial value chain segments, including low-power processor and middleware technologies, algorithms and code design, applications and systems, services and engineering, interconnections, know-how and skills, for the next generation supercomputing era;

- To promote the uptake and systematic use of research and innovation results generated in the Union by users from science, industry, including SMEs, and the public sector.

As to the governance of EuroHPC JU, there are three bodies in the EuroHPC Joint Undertaking:

- The Governing Board, composed of representatives of the EU and Participating States. The Commission and each Participating State appoint one representative in the Governing Board. Each representative may be accompanied by one expert.
- The Industrial and Scientific Advisory Board consists of the Research and Innovation Advisory Group (RIAG) and the Infrastructure Advisory Group (INFRAG) which provide independent advice to the Governing Board on the strategic research and innovation agenda and on the acquisition and operation of the supercomputers owned by the Joint Undertaking.
- The Executive Director is the chief executive responsible for day-to-day management of the Joint Undertaking.

The EuroHPC funded Research & Innovation actions currently address extreme scale computing technologies (hardware, software, methods and algorithms for key applications), HPC and data centric environments and application platforms, and industrial software codes for extreme scale computing environments and applications. These have been complemented with actions aiming at widening HPC skills and use, the creation, networking and support to the operation of national HPC Competence Centres, and actions to foster the innovation potential of SMEs. In the period 2021-2022 the EuroHPC Work Programme will address the next building blocks for the development of the exascale HPC ecosystem, including the development of a European low power processor and the integration of the processor and other technologies in pilots.

For what concerns the development of HPC Infrastructure in Europe, EuroHPC aims to deploy and support the operations of three precursors to exascale supercomputers (systems with sustained performance at least 150 PFlops) in the period 2021-2022 in three locations: Kajani (Finland), Bologna (Italy) and Barcelona (Spain). EuroHPC is also co-funding the acquisition of five petascale supercomputers (systems with sustained performance between ~5-20 PFlops) in Ostrava (Czech Republic), Minho (Portugal), Sofia (Bulgaria), Maribor (Slovenia) and Bissen (Luxembourg). These systems are also expected to become operational end of 2020 beginning of 2021.

2.2 Applications

The importance of a strong HPC applications ecosystem has been periodically highlighted by the PRACE SSC [11] and PRACE User Forum. This has been acknowledged by the EC [1] through the large funding allocated to this pillar. Applications are the core Intellectual Properties of many communities, a strong asset for European research, academic and industrial, for which Europe has often a leading position worldwide. To coordinate the needed effort, European Centres of Excellence in Computing Applications (CoEs) have been established to address specific need of communities (Weather and Climate, Material Science, Medicine, etc.) or transverse needs (industry, algorithm, etc.). After a first selection of CoEs in 2015, the European Commission recently reviewed the communities supported by awarding a second generation of thirteen CoEs in 2018 [16] and 2020. These cover a wide collection of scientific domains, including bioinformatics,

biomedical sciences, climate sciences, combustion, energy and engineering, materials, personalised medicine, social sciences and solid earth, as well as the transversal topic of computing performance, each of them covered by one CoE. The second generation of CoEs builds on the success of the first selection, and will highly contribute to strengthen Europe's leadership in HPC applications through their associated services, such as: developing, optimising (including if needed re-design) and scaling HPC application codes towards peta- and exascale computing; testing, validating and maintaining codes and managing the associated data; quality assurance; co-design of hardware, software and codes; consultancy to industry and SMEs; research in HPC applications; and addressing the skills gap in computational science.

This strong contribution to the applications pillar is further enhanced by the highly specific application developments of FETHPC projects and EPI (European Processor Initiative), and with code-enabling activities of the PRACE-IP projects and PRACE High-Level Support Teams (HLSTs) [17]. In addition, new usage paradigms and domains for HPC are developing, such as Humanities or Artificial Intelligence, with different needs and constraints, requiring innovative ways to access resources. The Capital Expenditure (CAPEX) of a HPC infrastructure is highly dependent on the portfolio of applications that will run on the system during its lifetime, and the efficiency (time to solution and energy to solution) is highly dependent of the appropriateness, “good match”, of these applications with the technologies embedded within the HPC systems. There is no easy or obvious choice, as performance is the result of trade-offs, trying to mitigate as much as possible any bottlenecks.

2.3 Technology

2.3.1 ETP4HPC

The ETP4HPC Association [18] was created in 2012, to be a voice for European HPC suppliers and promote HPC technologies development, and in particular to prepare input and R&D recommendations to the EC in this area. In 2014 a ‘contractual Public Private Partnership’ in HPC (cPPP) was signed between the EC and ETP4HPC association [19]. A significant fraction of the funding provisioned under this cPPP was dedicated towards HPC technology R&D [18], namely the FETHPC calls (part of the “Future and Emerging Technologies” branch of the successive H2020 Work Programmes). Between 2014 and 2018, 32 FETHPC projects were selected with a total funding of approximately € 175 million. With the aim to develop HPC systems hardware and software building blocks in the areas of HPC node architecture, system and middleware, programming environment and tools, the FETHPC projects have already produced a number of innovations and prototypes [20][21], co-developed between technology suppliers (large companies or SMEs), research organisations and end users, sometimes leveraging other innovations dedicated to the wider market of data centres as a whole.

The ETP4HPC Strategic Research Agenda [22], updated every 2 years since 2013, has been the main source of advice and influence regarding the FETHPC call contents. ETP4HPC also actively participates in the overall EU HPC ecosystem development. ETP4HPC members are technology suppliers and research organisations.

In addition, the EC also implemented in 2017-2018 an important new call to establish a Framework Partnership Agreement on European low-power microprocessor technologies, in order to establish

a stable and structured partnership between the EC and committed institutions and organisations. The European Processor Initiative (EPI) consortium was selected to co-design, develop and bring to the market a European low-power microprocessor, one of the core elements needed for the development of the European supercomputers with exascale capacity [23][24]. The co-design aspect of EPI is a key factor to provide a next generation of processors that fully reap the benefits of energy efficiency for relevant European applications.

In October 2018, the EuroHPC Joint Undertaking [3] was created and is now being implemented and ramping up. EuroHPC JU built upon the HPC cPPP to continue the HPC R&D funding towards exascale, from 2019 onward, more strongly coordinating the follow-ups of FETHPC and EPI projects. Members of the EuroHPC JU are the EC, 32 EU members and associated states and the private members ETP4HPC and the BDVA (Big Data Value Association [8]). ETP4HPC is represented in the EuroHPC JU Research and Innovation Advisory Group (RIAG).

The outcomes of the cPPP phase – 2014-2018 – have been documented by annual Progress Monitoring Reports (PMRs [25]). The 2018 PMR (published end of Summer 2018) summarises this 4-year period of joint support of HPC technologies and applications by H2020. In particular, positive effects are observed regarding job creation (both in research and HPC supply industry in Europe), IP creation, and private companies' extra investments – which leverage the public funding effort in initial R&D in order to productise solutions and bring them to the market. A number of European SMEs in particular have clearly benefitted from H2020 funded actions which led to augmentation of staff, business and turnover.

Since the EC, based on the PPP recommendation, funded CoEs as well as FETHPC projects, it also supported the evolution and improvement of many HPC applications, in addition to many innovative hardware and software building blocks for HPC solutions. This helped CoEs contribute to evolutions of community codes (in terms of features and/or portability and/or performance improvement and scaling).

These efforts transitioned smoothly in the EuroHPC Research & Innovation Pillar from 2019 onward. For this purpose, EuroHPC private members (ETP4HPC and BDVA) are sustaining the development and updates of their Research Agendas, together with the HPC wider ecosystem and leading stakeholders and representative entities such as PRACE, CoE representatives, AIOTI [7], and also with international collaborations (such as BDEC [9]). Taking into account not only Big Data, but also AI and IoT trends in advanced computing is a necessity. The point is to develop HPC both towards extreme scale (exascale and beyond) but also to extend its use and insert it in a digital continuum from edge to cloud and interconnected HPC centres. ETP4HPC and BDVA help the communities to express recommendations and priorities towards EuroHPC Advisory Groups and its Governing Board which eventually decides on R&I funding.

2.3.2 EPI

The European Processor Initiative (EPI) is an ambitious program to develop chips integrating off-the-shelf 64-bit architecture CPU cores with Vector Extension and RISC-V based heterogeneous accelerator cores. The overall aim of EPI is to develop IP owned in Europe for low-power microprocessors for the global market. Even though focus is on delivering chips for HPC, and in particular for Exascale supercomputers, the automotive industry for edge-HPC and the broader data

centre market will also be targeted. The rationale is to reach higher-volume markets that can compensate the considerable R&D costs involved in chip development and go-to-market. For the implementation of this vision, the 27 European partners of the EPI consortium have signed a Framework Partnership Agreement (FPA). This FPA is currently planned to cover two Specific Grant Agreements (SGAs) with a total budget of €120M. These two SGAs will span a total period of four years, with SGA1 running from December 2018 to November 2021, and SGA2 (handled by EuroHPC JU) from November 2020 to April 2022, and will allow the consortium to develop the technologies and tap out two revisions of the EPI 1st generation processor. Under SGA2 the initial technologies will be optimised and performances increased, and revision 2 of the EPI 1st generation processor will be taped out. This chip will benefit from the experience gathered during SGA1, both in the development and usage of the EPI technology. Following this, EPI expects to develop the 2nd generation of the processor and the related technologies in subsequent SGAs which will target Exascale level systems and enable the derivation of chips for large-volume markets.

3 The Analysis of the HPC Landscape

3.1 The HPC Ecosystem Summit, Poznań, 14 May 2019

An HPC Ecosystem Summit (see Annex 6.1) was organised by the PRACE-6IP project on 14 May 2019 during the EuroHPC Summit Week 2019 in Poznań, Poland. The Summit was attended by more than 50 representatives from the European Commission, PRACE, GÉANT, CoEs and FETHPC projects, EXDCI, and ETP4HPC, among others. The objective of this Summit was to present current activities and discuss future roles and responsibilities of the key European HPC stakeholders within the landscape. The outcome of this Summit was expected to furnish a vision of the architecture and integration of the HPC services with European Open Science Cloud (EOSC), EDI, data services, etc. for the communities. The discussion during this Summit allowed to clarify the results of a preparatory survey and to define further stratification actions.

3.2 The HPC Ecosystem Survey

In order to prepare for the HPC Ecosystem Summit, a dedicated survey (see Annex 6.2) with 10 questions was sent to 81 contacts (coordinators of CoEs, FETHPC projects, EuroHPC JU, ETP4HPC, BDVA, GÉANT, FocusCoE, EPI, EOSC, EGI, EUDAT, OpenAire, eInfraCentral, EXDCI). For bigger projects or umbrella organisations only the coordinator of the project or organisation was contacted. The contacts were asked in more detail to indicate which of the three pillars they are part of, if they will be able to attend the HPC Ecosystem Summit and take part in the discussions, to indicate their specific domain and include a list of their services. Moreover, they were asked to indicate possible overlap and collaboration with other initiatives or organisations. The main part of the survey was the self-evaluation of the current actors concerning their role in the European HPC landscape provided through the answers to the following matrix as shown in Figure 2.

	Developer	Coordinator	Provider	User/Beneficiary	Enabler
HPC Policy					
HPC Technology (industry, hard & soft)	<ul style="list-style-type: none"> <i>Developer: institution in charge of preparing materials for the development activity</i> <i>Coordinator: institution in charge of collecting materials from developers and of coordinating their implementation</i> <i>Provider: institution in charge of providing the services to execute the activity</i> <i>User/beneficiary: institution that benefits from the activity</i> <i>Enabler: institution that enables the activity by providing the necessary services that are not part of the core of the activity</i> 				
HPC Computing Services					
HPC Training					
HPC Application Enabling and User Support					
HPC Research					

Figure 2: Self-evaluation matrix of role in the European HPC landscape

3.3 The Services in the European HPC landscape

3.3.1 HPC Policy

EuroHPC JU will develop the policy in terms of funding and the main guidelines. The Research and Innovation Advisory Group (RIAG) and the Infrastructure Advisory Group (INFRAG) are the information gathering bodies in the EuroHPC JU. This will include inputs from PRACE, ETP4HPC and from EXDCI and FETHPC (mostly via ETP4HPC for FETHPC) projects as shown in Figure 3.

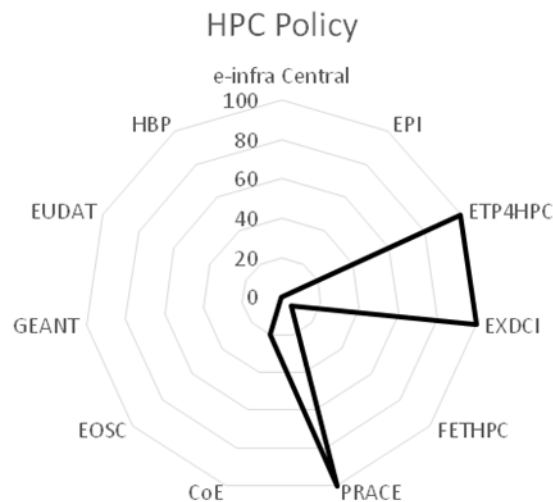


Figure 3: Provision of HPC Policy in % of positive responses in the respective stakeholder groups

3.3.2 HPC Technology

The provision of HPC technology should be driven by the FETHPC projects and the European Processor Initiative (EPI), with the goal to develop European Technology for Exascale Computing.

Surprisingly, only some FETHPC projects see themselves as HPC technology provider. However, 80% of the FETHPC projects declared to develop HPC technology. Some CoEs also indicated a contribution to the HPC technology, since there are some of them with a co-design approach, see Figure 4. A more detailed analysis has been reported by the EXDCI-2 project [16].

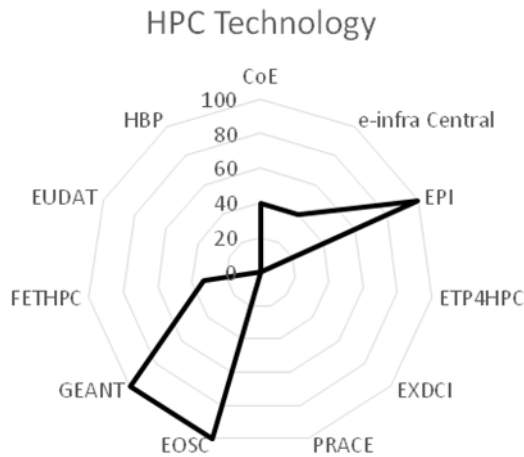


Figure 4: Provision of Technology in % of positive responses in the respective stakeholder groups

3.3.3 HPC Computing Service

The provision of HPC Computing Service refers to making available HPC resources for testing, scaling and production. PRACE via its members is the major European HPC resources provider, as shown in Figure 5. Additionally, EOSC and Human Brain Project (HBP) also presented themselves as resource providers. Indeed, via EGI and research Infrastructures EOSC will provide access to existing numerical services that are compliant with EOSC rules, though at a lower scale compared to PRACE computation resources. HBP also provides access to storage and computation resources via the FENIX infrastructure (ICEI project), funded by the EC in the context of the Framework Partnership Agreement of the HBP. FENIX is a federated HPC and data infrastructure.

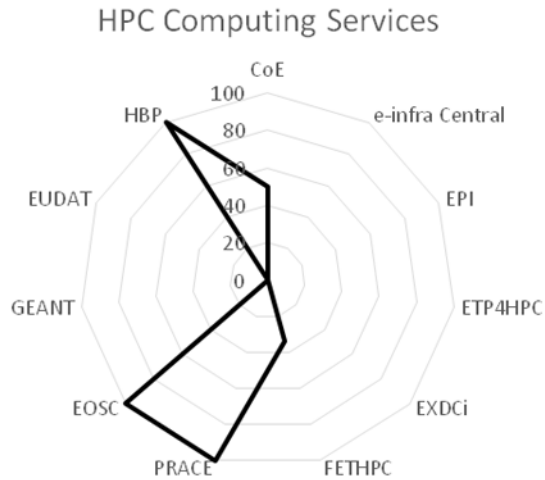


Figure 5: Provision of HPC Computing Service in % of positive responses in the respective stakeholder groups

3.3.4 HPC Training

The results from the survey showed a significant number of contributions to HPC Training services, including PRACE, HBP, EOSC, CoEs and FETHPC projects. In Figure 6, the percentage of the received positive answers is shown. While the trainings from HBP, EOSC and FETHPC were identified as independent and complementary, a potential overlap was identified between the training offer of PRACE and that of the CoEs. This has been already identified in previous discussions and through the FocusCoE coordination action, where a decision was taken to focus PRACE training on general and cross-disciplinary HPC topics, while CoEs would focus on topical trainings.

In order to make all training offers well-known, they will be collected and made available in a centralised European HPC portal (see section 4). This will be based on a joint training database, to be fed with training offers from all national and European actors; this database will be shared and will include categories to allow searching for specific trainings.

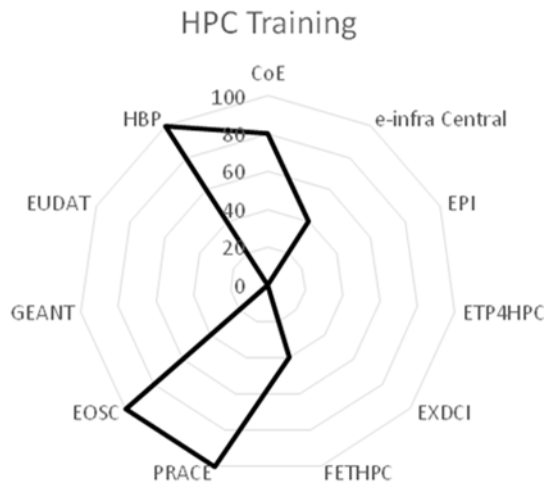


Figure 6: Provision of HPC Training in % of positive responses in the respective stakeholder groups

3.3.5 HPC Application Enabling and User Support

The survey showed again a significant number of actors contributing to HPC Application Enabling and User Support activities as presented in Figure 7. After the discussion, it was concluded that this item required further stratification, according to the additional dimensions of support levels and targeted users.

HPC support is classified in four levels depending on the scope of the support provided, which ranges from basic, short-lived helpdesk support to long-term refactorisation effort, including horizontal performance analysis by the POP CoE. While some overlap could initially be identified in medium-term support (level 2 and level 3) between the PRACE HLSTs [17] programme and CoEs, this was differentiated through their target users.

Similar to training, the available catalogue will be collected and made available in a centralised European HPC portal managed by PRACE (see section 4). Further analysis on this service will be carried out by the PRACE-6IP project.

Within EOSC, application enabling has been identified as one of the most important services to support research communities and use cases with complex digital needs. This activity is being organised through community specific Competence Centres and through an Early Adopter Programme that is a vehicle to provide in a coordinated and cross-community manner the necessary expertise leveraging existing human networks from e-Infrastructures and Research Infrastructures⁴.

⁴ <https://www.eosc-hub.eu/eosc-early-adopter-programme-2nd-call>

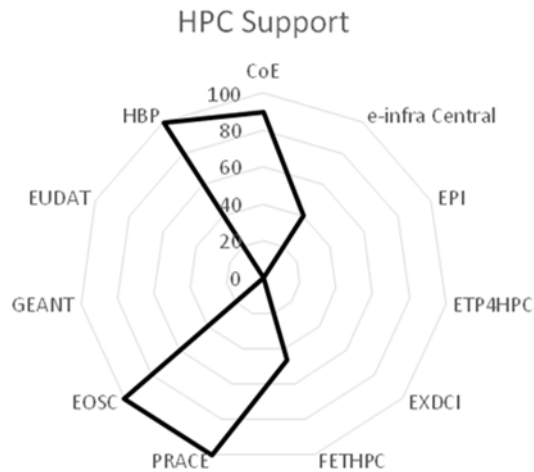


Figure 7: Provision of HPC Support in % of positive responses in the respective stakeholder groups

3.3.6 HPC Research

The survey showed that research in HPC is mainly executed by the actors in the HPC pillar of applications, meaning by the CoEs and FETHPC projects (Figure 8). This would include also EPI when one considers research in HPC technology. However, EPI indicated HPC Research as Developer and not as Provider.

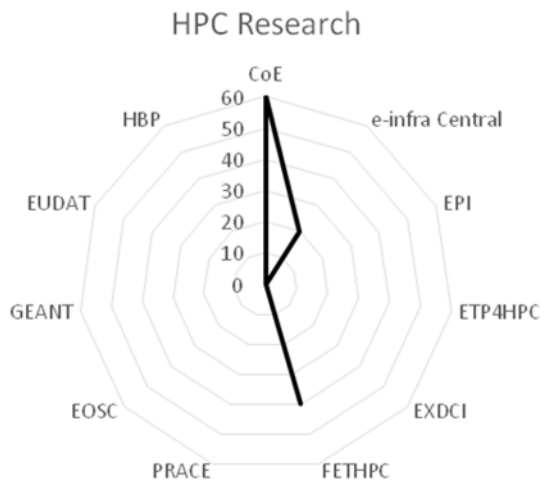


Figure 8: Provision of HPC Research in % of positive responses in the respective stakeholder groups

3.4 European HPC Ecosystem Summit, SC19, Denver, USA

A follow-up session after the landscape survey was organised by the PRACE-6IP project on Thursday, 21 November 2019 during the SC19 conference in Denver, USA, in the form of a Birds of a Feather session. The session was attended by more than 40 representatives from PRACE, GÉANT, CoEs and FETHPC projects, EXDCI, and ETP4HPC, among others. The objective of this

follow-up session was to present an updated analysis of the European HPC landscape and a first insight into the new HPC in Europe portal that PRACE-6IP is developing based on all the inputs collected (see section 4). The discussion during this session allowed to improve the objectives of this service portal while clarifying the difference with other initiatives.

3.5 Link to other e-Infrastructures

PRACE is preparing for the use of HPC and data resources by other infrastructures and e-Infrastructures. With the increasing amount of data, traditional workflows will have to be changed in order to cope with the data. This is especially true for Large Scale Scientific Instruments, e.g. CERN and the Worldwide LHC Computing Grid (WLCG) data centres federated in EGI [27], or the SKA telescope.

The European Open Science Cloud (EOSC) was designed to increase the value of scientific data assets by making them easily available to a greater number of researchers, across disciplines (interdisciplinarity) and borders (EU added value), and to reduce the costs of scientific data management, while ensuring adequate protection of information/personal data according to applicable EU rules. EOSC is one of the major actions of the Communication on a ‘European Cloud Initiative’ of April 2016 [2]. The European Open Science Cloud will offer 1.7 million European researchers and 70 million professionals in science and technology a virtual environment with open and seamless services for storage, management, analysis and re-use of research data, across borders and scientific disciplines by federating existing scientific data infrastructures, today scattered across disciplines and Member States. Part of EOSC’s mission is to join existing and emerging data infrastructures. To be part of EOSC, an infrastructure needs to comply with the rules of participation that define the rights, obligations and accountability of its various actors.

As one of its underlying layers, PRACE is not formally part of the EOSC but is compliant with main rules of participation, working on a referenced joint service catalogue, enabling users to find and access the HPC resources also in the EOSC. While new complementary ways to access converged HPC and AI resources in Europe are foreseen (such as AI4EU [5]), to respond to new usage models, the allocation of large resources in a coordinated manner across e-Infrastructures, in HPC like in other fields of open science, will probably still be mainly based on a peer-review process assessing scientific excellence, which is not contradictory with EOSC rules. Specific dynamic access to HPC resources could also take place. In addition, it is planned also to integrate EOSC training in the HPC in Europe portal (see next section) and make the training offers accessible also for EOSC and HPC ecosystem.

4 Next Stage – the European HPC Portal

The objective of this section is to describe the characteristics of the HPC in Europe portal, in order to facilitate a collective definition of this new portal of services by PRACE and many other relevant stakeholders.

The concept of the portal and the categories of services that will be included in will be defined here, as well as the navigation through the portal and input mechanisms.

After a first version produced by PRACE-6IP project, this effort will be shared with other European HPC stakeholders in order to make this a collaborative activity.

4.1 Branding and Strategy

The development of this HPC in Europe portal is an answer to the requests of EC reviewers of the PRACE-5IP and PRACE-6IP projects. It will include the inputs of relevant European HPC stakeholders. All contributors will be acknowledged.

The new portal will have a neutral branding (i.e. not PRACE-branded), possibly based on or inspired by the EuroHPC corporate image. This is an important element to depict the neutrality and vast scope of the services broadcasted through the portal.

The services collected and displayed in the portal will include calls for proposals, activities, events, materials and other related resources. The names of categories and descriptors should not be related to any provider as much as possible.

The navigation through the portal needs to be easy and clear. The portal will include clear menus and filters, described in the following sections. In all cases, the portal will provide the necessary information to guide European HPC users to the services of their interest (i.e. the portal will not be a simple collection of links to external providers).



Figure 9: Mock-up of the HPC in Europe Portal

The strategy for this portal is rather different to that of the EOSC catalogue and marketplace, although it is planned to collaborate and link the services between the two portals in the future. The EOSC initiative has dedicated a strong effort to define standards and rules of participation that would allow integration of services and resources for the entire ESFRI e-infrastructure layers (such as computing, networking, data management, storage, training & support, processing & analysis), with a focus on data services and special attention to direct access services. This is complementary to the HPC in Europe portal, focused on structuring the European offer of HPC services and resources across a number of categories and groups of interest agreed with the major actors in the field.

4.2 Menu bar

The menu bar of the portal will group the offer of services according to the following tracks and categories:

- HPC Access
 - Access to HPC systems
 - Complementary HPC access
 - Development and benchmark access
 - Prototype HPC Access
 - European HPC systems
- Training and events
 - Training events
 - HPC events
 - On-demand training offers
 - Online training

- Training materials
 - Academic programmes
 - Mobility and mentoring
- Support
 - High-level HPC support
 - Domain-specific support
 - Support to Industry
- Applications
 - European Centres of Excellence in HPC
 - Simulation services
 - Consulting services
 - Prototyping services
 - Benchmark services
- Technology
 - Software developments
 - Hardware developments
 - HPC prototyping
- Documentation
 - Map of HPC systems
 - White Papers and BPGs
 - Use cases and Success Stories
 - HPC Media
 - ETP4HPC
 - European Processor Initiative
 - FETHPC projects results
 - Artificial Intelligence, Deep Learning, Machine Learning
 - Quantum Computing, Quantum Communication Initiative
 - Cyber Security

4.3 Main body

The main body of the portal will group the offerings of services according to their scope and maturity level. The audiences and topics below are foreseen. Some topics may be highlighted on the landing page, while others would be accessible only on the audience section page.

- Research
 - Access to HPC systems
 - Support to HPC users
 - Advanced training
 - HPC prototyping
- Industry
 - Access to HPC systems
 - Resources for Industry
 - Specific for SMEs

- Support for SMEs
 - HPC access for SMEs
- Skills development
 - Guide to HPC training
 - Courses, workshops
 - Online learning
 - Academic programmes
 - Mobility and mentoring
- HPC Communities
 - Community access to HPC
 - Domain-specific training
 - Domain-specific support
 - On-demand training
 - Related communities
 - Artificial Intelligence, Deep Learning, Machine Learning
 - Quantum Computing, Quantum Communication Initiative
 - Cyber Security
- General public, stakeholders and policy makers
 - Media and resources
 - Map of HPC systems
 - White Papers and BPGs
 - Use cases and Success Stories
 - Events (rotating highlights)
 - Technology information
 - European Processor Initiative
 - FETHPC projects results
 - ETP4HPC

4.4 Service groups

The navigation modes will lead to the group of services that match the track/category/audience/topic selected. The service group view will include enough details to allow users identifying the services of their interest directly on the portal, before following the access link. Examples of these groups are shown below:

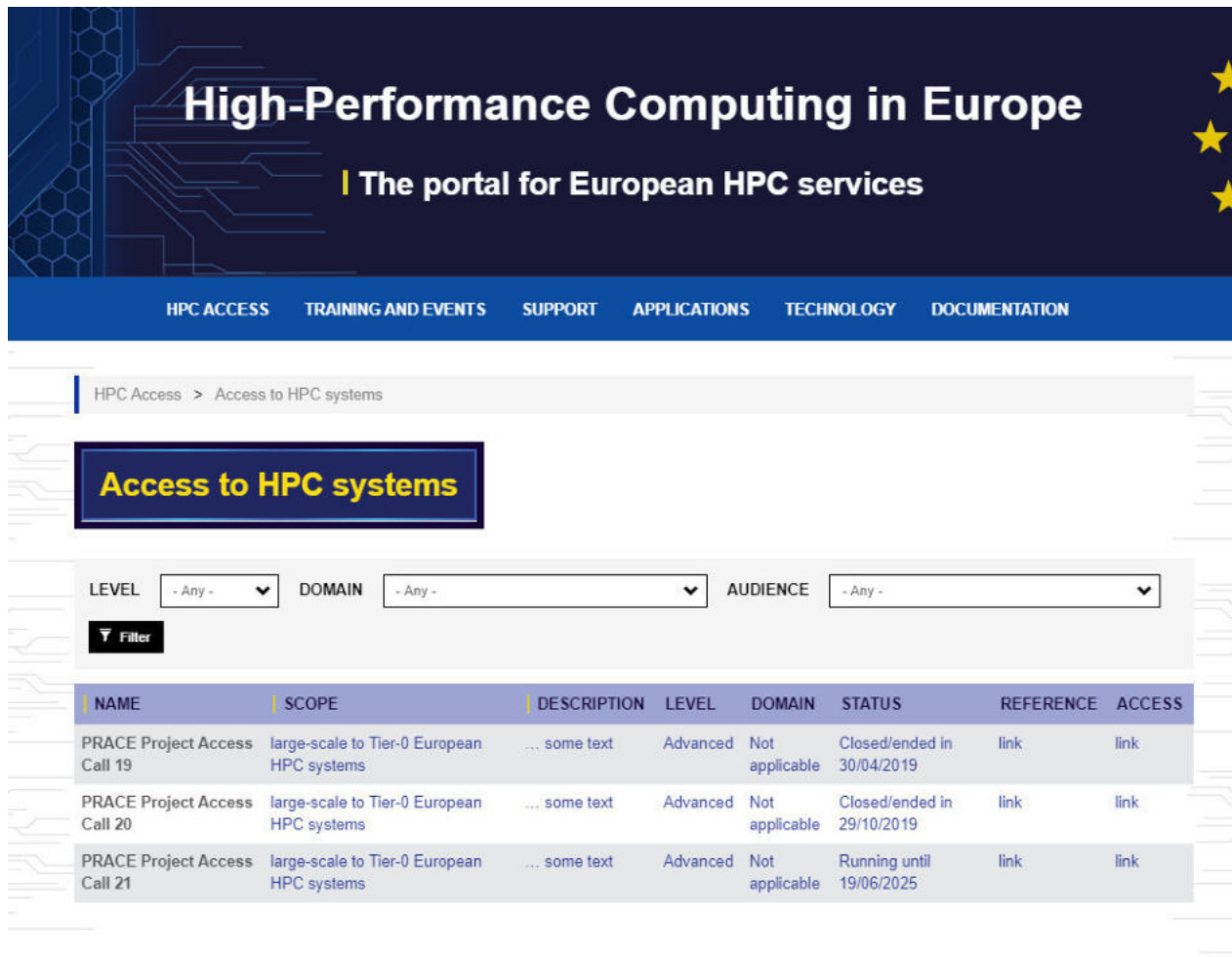


Figure 10: Introduction to Access to European HPC resources

It is expected that some selections may lead to a large list of results. For those cases, the portal will include filters on maturity levels and related scientific domains (when applicable) to facilitate the search of services.

4.5 Interactive map

The portal will include an interactive map that will display notably the location of HPC systems and Centres of Excellence, and other services where location is deemed relevant, e.g. training offers.

4.6 Service description

Each service will be assigned at least to one category (service-oriented) and one topic (audience-oriented), which will determine their tracks and target audiences. Additionally, services will be assigned to the centres/institutions (location-based) where they are delivered. Service description will include as well:

- Title
- Scope (short)
- Description (long)
- Dates
 - Start/end of the service
 - Validity/last update of the service
- Categorisation
 - Target audiences
 - Track categories
 - Maturity/difficulty level
 - Scientific domain
- Centre(s) of delivery
- Owner of the service
- Links to
 - Official documentation/description
 - Registration/access to the service

All these fields will be incorporated into the main table that will serve as a basis for the portal. The links in the portal will show all the matching items in this table. A preliminary table with model services will be prepared, in order to test if the fields are sufficient or further details are needed.

4.7 Management and acknowledgement

The portal has been designed as a framework where all interested stakeholders can contribute. PRACE will be responsible for the design, developments and technical maintenance. Stakeholders will be allowed to upload, update and remove their related HPC services; specific accounts will be created to that end. PRACE will offer the possibility to co-develop automated imports with the major European HPC services providers. PRACE-6IP project will dedicate some additional effort to the review and update of the data in the portal.

All contributors to the portal, that is all stakeholders uploading services will be acknowledged in a dedicated section.

5 Conclusions and Next Steps

After the analysis of the services of the different actors in the HPC ecosystem, it is clear that further coordination is needed at European level to leverage the strong, but scattered, skills of European players, in order to compete with united effort from USA, China or Japan in the race to exascale. To that end, the following high-level service architecture is proposed:

- European HPC technologies will be developed by projects under the umbrella of EuroHPC R&I pillar, including EPI, and continuing and leveraging H2020 FETHPC projects. CoEs and PRACE will collaborate by providing user requirements and co-designing the new technologies. In addition, PRACE will support by providing access to the FETHPC

prototypes and give the related infrastructure feedback while CoEs and other users will provide end-user feedback.

- Access to HPC resources will be provided mainly by PRACE, while network connectivity will be provided by GÉANT. Other, more specific computing resources will be provided by dedicated infrastructures, e.g.: FENIX from HBP, EGI for communities like high-energy physics, astronomy and astrophysics etc., and Cloud access to heterogeneous computing facilities funded at national level.
- The wide offer of training in HPC will be provided by many actors, where PRACE will focus on the general and cross-disciplinary training, leaving more domain-specific training for CoEs.
- Application enabling will be provided by PRACE as a first contact point, along with high-level support to implementation through PRACE HLSTs. Long-term support and specific support for codes of general interest will be provided by the relevant CoEs. The POP CoE will provide transverse performance analysis services.

This high-level provision of HPC services by PRACE, GÉANT, CoEs, EPI and FETHPC projects will be complemented by the pool of national HPC services, to be integrated within this architecture. In this way, the new HPC in Europe portal will allow integration of the complete catalogue of HPC services throughout Europe, with a special emphasis in computing, training and support services. Following a user-driven approach, this will significantly increase awareness of European HPC resources and services, and strongly facilitate their access by all European audiences. The important role of the EuroHPC JU will be acknowledged in the portal as well.

Recently, INFRAG and RIAG has embarked on a mission to analyse the European HPC landscape. This overview and analysis will be helpful in the discussion and definition.

6 Annex

6.1 Agenda and Minutes of the HPC Ecosystem Summit

6.1.1 Agenda

For this meeting, the following agenda was sent in advance with the e-mail invitation:

Programme:

14:30 Welcome (EC/PRACE) – Setting the scene

14:40 HPC Ecosystem

14:50 Results from the Survey

15:00 Panel Discussion

- Participants: all involved stakeholders
- Topics: **Training, Support, Services, Research, Technology, Policy**
- Questions: Where are overlapping tasks? Where is potential for cooperation?

16:30 Conclusion

16:50 Next Steps

17:00 End of Meeting

6.1.2 Minutes

The following part of this section reports the discussions that took place during this HPC Ecosystem Summit in Poznań, 14 May 2019:

14:30 Welcome (EC/PRACE) – Setting the scene

Florian Berberich (FB), PRACE-6IP and Leonardo Flores (LF), EC open the meeting and thank the participants for helping to define the roles in the HPC ecosystem.

14:40 HPC Ecosystem

FB's presentation (see attachment):

Objectives of the HPC Ecosystem Summit:

- Set the roles (who does what in the future)
- Involve all relevant HPC players
- Publish a vision of the architecture and integration of the services with EOSC, EDI, data services, etc. for the communities

14:50 Results from the Survey

FB informs that the survey was sent to 81 contacts (coordinators of CoE, FETHPC projects, EuroHPC, ETP4HPC, BDVA, GÉANT, FocusCoE, EPI, EOSC, EUDAT, OpenAire, eInfraCentral, EXDCI). Almost 50% received feedback, but no reply from EuroHPC.

The received answers were from: 10 CoEs, 15 FETHPC projects, EOSC, EPI, HBP, FocusCoE, GÉANT, ETP4HPC, and PRACE.

Analysis of the survey results: focus on the provider aspect.

- HPC policy provider:
 - Assumed role of EuroHPC.
 - Answers received – indicate to provide HPC policy: CoEs (2/10), ETP4HPC (1/1), EXDCI (1/1), FETHPC (1/15) and PRACE (1/1).
 - The definitions are explained in this first category with examples
 - The *developer* is the institution in charge of preparing materials for the development activity, in this case ETP4HPC.
 - The *coordinator* is the institution in charge of collecting materials from developers and of coordinating their implementation, in this case EuroHPC.
 - The *provider* is the institution in charge of providing the services to execute the activity, in this case it is still to be clarified if this will be the EC or EuroHPC.
 - The *enabler* is the institution that enables the activity by providing the necessary services that are not part of the core of the activity, like GÉANT for HPC compute services, or the HPC-GIG and EXDCI-2 CSAs.
 - The survey is still open and answers can still be provided – EuroLab did not fill in the survey.
- HPC Technology provider:
 - Answers received - indicate to provide HPC technology: CoEs (4/10), eInfraCentral (2/5), EPI (1/1), FETHPC (5/15), GÉANT (1/1), EOSC (1/1)
 - The answers indicate a provider role for ETP4HPC and CoEs → The questions were not clear enough. Some of the CoEs do co-design which can be interpreted as technology provision as well.
 - Serge Bogaerts (SB), PRACE aisbl, indicates that PRACE as coordinator of the EXDCI-2 CSA, answered for HPC Technology, but expecting to see ETP4HPC there as well. [After checking with ETP4HPC, it became clear that the first answers received were not on behalf of ETP4HPC but rather on behalf of the members of ETP4HPC, e.g. CEA. New answers were given by the ETP4HPC office which reflect the role of ETP4HPC].
- HPC Computing Service provider:
 - Answers received - indicate to provide HPC services (provide access to HPC compute resources): CoE (5/10), eInfraCentral (2/5), FETHPC (5/15), PRACE (1/1), EOSC (1/1), HPB (1/1).
 - Guy Lonsdale (GL), FocusCoE, comments that the CoEs should have been providing this. Interesting that ETP4HPC is the provider of this, meaning of HPC compute

services. To be clarified with ETP4HPC: why did they indicate to be the provider of this service. [see comment concerning Technology provider].

- HPC training provider:
 - Answer received – indicate to provide HPC training: CoE (8/10), eInfraCentral (2/5), FETHPC (6/15), PRACE (1/1), EOSC (1/1), HPB (1/1).
 - Further discussions with EOSC are needed in order to clarify what type of training they are providing. For now, we have the CoEs-PRACE training collaboration.
 - GL indicates that ETP4HPC must have been answering about training for its members, for their organisation, not for the users. GL enquires about EXDCI-2's role. [See comment concerning Technology provider].
 - SB indicates that EXDCI-2 appears under PRACE. It was not clear in the survey if one should answer as representative of the organisation or of the project in which the organisation is involved.
 - Per Öster (PÖ), CSC, comments that EOSC provides training for HPC technology, data management or tools like notebooks, there is an overlap.
 - FB asks about the EOSC training portal.
 - Tiziana Ferrari (TF), EOSC, confirms that EOSC provides training coordination with the clusters, as joint events; it delivers training as EOSC hub. She adds that there is no overlap with the PRACE training, maybe one small overlap on accelerators. One of the reviewers' recommendations – deliver training, they see positive points because of the calendar, the need for coordination.
 - Annabel Grant (AG), GÉANT, enquires if a single portal is being planned.
 - FB confirms - the *HPC in Europe* portal linked to the Training Portal. Moreover, he adds that this portal could be linked this to EOSC training portal - this could be helpful for people looking for training information and find all relevant information in one place.
- HPC Application Enabling and User Support provider:
 - Answer received – indicate to provide HPC Application Enabling and User Support: CoE (9/10), eInfraCentral (2/5), FETHPC (7/15), PRACE (1/1), EOSC (1/1), HPB (1/1)
 - FB mentions that looking into detail, an overlap between the involved actors could be identified. PRACE is providing application and user support via the PRACE-IP projects and via its members via the High-Level Support Team (HLST) programme. Clarification with the PRACE partners is still needed. FB asks about CoEs' position for the application and user support and how are the CoEs supporting the users in this topic.
 - A representative from BioExcel answers that the applications are developed beforehand, BioExcel has four core applications. FB comments that if a code is not supported by BioExcel, the user can come to PRACE. The representative of BioExcel indicates that BioExcel works closely with the developer.
 - Dirk Pleiter (DP), CoE MaX, indicates that CoE MaX has a set of predefined codes and service framework supported.
 - FB underlines that each CoE will be asked for a list of codes and services to make available in the portal.
 - DP comments that important is to identify the gaps.

- SB draws the attention to the fact that application and user support is very wide. Need to take this into account, distinguish the overlap.
- FB comments that his understanding is that the CoEs are working more on the in-depth services. Are the CoEs available for a short time like 2-3 months support? The representative of BioExcel comments that the support is limited only if unique for the whole community. FB asks into which extend are the CoEs ready to provide user support. The representative of BioExcel replies that for big projects, for example for user with 50 million core hours, support is being provided.
- FB asks if the codes are supported by the CoEs, how the funding is being provided, and are the codes of general purpose or not.
 - BioExcel replies that for training: a collection of these promoting events would be appreciated as well as a common scheme. Oriol Pineda (OP), BSC adds that this is being prepared for the HPC in Europe portal, therefore a common action on this topic is needed.
 - TF replies that relating to the EOSC applications, the competence centres are meant to complete the ESFRI, to target the big projects. This is an opportunity to collaborate with the centres, to redirect the users to the right provider. FB confirms, adding that at least this can ease the collaboration between each other. The Centres of Competence mentioned, are not the same as those of the EuroHPC. PÖ comments that the same applications can be used in different environments, on the large scale HPC. FB indicates that the idea of a joint training database could be a good solution to get an overview.
- HPC Research provider:
 - Answer received – indicate to provide HPC Research: CoE (6/10), eInfraCentral (1/5), FETHPC (6/15).
 - Developer role is clear.
 - Provider role – FETHPC, ETP4HPC and CoEs interpreted this as software research, then it makes sense.
 - DP adds that CoE MaX does co-design, so it explains their answer.
 - GL indicates that no research at all is being done by ETP4HPC, apart from SRA. [see comment concerning Technology provider ETP4HPC].

15:00 Panel Discussion

- Participants: all involved stakeholders
- Topics: **Training, Support, Services, Research, Technology, Policy**
- Questions: Where are overlapping tasks? Where is potential for cooperation?

HPC Policy:

LF enquires who provides the vision. The EC have provided input to RIAG and INFRAG. EuroHPC will do the policy in terms of funding and the main guidelines, and it is up to the stakeholders where to put the effort, where to engage. We need a conceptual framework. Operational infrastructure is the role of EuroHPC. The Infrastructure and Technologies Pillars still need to be clarified. We need the framework for discussion. Application can be also a part of the service.

FB comments that EuroHPC defines the policy, no overlapping.

LF confirms - the HPC policy is a clear case. But the members of the association are not clear, so when we speak about ETP4HPC, we talk about the association.

PÖ adds that the Member States are part of EuroHPC, and this is an opportunity to put the policy in place.

HPC Technology:

FB asks if any overlapping at technology level could be reported. PRACE is not involved in this pillar. ETP4HPC and the FETHPC projects develop the technology.

There is an overlap, not much, but the gaps need to be clarified between the stakeholders. What is coming in the next years and who is going to provide that? The microprocessor, so many things come additionally.

DP comments that PRACE could help FETHPC projects in the selection of the co-design projects. They can also help bring new users in prototype-based services. PRACE could play an important role to fill in the gap.

LF adds that EXDCI is doing the mapping. Jean Francois Lavignon started that. With whom are you collaborating to do that?

FB indicates that also cooperation at this level is needed. ETP4HPC is doing this and is being involved in the SRA preparation groups.

Eugene Griffiths (EG), BSC comments that SRA needs to fit in EuroHPC.

HPC Computing Service:

FB indicates that the feedback received is misunderstanding and this will be double checked [done]. EOSC access to computer resources, but no overlap between EOSC and PRACE, we need to facilitate the user to find the right offer.

Certain categories of users are looking for services that the academic sector cannot offer.

FB comments that example of use cases between EGI and PRACE need to be identified.

TF adds that the community has a composite need and does not go to more providers. This means besides having different providers in Europe, coordinated application enabling, coordinated capacity management is needed.

FB adds that cloud approach with invisible provider might work for some demands. But PRACE users need to know where they can run their codes. So this contradicts with the cloud idea.

HPC Training:

FB comments that it is planned that training from other providers should be made available via the planned portal HPC in Europe.

TF enquires about SME specific support from PRACE side.

FB indicates SHAPE, the SME HPC Adoption Programme in Europe. Now discussions are ongoing on how to improve inside PRACE. The resources are available based on open R&D, results have to be published. How is it in EOSC?

TF replies that in EOSC there is no scientific evaluation and programme for offering vouchers for a given time and capacity.

FB suggests to compare these two initiatives and promote both of them together.

GL underlines the clear interest to collaborate from FocusCoE, but he points out to the label issue.

FB confirms, indicating that first it was proposed the PRACE portal as a joint platform, but the CoEs did not agree with this proposal. Now, we suggest a joint data base, with no logo. I could be also linked to the PRACE Training Portal which provides further material.

LF indicates that he understands the struggle with this label, but the users need to be considered – they need a single entry point with an explanation of what is being provided. He encourages all the stakeholders to collaborate. A common understanding of the services that are out there needs to be defined.

Mark Asch (MA), EXDCI-2, comments that in EXDCI a specific task was supposed to do this portal and enquires about the outcome.

FB indicates that EXDCI was supposed to do a job portal, which does not exist anymore. There was no training portal to be done by EXDCI. The job portal is now included in HiPEAC.

HPC Application Enabling and User Support:

FB indicates that PRACE will try to collect the codes which the CoEs are working with, as well as their capability to give other support to the user support. The difference between the short-term user support – just porting the code - and long-term support should be kept in mind.

LF enquires why the EC is paying the CoEs to develop their codes.

FB comments that in PRACE different support levels are defined: level 1 – basic support, such as password; level 2 – short-term support; level 3 - long-term support, and level 4 - refactoring a code. High-Level Support Teams are between level 3 and 4.

LF points out to a typical example: POP can analyse my code, but the user does not know when to go to PRACE or not.

FB indicates that PRACE agreed to collaborate closer with POP to do this profiling of the code.

HPC research:

FB comments that for soft- and hardware, ETP4HPC and CoEs were identified; Software is being provided only by the CoEs.

16:00 Conclusion

FB concludes the discussions and enquires how to proceed with this exercise. PRACE-6IP will provide a summary of the discussion, how we can see the ecosystem, with the possible collaboration with the different stakeholders. He enquires the need of a follow-up meeting.

OP, BSC comments that training and support still need to be clarified and further questionnaires on these topics might be needed.

One attendee comments that common services are visible and asks how all the stakeholders can manage this coordination.

European HPC Ecosystem Report

FB indicates that this can be reflected in the document as well – PRACE can provide a solution for today's HPC ecosystem and at the same time a future vision with more integrated services. PRACE will write such a document and all other stakeholders will be asked to comment and depending on the topic, more specific meetings in order to refine this exercise will be organised.

FB adds that additional answers to the survey are expected. These will be taken into account for the conclusions. [done]

16:30 End of Meeting

6.1.3 Slides presented at the Summit: European-HPC-Summit-20190514.pdf.

6.2 HPC Ecosystem Survey

The European Commission recognised the need for an EU-level policy in HPC to optimise national and European investments, addressing the entire HPC ecosystem and adopted its HPC Strategy on 15 February 2012 and published the communication 'High Performance Computing: Europe's place in a Global Race' [COM(2012) 45 final]. Since then the European Commission increased the investment in HPC significantly and supported the three HPC pillars: Technology, Infrastructure and Applications with various projects and initiatives.

Recently the EuroHPC Joint Undertaking was founded. EuroHPC will permit the EU and participating countries to coordinate their efforts and share resources with the objective of deploying in Europe a world-class supercomputing infrastructure and a competitive innovation ecosystem in supercomputing technologies, applications and skills.

The PRACE-5IP and -6IP projects will organise therefore a HPC Ecosystem Summit in order to facilitate creating a coherent HPC landscape including access to HPC resources, services for users and research. This Summit will help to clarify the future roles of each actor in the field.

The aim of this survey is to provide in advance detailed information about each of the actors in the field and to support the discussion during the Summit.

HPC player details:

1. Project name
2. Organisation
3. Please select: I am part of
 - Technology Pillar
 - ETP4HPC
 - FETHPC
 - EPI
 - Other
 - Infrastructure Pillar
 - PRACE
 - GEANT
 - Application Pillar
 - CoE
 - Other
 - Else
 - EOSC
 - BDVA
 - Other
4. Contact details
 - Name:
 - First Name:

Position:
E-Mail:
Tel:

5. Will you attend the HPC Ecosystem in Poznan on 14 May 2019?

Yes

No

6. Where do you see/place your organisation in the following matrix:

	Developer	Coordinator	Provider	User/Beneficiary	Enabler	Not applicable
HPC Policy						
HPC Technology (industry, hard&soft)						
HPC Computing Services						
HPC Training						
HPC Application Enabling and User Support						
HPC Research						

Definitions:

- Developer: institution in charge of preparing materials for the development activity
- Coordinator: institution in charge of collecting materials from developers and of coordinating their implementation
- Provider: institution in charge of providing the services to execute the activity
- User/Beneficiary: institution that benefits from the activity
- Enabler: institution that enables the activity by providing the necessary services that are not part of the core of the activity
- HPC Policy: institution related to the definition, development, enablement, implementation or funding of HPC policies, or their beneficiaries.
- HPC Technology: institution related to HPC software and hardware industry
- HPC Computing Services: institution involved in the access to HPC computing resources (cycles)
- HPC Training: institution involved in training in HPC
- HPC Application Enabling and User Support: institution involved in the support to HPC users, e.g.: application enabling,
- HPC Research: institution performing research in HPC or related domains

7. Please indicate your scientific domain(s) (e.g. engineering, physics, biology,...):

-
-

8. Please include a list of your services (e.g. training, code enabling,...):

-
-
-
-

9. Where do you see overlap with other initiatives / organisation:

-
-

10. Where do you see possible collaborations with other initiatives/ organisations in the near future?

-
-
-

11 Annex 4 - Peer review processes for the “Regular access mode” type of calls