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

D2.2

PRACE's strategic, scientific and industrial impact within the European HPC Ecosystem
Final

Version: 1.0
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Date: 31.07.2020

Project and Deliverable Information Sheet

PRACE Project	**Project Ref. №: INFRAEDI-823767**	
	Project Title: PRACE Sixth Implementation Phase Project	
	Project Web Site: http://www.prace-project.eu	
	Deliverable ID: < **D2.2**>	
	Deliverable Nature: < Report >	
	Dissemination Level: PU*	**Contractual Date of Delivery:** 30 / 09 / 2020
		Actual Date of Delivery: 31 / 07 / 2020
	EC Project Officer: Leonardo Flores Añover	

* - The dissemination level are indicated as follows: **PU** – Public, **CO** – Confidential, only for members of the consortium (including the Commission Services) **CL** – Classified, as referred to in Commission Decision 2005/444/EC.

Document Control Sheet

Document	**Title: PRACE's strategic, scientific and industrial impact within the European HPC Ecosystem**	
	ID: D2.2	
	Version: <1.0>	**Status:** ***Final***
	Available at: http://www.prace-project.eu	
	Software Tool: Microsoft Word 2016	
	File(s): D2.2	
Authorship	**Written by:**	Oriol Pineda, BSC; Stelios Erotokritou, CaSToRC
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	Approved by:	MB/TB

Document Status Sheet

Version	Date	Status	Comments
0.1	25/05/2020	1st Draft	1st compiled version
0.2	06/07/2020	Complete Draft	Submitted for internal review
0.3	17/07/2020	Revised Draft	Version addressing the internal review comments
0.4	24/07/2020	Revised Draft after the second review	Submitted for MB/TB approval
1.0	31/07/2020	Final version	Approved by MB/TB

Document Keywords

Keywords:	PRACE, HPC, Research Infrastructure, PRACE, EuroHPC, Peer Review

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List of Acronyms and Abbreviations

AC	PRACE Access Committee
aisbl	Association International Sans But Lucratif (legal form of the PRACE-RI)
BoD	PRACE Board of Directors
CoE	Center of Excellence
CPU	Central Processing Unit
DECI	Distributed European Computing Initiative
EC	European Commission
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 Partner
GPU	Graphic Processing Unit
HM	PRACE Hosting Members
HPC	High Performance Computing; Computing at a high performance level at any given time; often used synonym with Supercomputing
KPI	Key Performance Indicator
PA	Preparatory Access (to PRACE resources)
PMO	Project Management Office
PRACE	Partnership for Advanced Computing in Europe; Project Acronym
PRACE 1	The initial period of the PRACE Research Infrastructure
PRACE 2	The upcoming next phase of the PRACE Research Infrastructure following the initial five year period.
PTC	PRACE Training Centres
RI	Research Infrastructure
SHAPE	PRACE SME HPC Adoption Programme in Europe
SME	Small and medium-sized enterprises
SWG	PRACE Strategy Working Group
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

List of Project Partner Acronyms

BADW-LRZ	Leibniz-Rechenzentrum der Bayerischen Akademie der Wissenschaften, Germany (3rd Party to GCS)
BILKENT	Bilkent University, Turkey (3rd 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 (3rd Party to GENCI)
CENAERO	Centre de Recherche en Aéronautique ASBL, Belgium (3rd Party to UANTWERPEN)
CESGA	Fundacion Publica Gallega Centro Tecnológico de Supercomputación de Galicia, Spain, (3rd 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 (3rd Party to BSC)
CYFRONET	Academic Computing Centre CYFRONET AGH, Poland (3rd Party to PNSC)
DTU	Technical University of Denmark (3rd 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 (3rd Party to BSC)
INRIA	Institut National de Recherche en Informatique et Automatique, France (3rd Party to GENCI)
IST-ID	Instituto Superior Técnico for Research and Development, Portugal (3rd 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 (3rd Party to SNIC-UU)
KULEUVEN	Katholieke Universiteit Leuven, Belgium (3rd Party to UANTWERPEN)
LiU	Linkoping University, Sweden (3rd Party to SNIC-UU)

MPCDF	Max Planck Gesellschaft zur Förderung der Wissenschaften e.V., Germany (3rd Party to GCS)
NCSA	NATIONAL CENTRE FOR SUPERCOMPUTING APPLICATIONS, Bulgaria
NTNU	The Norwegian University of Science and Technology, Norway (3rd 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 (3rd Party to UCPH)
SIGMA2	UNINETT Sigma2 AS, Norway
SNIC-UU	Uppsala Universitet, Sweden
STFC	Science and Technology Facilities Council, UK (3rd Party to UEDIN)
SURFsara	Dutch national high-performance computing and e-Science support center, part of the SURF cooperative, Netherlands
TASK	Politechnika Gdańska (3rd Party to PNSC)
TU Wien	Technische Universität Wien, Austria
UANTWERPEN	Universiteit Antwerpen, Belgium
UC-LCA	Universidade de Coimbra, Labotatório de Computação Avançada, Portugal
UCPH	Københavns Universitet, Denmark
UEDIN	The University of Edinburgh
UHEM	Istanbul Technical University, Ayazaga Campus, Turkey
UIBK	Universität Innsbruck, Austria (3rd Party to TU Wien)
UiO	University of Oslo, Norway (3rd Party to SIGMA2)
UL	UNIVERZA V LJUBLJANI, Slovenia
ULIEGE	Université de Liège; Belgium (3rd Party to UANTWERPEN)
U Luxembourg	University of Luxembourg
UM	Universidade do Minho, Portugal, (3rd Party to UC-LCA)
UmU	Umea University, Sweden (3rd Party to SNIC-UU)
UnivEvora	Universidade de Évora, Portugal (3rd Party to UC-LCA)
UnivPorto	Universidade do Porto, Portugal (3rd Party to UC-LCA)
UPC	Universitat Politècnica de Catalunya, Spain (3rd Party to BSC)
USTUTT-HLRS	Universitaet Stuttgart – HLRS, Germany (3rd Party to GCS)
WCSS	Politechnika Wroclawska, Poland (3rd Party to PNSC)

Executive Summary

The objective of this deliverable is to report on the impact of PRACE as a consolidated European Research Infrastructure. On top of the public PRACE Key Performance Indicators (KPIs), this deliverable includes statistics and internal indicators used by the PRACE Board of Directors to manage the infrastructure and report to PRACE Council and PRACE Strategy Working Group, with a special focus on the PRACE 2 programme and industrial engagement.

The set of indicators demonstrates the excellence of PRACE after 10 years of service to the European research community. The figures indicate how PRACE has been able to react to the changes in the HPC landscape both within Europe and globally. The indicators have been used to encourage investments in HPC and development of improved services to European HPC users. These indicators also show how the PRACE 2 programme has successfully taken over PRACE 1.

Overall, the collection of statistics, indicators and KPIs of this deliverable provides a global overview of the status of PRACE after 10 years of the infrastructure, and contributes to prepare for the challenges that will come in the next years with the EuroHPC Joint Undertaking.

1 Introduction

The objective of this deliverable is to report on the impact of PRACE as a consolidated European Research Infrastructure through a set of statistics, internal indicators and KPIs. This work builds on the efforts started in 2012 with the PRACE-3IP project to assist the association on impact assessment.

The work has focused on analysing PRACE activities and extracting the appropriate information for PRACE aisbl bodies, i.e.: PRACE Council, PRACE Strategy Working Group and the Board of Directors (BoD) of PRACE, according to their needs throughout the duration of the project.

This deliverable describes the activities undertaken by Task 2.4, and is structured as follows:

- Section 2 reports on the impact of PRACE through different sets of indicators, namely the public KPIs, PRACE aisbl internal indicators, PRACE 2 indicators, statistics to analyse industrial engagement and a first insight into Tier-1 statistics;
- Section 3 briefly updates on the developments of the Map of HPC services as part of the new “HPC in Europe” platform;
- Section 4 includes the summary conclusions of this analysis.

2 PRACE-RI Key Performance Indicators

2.1 PRACE aisbl KPIs

A **performance indicator** or **Key Performance Indicator** (**KPI**) is a type of performance measurement. KPIs evaluate the success of an organisation or of a particular activity in which it engages. The work on Key Performance Indicators in the context of PRACE-RI started as early as the first Implementation Phase (PRACE-1IP) project in 2010 and continued to evolve in the succeeding series of PRACE-IP projects until today.

Deliverable D2.4.1 in PRACE-1IP [1] described in detail all aspects regarding monitoring and reporting in PRACE-RI. After a period of refinement and elaboration by PRACE aisbl, a total of 15 variables were finally selected as official PRACE-RI KPIs and became publicly available on the official PRACE website (https://prace-ri.eu/about/statistics-kpis/). These KPIs rely on actual data collected on a yearly basis.

The work on PRACE-RI KPIs has continued since then, with the corresponding tasks in WP2 focusing on the development and analysis of internal indicators that should help to understand the usage and trends of HPC users in PRACE, and the impact of the PRACE 2 programme in European research.

2.1.1 PRACE's impact on evolving research

Number of projects

This indicator collects the number of proposals received and compares with those ranked above the scientific excellence threshold (as set by PRACE Access Committee, composed of world-class researchers from a wide variety of scientific domains) and then with the number of proposals awarded. The objective of this indicator is to depict the quality of the applications received and oversubscription in PRACE calls. Figure 1 shows the evolution of these three metrics.

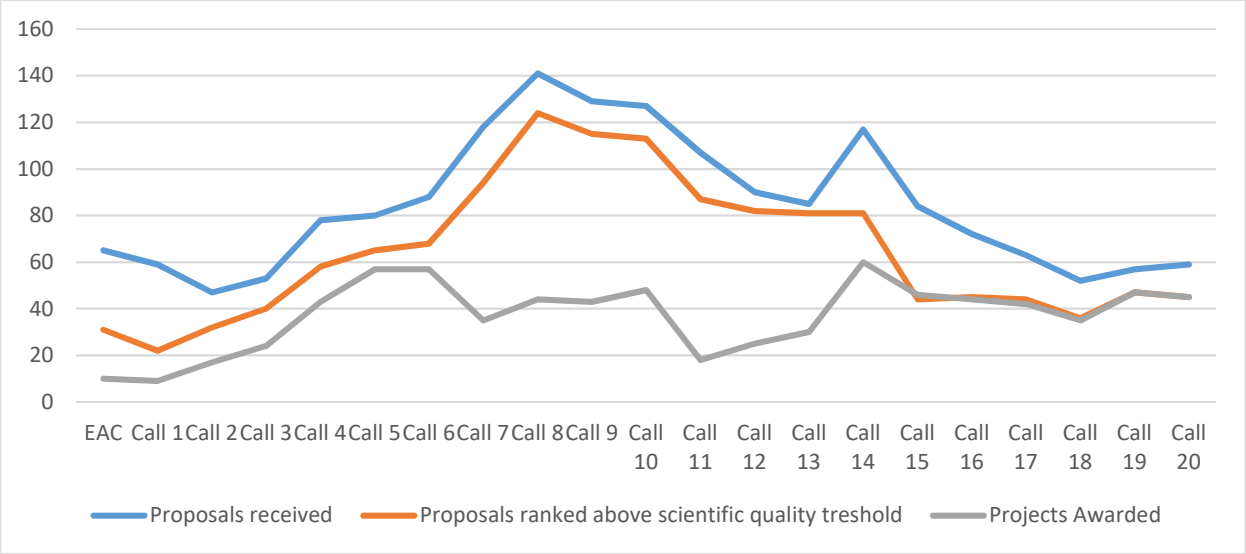

Figure 1: Total number of proposals received, proposals ranked above scientific excellence threshold and projects awarded

The gap between the number of proposals received and those ranked above the scientific quality threshold indicates the **average quality of the proposals received**. The lower the gap, the higher the average quality. It can be seen in Figure 1 how this gap has been reducing since the first PRACE Call (EAC) to the call before the PRACE 2 programme (13th Call); this indicates how users learned to better prepare their proposals. In Call 14 this gap increased again due to the stronger requirements set by this new programme, then slowly decreased afterwards, indicating again that users were able to react to these new conditions.

The **number of proposals ranked above the scientific threshold** is used as a measure of the effective oversubscription of PRACE calls, by considering only those proposals with the necessary scientific quality according to PRACE Access Committee. During the PRACE 1 programme (EAC to 13th Call) we can see an effective oversubscription leading to certain proposals not funded due to lack of resources: from the 7th Call to the 13th this has been excessively higher, which indicates that a number of high-quality proposals could not be funded. The apparent decrease of scientific quality observed with the PRACE 2 programme (from call 14th onwards) is in fact the result of the increased quality threshold set by the new Access Committee; after this increased threshold, nearly all proposals considered scientifically excellent are funded under the PRACE 2 programme. Further insight and discussion on these details can be found in the next section, PRACE aisbl internal indicators, under the over-demand and allocation ratios.

Non-recurring users

This indicator shows the percentage of proposals submitted by non-recurrent Principal Investigators (PIs) and the percentage of projects awarded to them. The target of this metric is that new applicants and new awardees represent an important percentage, as a sign of the capacity of PRACE to attract and serve new users and their projects. Figure 2 shows the trend for this metric.

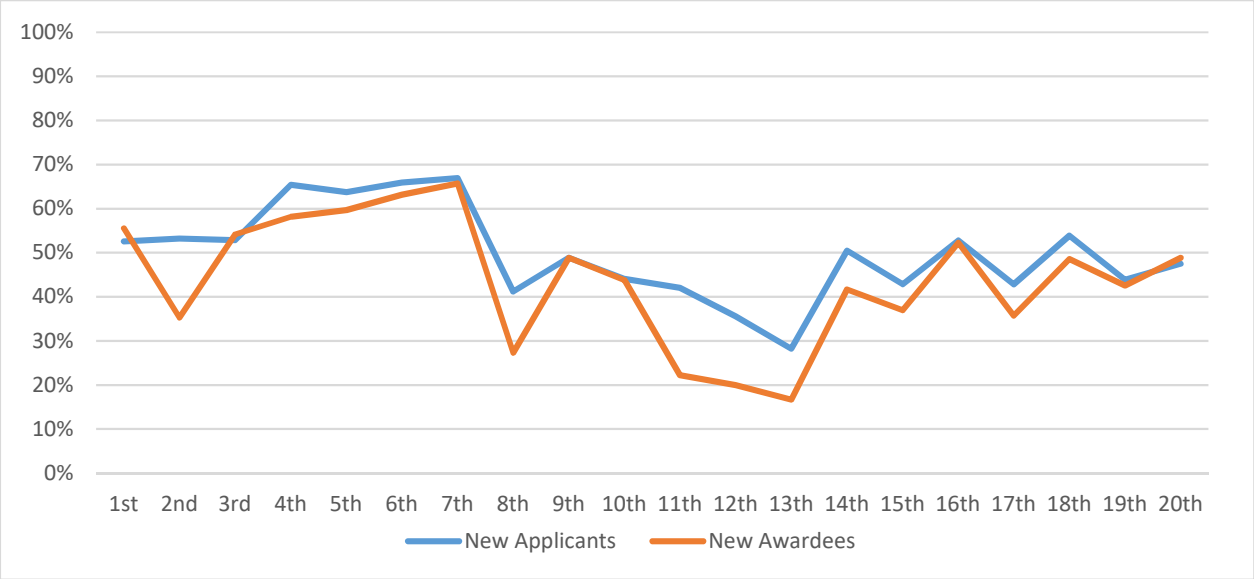

Figure 2: Percentage of new applicants and new awardees in each PRACE call

The percentage of first-time applicants is relatively high, with an average of 50% of project proposals submitted by new applicants that had no previous experience as PIs of a PRACE Project Access proposal. This indicates that PRACE is continuously attracting new PIs, while remaining an essential support for existing users..

International and transnational cooperation

This indicator collects the number of "foreign projects" and the resources awarded to them. Foreign projects are defined as projects with Principal Investigators (PIs) from a different country (recorded as the country of the PI's primary institution) than the system on which the research is executed. The target for this indicator is to maintain the trends above 50%. Figure 3 shows the evolution of this metric.

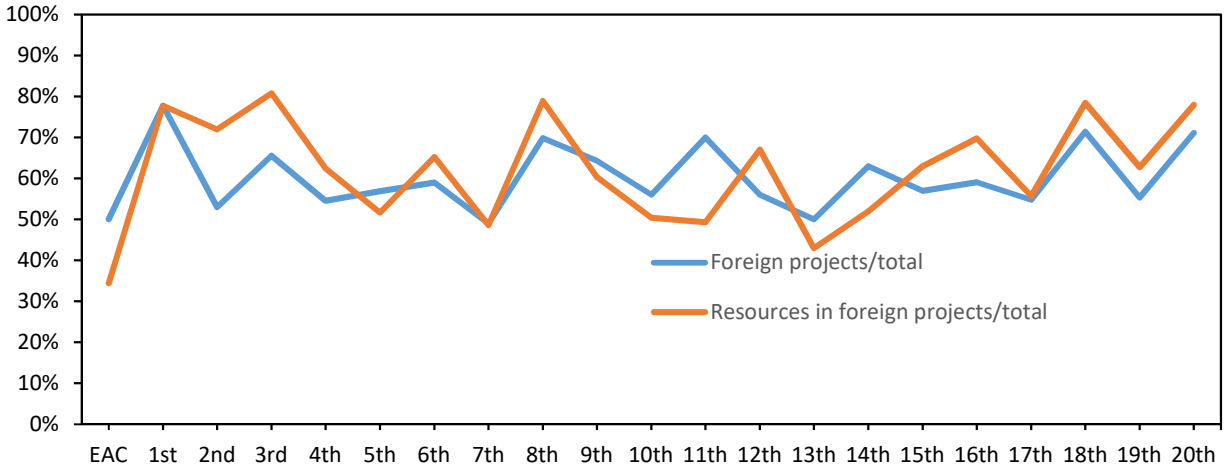

Figure 3: Ratios of awarded 'foreign' projects and resources for awarded 'foreign' projects

Two-thirds (63%) of the resources are awarded to foreign projects. The ratio of awarded foreign projects remains rather stable over time. This shows that the nationality of the PI's institution does not influence the chances of a project being awarded. It also demonstrates PRACE's impact in the enhancement of European and international collaboration.

Co-funding

This indicator collects the sources of complementary funding for PRACE awarded projects. Even if there is no numeric target set for this indicator, the objective is to assess the volume of PRACE projects developed within larger scientific initiatives, where HPC resources are part of the project's needs.

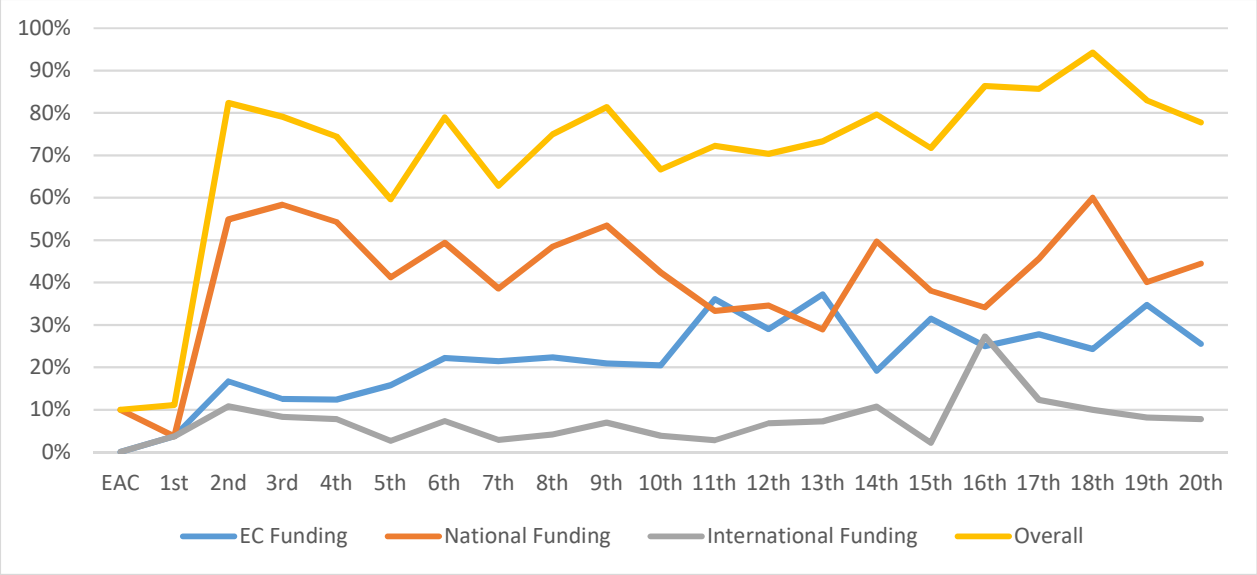

Figure 4: Ratios of awarded projects with EC, National, and International support

On average, 75% of PRACE users have declared that their awards are complemented with EC, national or international funds. The major fraction corresponds to national projects, which is slowly showing a downward trend since the 10th Call. EC funding shows an increasing trend, coinciding with the implementation of the H2020 programme. International funding remains low, with 8% being the average contribution. The result is considered as positive, where only 25% of the projects awarded are independent endeavours or projects that fail in communicating their relation with larger initiatives.

2.1.2 PRACE's impact on growing know-how in Europe

Since 2008, PRACE has been engaged in providing top-class education and training for computational scientists in Europe through the PRACE Training Centres (PTCs), the International HPC Summer School and Seasonal Schools, with a clear increase of registered participants.

Six PTCs were first established, and these are Barcelona Supercomputing Centre (Spain), CINECA – Consortio Interuniversitario (Italy), CSC – IT Center for Science Ltd. (Finland), EPCC at the University of Edinburgh (UK), Gauss Centre for Supercomputing (Germany) and Maison de la Simulation (France). After the rapid increase between 2010 and 2012, a plateau is evident since 2012. As this indicated that the maximum capacity of PRACE training offerings had been reached, 4 new PRACE Training Centers were opened in 2017 – in IT4Innovations (the Czech Republic), GRNET (Greece), ICHEC (Ireland) and SURFSara (The Netherlands). This acts as a second layer of training and education, below the previous PTCs. The network of PRACE Training Centers was further extended in 2019 with the addition of 4 new PTCs, those of TU Wien (Austria), UANTWERPEN (Belgium), University of Ljubljana (Slovenia) and SNIC (Sweden).

PTC training events, Seasonal Schools and the International HPC Summer School are offered free of charge to eligible participants.

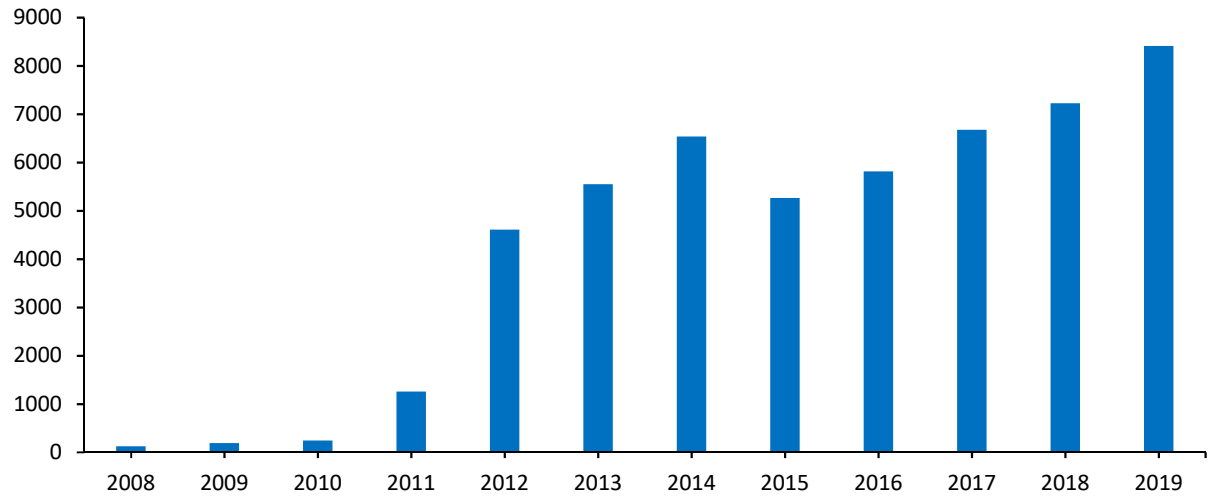

Figure 5: Number of person-days registered at PRACE Training days between 2008 and 2019

Figure 5 shows that between August 2008 and December 2019, PRACE provided close to 52 000 participant-days of training through attendance-based courses, with an upward attendance trend. **PRACE courses were attended by over 16 400 individuals.** This shows the effectiveness of PRACE in attracting, training and retaining competences.

In 2019, the number of participants attending PTCs courses was 2618 (359 with non-academia affiliation). 86% of participants attending PTCs trainings days have academic affiliation, illustrating the impact of such events on research and scientific communities, in particular for early stage researchers and PhD students.

A clear difference of attendance is observed between the first and second semester of 2019. As observed in Figure 6, the total number of attendances registered in the first semester (Q1 and Q2) is significantly higher than during the second semester (Q3 and Q4). This indicates that the bulk of the training offered occurs in the first semester, with a notable drop in attendance during Q3 which corresponds with the summer and winter vacation periods.

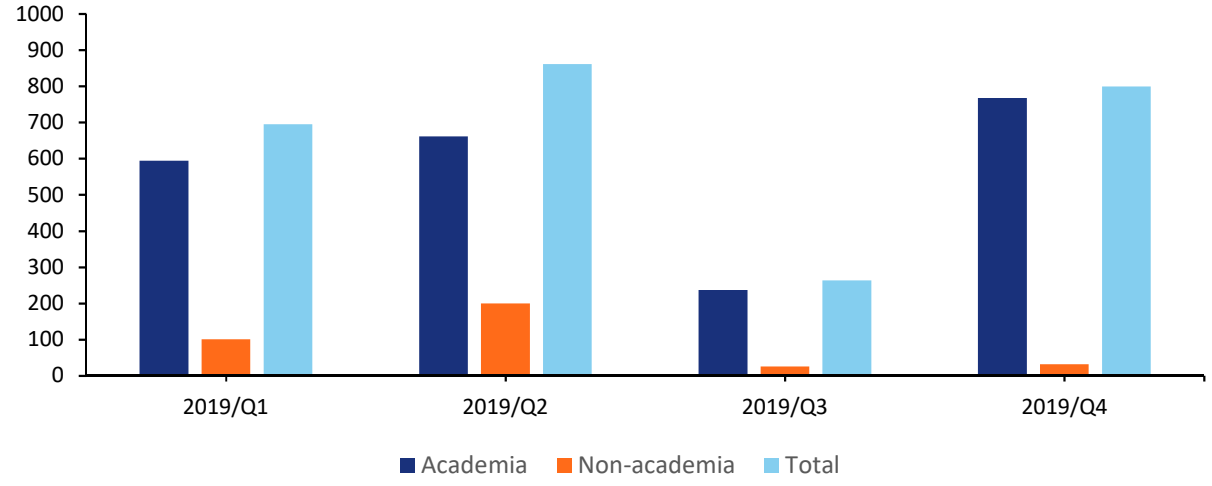

Figure 6: Number of person-days registered at PRACE Training days in 2019

2.1.3 PRACE's impact on attracting the industrial sector

Industrial participants in PTCs

The average participation of industry in PTC trainings is 15.42% between 2012 and 2019. The increasing **interest from industry in participating in HPC training** is visible in Figure 7. Industrial participants enjoy the same service as academic trainees and can attend PTC courses free of charge.

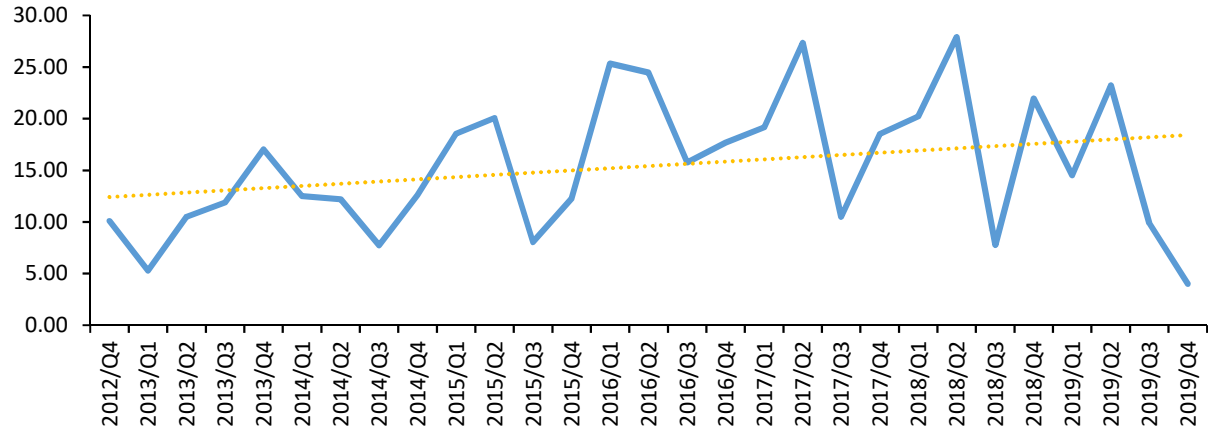

Figure 7: Industrial participation in PTCs training days, and related trend line

Non-academic use of PRACE HPC resources

PRACE opened its Calls for Proposals to non-academic applications in mid-2012. This can take the form of a project led by a Principal Investigator coming from a private company, or a researcher from industry collaborating in an academia-led project. The number of applications with non-academic participation can be seen in Figure 8. Up to Call 18, applications with a non-academic PI have submitted proposals for PRACE resources in applications with an academic PI. This was changed in Call 19 where an "Industry Access Pilot" which offered Principal Investigators from industry the possibility to apply for Single-year access to a special Industry Track which prioritised 10% of the total resources available. This will continue in future calls and we expect an increasing non-academic use of PRACE HPC resources.

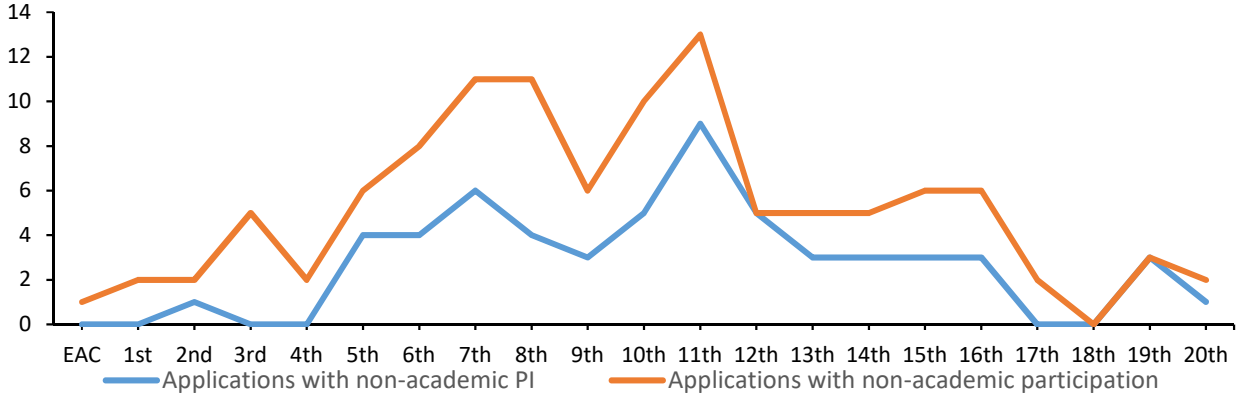

Figure 8: Industry participation in PRACE

2.2 PRACE aisbl internal Indicators

The PRACE Board of Directors maintains a set of internal indicators aimed at having an objective picture of the infrastructure and its relative position in the global HPC ecosystem. These indicators, presented herein, are used to report to the PRACE Council and eventually for dissemination purposes.

Aggregated capacity of PRACE systems per call

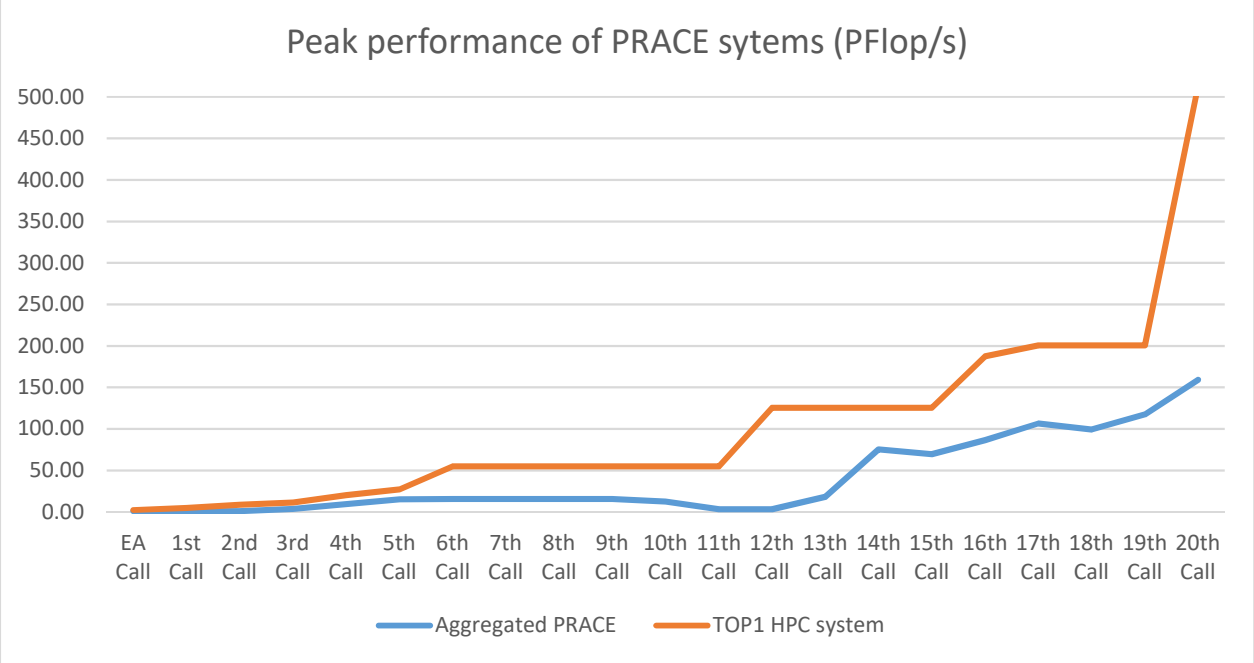

Figure 9: Peak performance of PRACE systems (PFlop/s)

The scope of the indicator demonstrated in Figure 9 is to monitor the computational capacity of PRACE infrastructure (as the aggregated capacity of PRACE systems), while also comparing it with the most powerful system in the world at the same moment. The target is to identify those periods when the capacity of PRACE as a whole is not competitive in the global HPC race and this is used to encourage the relevant stakeholders to increase their continued investment in HPC capacity and offer to PRACE.

Figure 9 shows how PRACE has been constantly increasing the computational capacity, from 1 PFlop/s in 2010 to 160 PFlop/s in 2020. The reduction of capacity in Calls 11 and 12 corresponds to the transition from PRACE 1 to PRACE 2. Even if the aggregated capacity of PRACE as a whole has never exceeded that of the most powerful system in the world, the infrastructure has been able to react to the jumps of 2016 and 2018 with the contributions of the upgraded PRACE 2 systems in Call 14, Call 17 and Call 20. The last update of the TOP500 list includes the supercomputer Fugaku, recently deployed in Japan, with more than 500 PFlop/s of peak performance. Even if PRACE is currently far from that, the start of services of the new EuroHPC JU systems in 2021 is expected to reach an aggregated capacity above this figure, thus bridging the gap again.

Evolution of resources (offered, requested and awarded) per call

This indicator is complementary to the PRACE-RI KPI monitoring the number of proposals received and projects awarded.

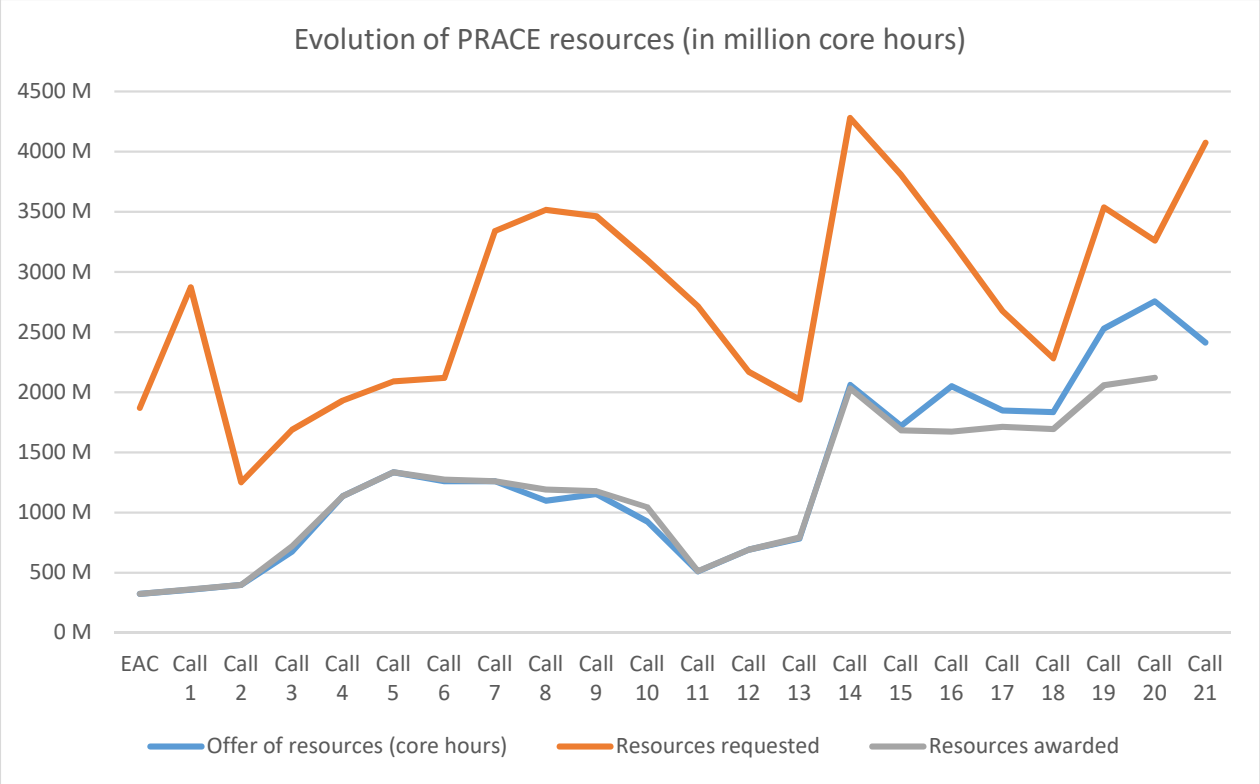

Figure 10: Evolution of PRACE resources

The scope of these statistics is to monitor the evolution of resources offered, requested and awarded across PRACE calls. The target is to verify that the demand for PRACE resources is always above the offer, and also to check the capacity to allocate these resources to HPC projects. Figure 10 shows the increases and decreases in PRACE offered resources due to the phase-in/phase-out of the PRACE 1 and PRACE 2 programmes, and the normally parallel trend in requests of resources and resources awarded. Further information can be obtained by comparing the offer of resources with the resources requested (over-demand ratio, Figure 11 and with the resources awarded (allocation ratio, Figure 12), especially regarding the gap between the offer of resources and the resources awarded that can be seen starting in Call 15.

Over-demand ratio

The scope of this indicator presented in Figure 11 is to monitor closely the over-demand for PRACE resources across calls. The objective is to identify those moments when the demand is too high or too low, in order to take the corresponding measures. The target for this indicator is that the over-demand stays between 150% and 400%.

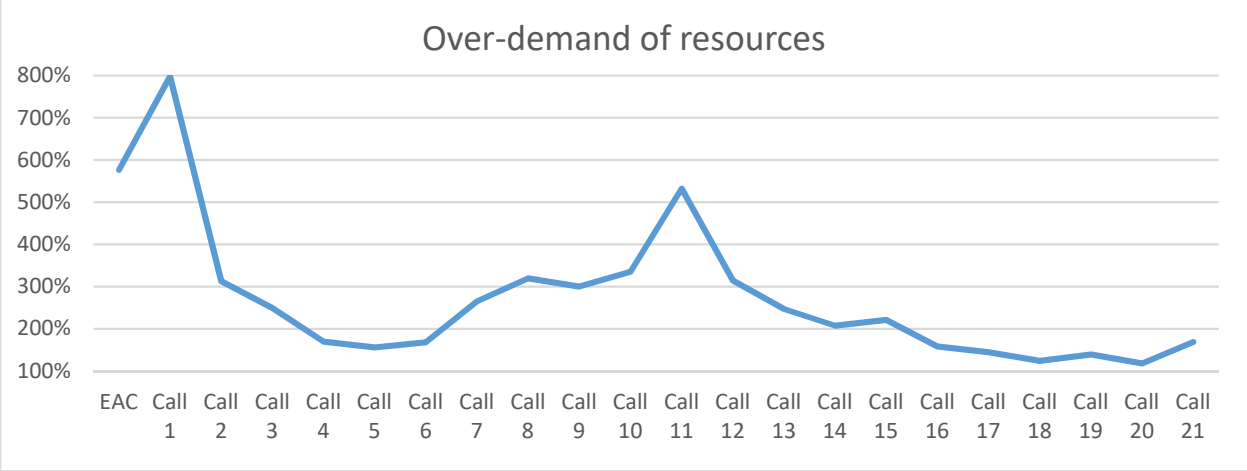

Figure 11: Over-demand for PRACE Resources

We consider that an over-demand above 400% could imply excellent projects not being awarded, leading also to frustration of applicants. This superior threshold has been exceeded in two occasions, at the beginning of the PRACE infrastructure and during the transition from the PRACE 1 to the PRACE 2 programmes. In both cases, the offer of resources was increased in later calls.

On the other hand, we consider that an over-demand below 150% does not guarantee enough competition to secure the excellence of projects funded. Competition for resources is typically used as a method to ensure such excellence. When there is not enough competition, then other mechanisms have to be incorporated. This lower threshold has only recently been breached during the PRACE 2 programme. On these occasions, the scientific excellence threshold has been used to ensure that only high quality projects are awarded.

Allocation ratio

The scope of this indicator presented in Figure 12 is to monitor the percentage of resources allocated, as compared to the offer per call. The objective is to identify under-allocations that could indicate issues in the review process or allocation mechanisms. The target of this indicator is to achieve >100% allocation in every call.

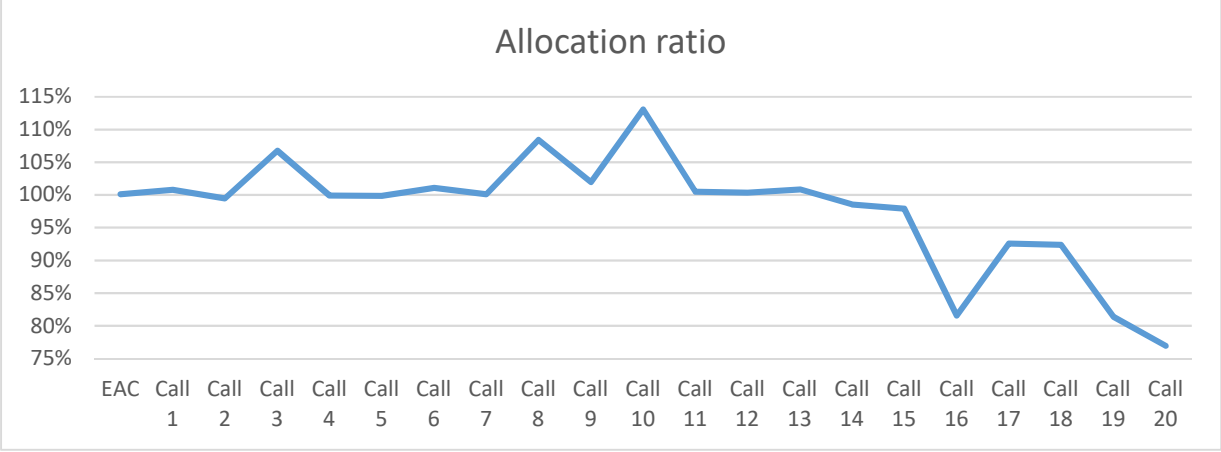

Figure 12: Allocation ratio (awarded vs. available)

The target for this indicator has been consistently reached until Call 13 included, meaning that the initial offer of resources has been fully allocated or even exceeded through the contribution of additional resources to accommodate further projects. With the start of the PRACE 2 programme in Call 14, PRACE is experiencing problems to fully allocate the resources available to HPC projects. This has been analysed and the following three major motives have been identified:

1. The PRACE 2 programme is promoting large and ambitious projects, with typical sizes that range from 10% up to 70% of a given system. Under this situation, in some cases it is impossible to allocate the last 5-10% of each system, due to the lack of suitable projects capable of using such small fractions of resources in a meaningful manner;
2. Related to this, the PRACE 2 programme has set a high threshold on scientific excellence;
3. The systems offered include state-of-the-art technologies, in some cases the first of their kind in the world, and this creates difficulties in having sufficient users ready to fully use such systems from the very beginning, especially for highly innovative architectures like the novel AMD-Rome processor.

While this third option is considered a healthy by-product of PRACE's high quality, the other two options have triggered the need to develop additional access schemes to PRACE resources that could benefit from the unallocated resources while keeping the high excellence standards of PRACE.

Details about PRACE architectures

Since the PRACE Preparatory Phase project, there have been sustained efforts in developing prototypes and testing future technologies that could be used for next-generation Tier-0 systems. While prototypes developed within PRACE-IP projects have never been used for production, PRACE has made available to its users a wide variety of general-purpose computing technologies: GPU accelerators were included in PRACE as of 6th Call with Curie Hybrid system, and Xeon Phi processors were included in the 9th Call with MareNostrum3 hybrid partition. The following figures compare the evolution of PRACE resources, split into general-purpose resources, Xeon Phi resources and GPU-accelerated resources.

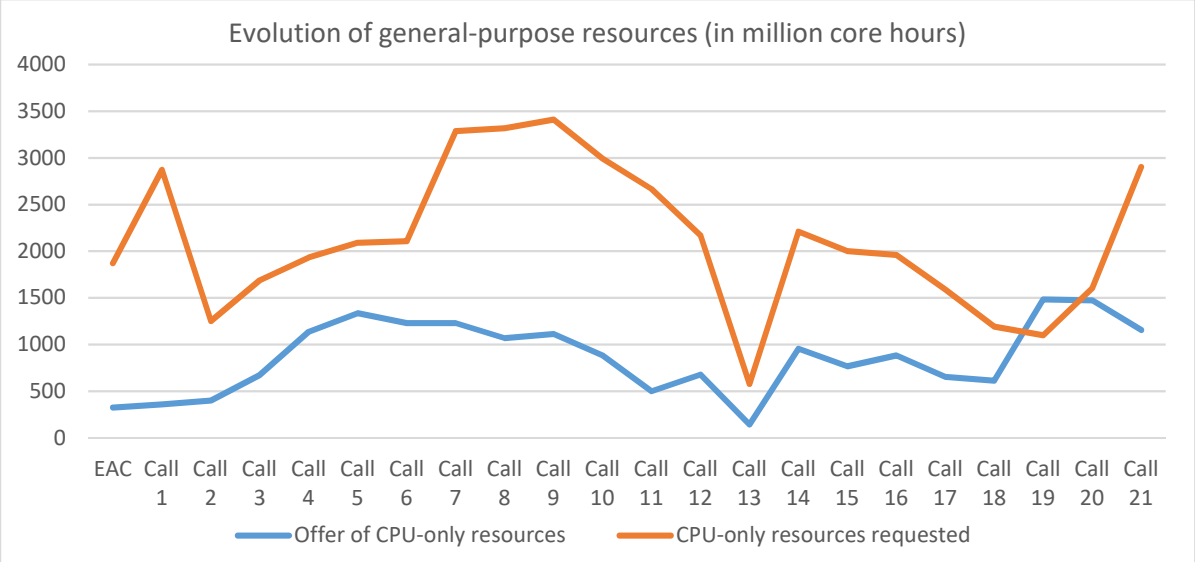

Figure 13: Evolution of PRACE resources according to architecture types – CPU resources

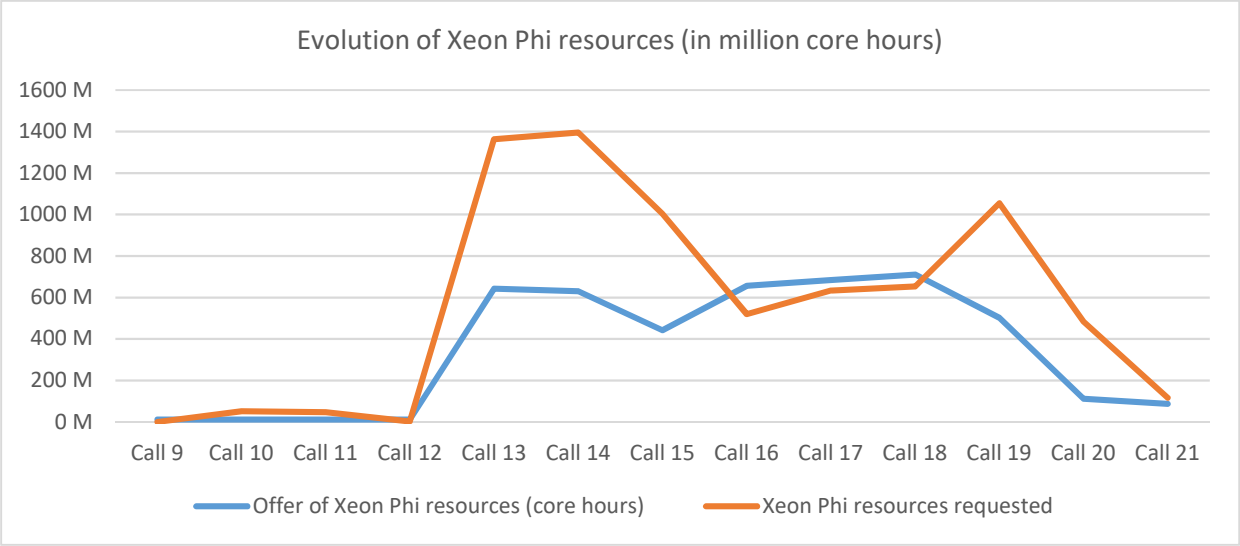

Figure 14: Evolution of PRACE resources according to architecture types – XEON Phi resources

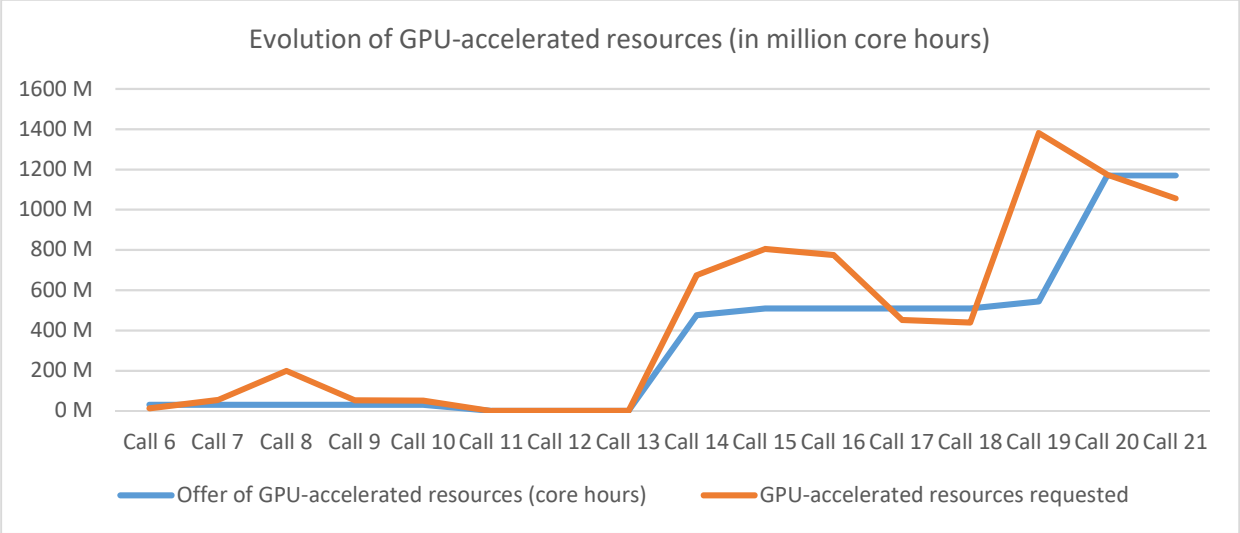

Figure 15: Evolution of PRACE resources according to architecture types – GPU resources

The scope of this indicator presented in Figure 13, Figure 14 and Figure 15 is to monitor the over-demand of resources across PRACE calls, with a view on the different architectures involved. The target is to identify the interest of the PRACE user community on the various architectures offered.

General-purpose resources have always represented the major fraction of PRACE portfolio, with an average sustained over-demand above 240% of the available resources. The curve shows a deviation around Calls 19 and 20 where the demand goes below or equals the offer: in these calls, two large systems with the novel AMD-Rome processor were incorporated into PRACE portfolio. The low demand for them can be accounted for their novelty and lack of user experience; this has returned to positive over-demand again in the last call.

Xeon Phi and GPU-accelerated resources had an initial fair acceptance, despite the low capacity of the systems and the small fraction of resources. This can be observed in Calls 9 to 12 for Xeon Phi, and Calls 6 to 11 for GPU-accelerated. After this initial success, large systems including Xeon Phi and GPU accelerated resources were incorporated into the PRACE portfolio, in Calls 13 and 14 respectively. These systems had a starting excellent acceptance, but the interest has slowly decreased call after call. A possible explanation for this decreasing tendency is that such systems have proved to be used effectively by only a limited fraction of HPC users. This explanation, together with the proliferation of such architectures in local clusters, may account for the decrease of researchers' dependency on these PRACE architectures.

Collaboration and interoperability

The scope of this indicator is to monitor the amount of proposals involving more than one country and proposals requesting more than one PRACE system. The target is to identify the collaboration and interoperability features of PRACE projects.

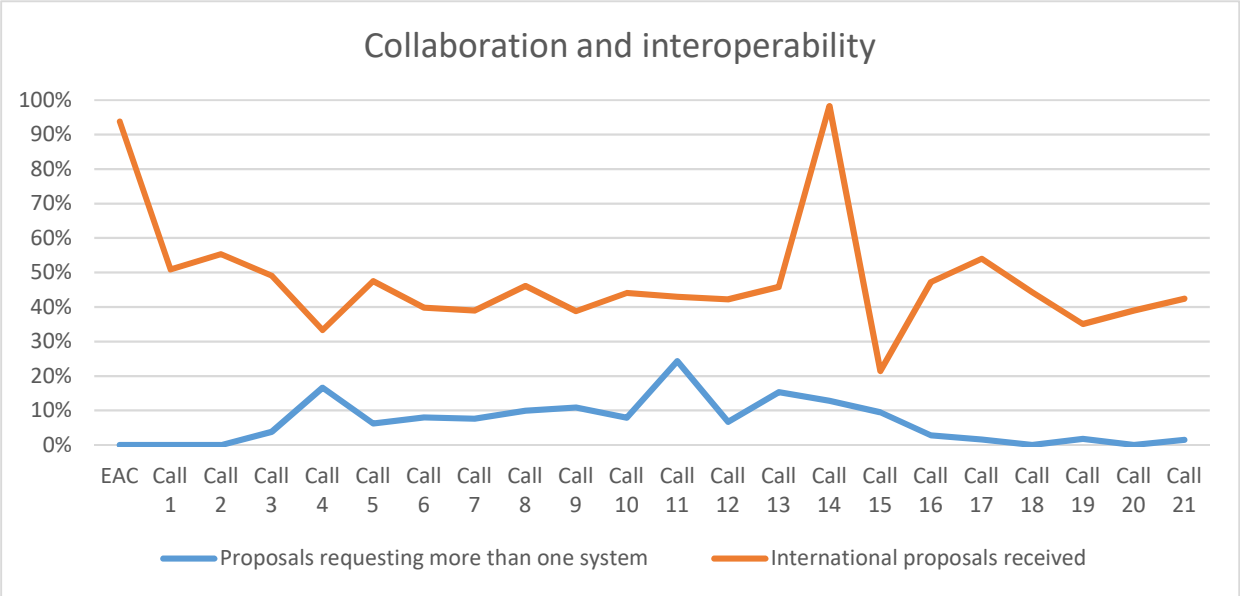

Figure 16: Proposals requesting more than one system

As seen in Figure 16, on average, 50% of the received proposals are international, meaning they involve research groups from different countries. This value is quite consistent, with some deviations at the beginning of both the PRACE 1 and PRACE 2 programmes. Even if there is no numeric target for this indicator, the current average value is considered a good sign of the capacity of PRACE to foster wide collaborations within European researchers.

In relation to interoperability, the average of proposals ready to use more than one system is below 10%. The value of this indicator is not consistent over time; it showed a maximum value of 24% in Call 11, and since then has been decreasing to nearly 0%. This trend needs an in depth technical analysis to understand the reasons behind this decrease. At this stage, this is neither considered positive nor negative, though it serves to balance the resources devoted to interoperability. In any case, it is quite clear that researchers do not see the benefit of running in more than one particular system, maybe related to the effort necessary (technical, admin, else) for interoperability.

2.3 PRACE 2 Indicators

The PRACE 2 programme began in 2017 with Call 14 where a set of constraints in the access to PRACE 2 systems were introduced, namely a target in the allocation of resources based on the nationality of the Principal Investigator of the Tier-0 projects. Whenever the targets are exceeded, i.e.: when allocating a proposal would deviate from the quotas set by the PRACE 2 programme, the corresponding Hosting Member (HM) is asked if it can accept the deviation. When this is not possible, movement of the corresponding proposal to another suitable system is attempted. When this is not possible, the Access Committee (AC) Chair is requested to confirm if the proposal is still viable with the highest available resources. When that is not possible, the proposal is rejected due to PRACE 2 constrains.

Even if these constraints have not been strongly enforced, the Board of Directors has defined a set of allocation indicators to understand the impact of these constraints in Project Access allocations. These are internal indicators used to report to PRACE Council about the usage and distribution of PRACE 2 resources and are presented in Table 1. For reference, the number of proposals received, proposals ranked above the scientific excellence threshold and projects awarded is provided in the same table.

Name	Description	Call 14	Call 15	Call 16	Call 17	Call 18	Call 19	Call 20
Ref.1	Number of proposals received	117	84	72	63	52	57	59
Ref.2	Number of proposals ranked above scientific excellence threshold	81	44	45	44	36	47	45
Ref.3	Number of projects awarded	60	46	44	42	35	47	45
RAS.1	Proposals moved from a PRACE 2 system to a PRACE 1 system *due to a potential deviation in the distribution of resources*	3	0	0	1	0	0	N/A
RAS.2	Proposals moved from a PRACE 1 system to a PRACE 2 system	6	2	4	0	0	1	N/A
RAS.3	Total proposals moved (RAS.1, RAS.2 and other movements)	20	3	8	9	13	12	13
RAS.4	Proposals where the HM accepted a deviation on the distribution of Resources	6	4	3	7	5	5	12
RAS.5	Proposals not allocated due to PRACE 2 constraints	0	0	0	0	0	0	0

Table 1: PRACE 2 internal indicators

Movement indicators

Indicator RAS.1 shows how the PRACE 2 quotas are not strongly enforced. Only in a limited number of cases have the quotas been applied and proposals have been moved from one system to another, in order to avoid major deviations on PRACE 2 constraints.

Indicators RAS.2 and RAS.3 are only used to provide a context to indicator RAS.1. While moving proposals across systems (RAS.3) is a normal operation in PRACE allocation of resources, the target is that RAS.1 values across calls remain lower than RAS.2 values and only a fraction of RAS.3 values. During the relevant period of these three indicators, the movement of projects due to PRACE 2 constraints (RAS.1) has remained under 7% of the total proposals moved.

It is worth noting that PRACE has entered in full PRACE 2 regime as of Call 20, meaning that the PRACE 1 programme is considered completed and all systems contribute now as part of the PRACE 2 programme. Therefore, indicators RAS.1 and RAS.2 are not applicable anymore, and indicator RAS.3 is not necessary for the comparison purposes it was set. Nevertheless, the fact that the value of this indicator for Call 20 is in line with the previous ones re-confirms that movement of proposals across systems is a standard PRACE procedure and not a by-product of the PRACE 2 programme. Analysis of the RAS.3 indicator, both backwards and forward, will be continued.

For reference, the total number of proposals received and the total number of proposals ranked above the scientific excellence threshold are included in the same table, in order to provide a relative meaning to these movement indicators.

Deviation indicators

Indicator RAS.4 collects those cases when a deviation of PRACE 2 allocation target is accepted. There is no target set for this indicator, though comparing it with RAS.1 shows the actual flexibility in the application of PRACE 2 constrains.

Unallocation indicator

Indicator RAS.5 is the most important one of this group. It collects the amount of proposals rejected due to the application of PRACE 2 target allocation of resources. Based on the PRACE 2 principles the target for this indicator is zero. This target has been achieved call by call so far, showing the lack of effective impact of PRACE 2 constraints in the allocation of resources, and that the main principle of “allocation of resources based on scientific excellence” of PRACE is still valid and followed with PRACE 2.

Distribution of resources

The Board of Directors monitors the distribution of resources allocated to Hosting Member countries and to PRACE 2 General Partner countries, in relation with the PRACE 2 constraints. This distribution is computed in node hours, the PRACE 2 contribution metric. The tables below summarise this distribution, per Hosting Member and in global for the PRACE 2 programme:

Resources allocated to HMs	CH	DE	ES	FR	IT	PRACE 2
Call 14	59%	79%		75%		72%
Call 15	100%	60%		90%		87%
Call 16	77%	55%		77%		66%
Call 17	59%	56%	43%	80%		58%
Call 18	67%	42%	65%	64%		62%
Call 19	60%	43%	37%	85%		60%
Call 20	67%	31%	58%	66%	52%	57%
Total	**70%**	**57%**	**51%**	**78%**	**52%**	**66%**

Table 2: Percentage of PRACE 2 resources allocated to PRACE Hosting Members

Resources allocated to GPs	CH	DE	ES	FR	IT	PRACE 2
Call 14	41%	21%		25%		28%
Call 15	0%	40%		10%		13%
Call 16	23%	45%		23%		35%
Call 17	41%	44%	57%	20%		42%
Call 18	33%	58%	36%	36%		38%
Call 19	40%	57%	63%	15%		40%
Call 20	33%	69%	42%	34%	48%	43%
Total	**30%**	**43%**	**49%**	**22%**	**48%**	**34%**

Table 3: Percentage of PRACE 2 resources allocated to General Partners (GPs) contributing to the PRACE 2 programme

The tables show again the flexibility in the implementation of PRACE 2 constraints, in regards to the allocation of resources. The vast majority of projects (99%) have been allocated on their system of choice or moved on technical or availability grounds; only 1% of the projects awarded have been moved to avoid a major deviation of PRACE 2 constrains, and none of the proposals received

have been rejected based on such constrains. This shows that the scientific excellence principle is the major driver of the PRACE 2 programme, as it was for the PRACE 1 programme. In detail, these two tables show a great variability in the resources allocated to HMs and to GPs, call by call, system by system and provider by provider.

Even in the absence of enforcement measures, after seven calls of the PRACE 2 programme, and running on its first extension, the distribution of resources between PRACE Hosting Members and PRACE General Partners has quite naturally converged to the target set originally (75% - 25%). At this stage, there are no measures requested from PRACE members to force such a convergence, again as an indicator that scientific excellence is the main direction of PRACE.

2.4 Industrial Engagement

The PRACE-6IP project has incorporated or enhanced a number of activities to increase industrial engagement, like the SHAPE+ programme, outreach to industry and pre-competitive R&D, among others. As part of these activities, PRACE aisbl has recruited an Industrial Liaison Officer to lead the outreach programme. This section collects statistics on these activities.

2.4.1 Industrial liaison

A new go-to-market strategy has been developed and tested "on the field" at 15 European trade shows in R&D – intensive industry sectors. This has included face-to-face interaction with managers of European SMEs and has brought the 'PRACE for Industry' programme to their attention. Direct professional relationships were created and nourished afterwards with managers of 127 organisations, most of them SMEs, from 20 different countries and 13 different industrial sectors. Among them were 15 professional networks of SMEs such as e.g. associations, business clusters, etc. in the Energy, Water, Bio and Aerospace sectors.

Despite the dramatic meltdown of economic activities on the continent in Q2 / 2020 due to the COVID -19 crisis, the 'PRACE for Industry' programme has been presented in numerous channels:

- **KWR** (R&D institute of national water industry / The Netherlands) [2]
  - Presentation at HQ to entire management team in January 2020.
- **Biz-up** (Business cluster Energy, Environment / Austria) [3]
  - Promotion article was placed in monthly newsletter (reach to > 1.000 SMEs) in February 2020. A second article with focus on SHAPE – call 11 followed in April 2020.
- **VRI** (Flemish Business Cluster Aerospace / Belgium) [4]
  - E-Mail plus application form for SHAPE – call 11 was distributed internally to entire membership base of 34 SMEs in April 2020.
- **ZENIT** (Business cluster Innovation / Germany) [5]
  - Video – workshop "High-Performance Computing and Low-Energy Computing" in June 2020.

- The programmes of three EU-funded initiatives were presented to 45 SMEs: TETRAMAX is part of the European Commission's Horizon 2020 innovation agenda. Its mission is to digitize European industries through customized and low-energy computing.

The consolidated outreach effort since the beginning of the project contributed as well to the increase of industry participation in PRACE programmes:

- The SHAPE 11th Call received 10 proposals in June 2020, the highest number of proposals since the 2nd Call in early 2015. Proposals came from Belgium, UK, Slovenia, Turkey and Germany (x2) and The Netherlands (x2), along with the first ever proposals from Cyprus and Portugal.
- The 'Industry Track' of Call 21 received 7 proposals, which represents a significant increase compared to the previous two calls where the 'Industry Track' was still run as a pilot project.

Next figures summarise the geographical distribution, industrial sectors, and status of the relation with PRACE of the contacts made.

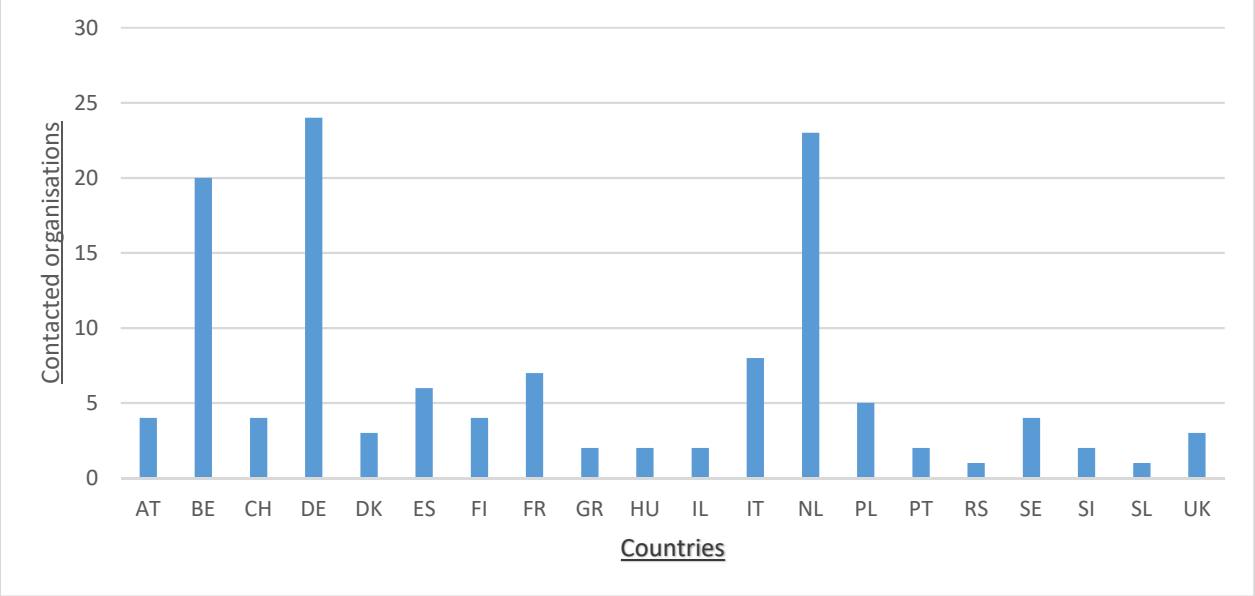

Figure 17: Countries of contacted organisations

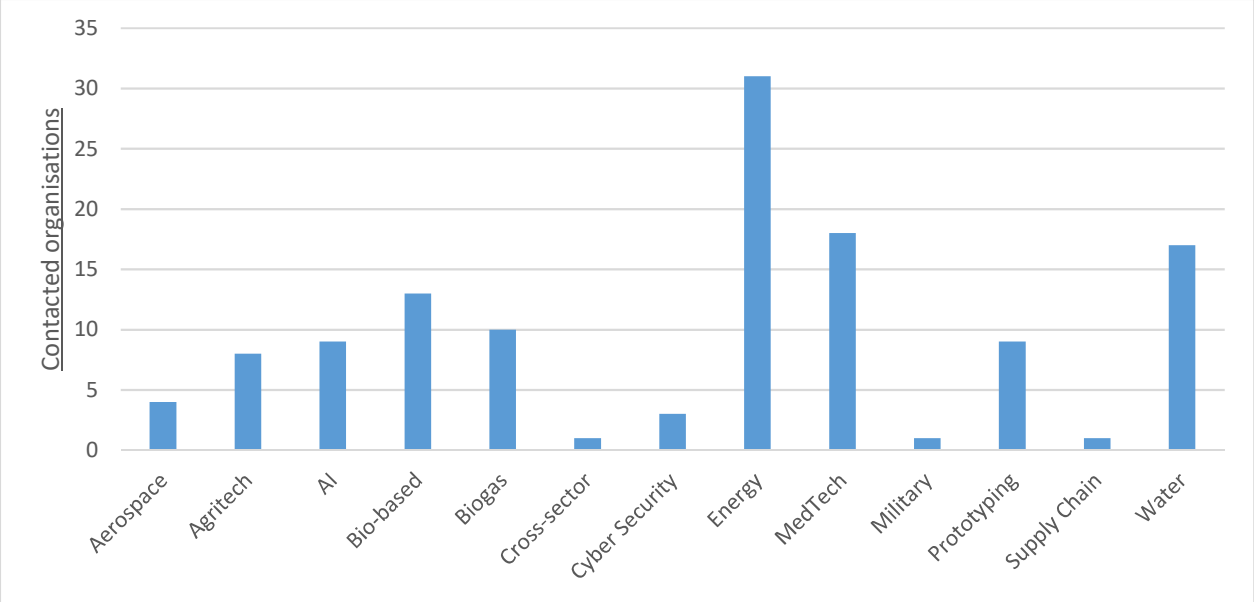

Figure 18: Industrial sectors of the contacted organisations

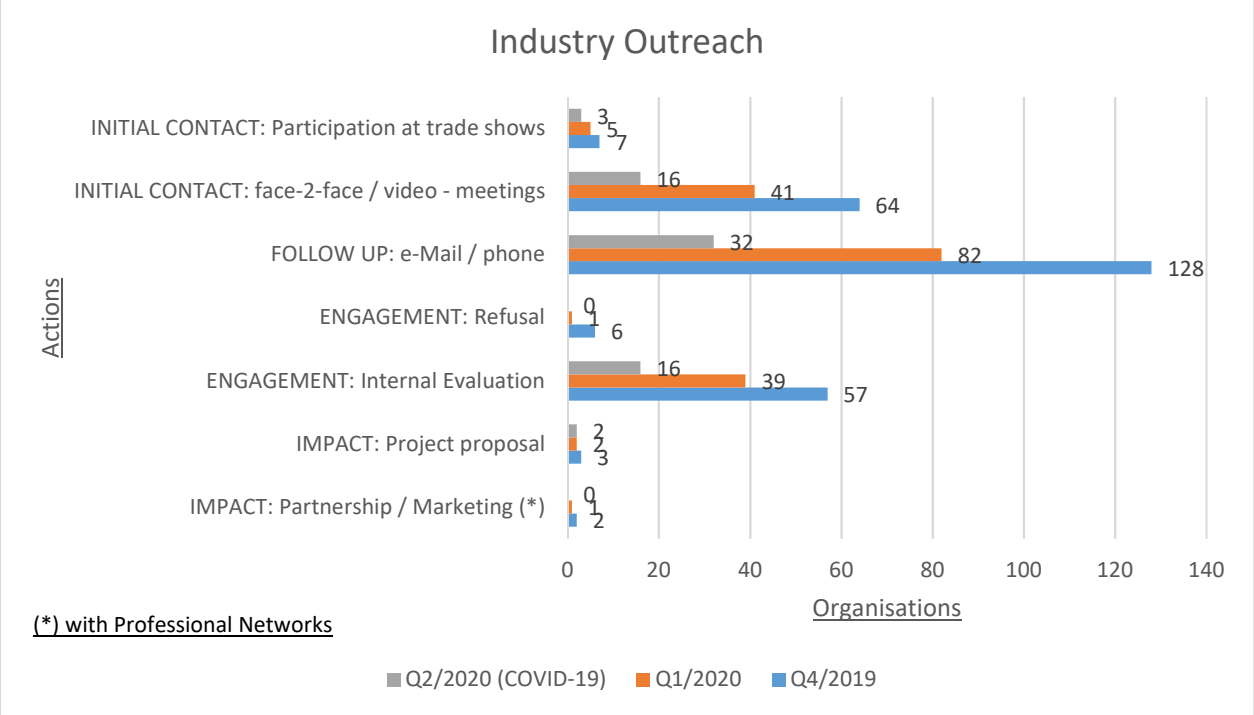

Figure 19: Level of interactions with contacted organisations

2.4.2 SHAPE Programme

Small and Medium Enterprises (SMEs) form the backbone of the European economy employing nearly 100 million people and adding over €4 trillion according to [6]. PRACE recognises the importance of SMEs and offers support to SMEs via the SME HPC Adoption Programme in Europe (SHAPE). SHAPE aims to raise awareness and provide European SMEs with the expertise necessary to take advantage of the innovation possibilities created by High-Performance Computing (HPC), thus increasing their competitiveness. Benefits to SMEs can include improvements in the quality of their products via an enhanced performance and accuracy of their models, or by reducing time to delivery, or by providing innovative new services to their customers. We recognise that there can be a number of barriers to SMEs when adopting HPC. These may include a lack of in-house expertise or a lack of available manpower, SMEs may have little or no access to suitable hardware, and an SME may be unwilling to take on the risk of committing to HPC without prior experience. Successful applicants to the SHAPE programme get support effort from a PRACE HPC expert and access to machine time at a PRACE centre. In collaboration with the SME, the PRACE partner helps them try out their ideas for utilising HPC to enhance their business. The unique pan-European network of HPC centres allows a centre to be chosen which is close to that of the SME, reducing the cultural and linguistic barriers that might otherwise exist with more remote support.

The SHAPE programme began with a pilot call in 2013 and has continued with a series of regular calls, so far supporting 55 SMEs across 15 countries within Europe. Following on from SHAPE projects, SMEs have reported tangible measurements of the Return on Investment (ROI), increased HPC skills and HPC awareness of staff, increased sales and new business, and lower operating costs. Several have continued HPC Access via in-house HPC systems or from other providers, while several have planned future engagement with other national and European industry programmes. This has been reported on in PRACE deliverables such as [7].

2.4.3 Tier-1 Industrial Access Statistics

The following table identifies, over all DECI (Distributed European Computing Initiative) calls throughout the years:

- The number of applications submitted, how many of these were accepted and how many rejected;
- The number of applications with industrial involvement submitted, how many of these were accepted and how many rejected;
    - The number of applications with an industrial Principal Investigator submitted, how many of these were accepted and how many rejected;
    - The number of applications with an industrial Collaborator submitted, how many of these were accepted and how many rejected.

DECI Call	Year	#Proposals / Accepted / Rejected	#Proposals with Industry/ Accepted / Rejected	#Proposals with Industry PI / Accepted / Rejected	#Proposals with Industry Collaborator / Accepted / Rejected
DECI-1	2005	30, 30, 0	0, 0, 0	0, 0, 0	0, 0, 0
DECI-2	2006	41, 28, 13	0, 0, 0	0, 0, 0	0, 0, 0
DECI-3	2007	62, 44, 18	0, 0, 0	0, 0, 0	0, 0, 0
DECI-3e	2007	14, 14, 0	0, 0, 0	0, 0, 0	0, 0, 0
DECI-4	2008	66, 42, 24	0, 0, 0	0, 0, 0	0, 0, 0
DECI-5	2009	75, 50, 25	1, 0, 1	1, 0, 1	0, 0, 0
DECI-6	2010	121, 56, 65	1, 0, 1	1, 0, 1	0, 0, 0
DECI-7	2011	54, 35, 19	3, 2, 1	0, 0, 0	3, 2, 1
DECI-8	2012	49, 33, 16	1, 0, 1	0, 0, 0	1, 0, 1
DECI-9	2012	45, 31, 14	2, 1, 1	1, 1, 0	1, 0, 1
DECI-10	2013	56, 37, 19	4, 3, 1	2, 2, 0	2, 1, 1
DECI-11	2013	115, 52, 63	1, 1, 0	1, 1, 0	0, 0, 0
DECI-12	2014	60, 34, 26	1, 1, 0	0, 0, 0	1, 1, 0
DECI-13	2015	114, 57, 57	2, 1, 1	1, 1, 0	1, 0, 1
DECI-14	2017	66, 40, 26	2, 1, 1	2, 1, 1	0, 0, 0
Total		**968, 583, 385**	**18, 10, 8**	**9, 6, 3**	**9, 4, 5**

Table 4: Overview of the DECI Calls

It is clear to see that the number of industrial DECI applications received is low – constituting just 2% of the total received with just over half of these being accepted. More efforts clearly need to be made to encourage DECI industrial applications.

3 Map of European HPC Systems

After a request from the EC, a ***demonstration*** webpage identifying European HPC systems on a map was developed in September 2018 and populated with systems provided by project Partners to PRACE-5IP PMO. This demo map can be found currently at http://82.116.198.186:8080/hpc-systems-map, and a screenshot of it can be seen below:

Figure 20: Screenshot of the map of European HPC systems

The map was developed using Drupal and uses a google maps overlay to geographically identify the location of HPC systems. Further to their location, the systems on the map can be filtered as to whether they are Tier-0 or Tier-1 systems, and by the Centres of Excellence (CoE) which a system may be associated. This demonstration map is updated periodically through internal calls to PRACE-IP project partners.

The map is currently under professional development, as part of the efforts of the new "HPC in Europe" platform [8]. The information will be integrated with that of the platform, which will allow to expand the usages of the map and include e.g.: a filter for HPC training events across Europe.

4 Conclusions

PRACE is nowadays an excellent European Research Infrastructure. This excellence relies on the contributions of all PRACE Members to the infrastructure, in terms of resources, expertise and work force, and on the support of the EC through the Implementation Phase projects.

The performance of the infrastructure in the provision of HPC and training services has been monitored closely, with a focus on industry. The tight link of the members of WP2 with PRACE governing bodies has enabled an exceptional alignment of objectives, allowing meaningful analysis of PRACE indicators and statistics. Deviations on the expected trends have been used to plan for corrective measures and future improvements.

A set of internal indicators, including specific PRACE 2 indicators, has been used to further confirm the capacity of PRACE to maintain scientific excellence as a main driver of its services. The results from the indicators have also served to prepare PRACE for the forthcoming EuroHPC era, with more powerful HPC systems available and a potentially wider community of users to serve.

Overall, the collection of statistics, indicators and KPIs of this deliverable provide a global overview of the status of PRACE after 10 years of the infrastructure, and contribute to prepare for the challenges that will come in the next years with the EuroHPC Joint Undertaking.