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Research Infrastructures**

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Performance Computing (HPC) service PRACE**



PRACE-1IP

PRACE First Implementation Project

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**Evolution scenarios for PRACE operational and procurement
model**

Final

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List of Acronyms and Abbreviations

AAA	Authentication, Authorisation and Accounting
AUP	Acceptable Use Policy
DEISA	Distributed European Infrastructure for Supercomputing Applications
DG	Directorate-General
EC	European Commission
EESI	European Exascale Software Initiative
ERA	European Research Area
ERC	European Research Council
ERIC	European Research Infrastructure Consortium
ESFRI	European Strategy Forum on Research Infrastructures
FP	Framework Programme
HeC	High end Computing
HPC	High Performance Computing
MB	Management Board
PRACE AISBL	PRACE Association International Sans But Lucratif

D2.2.1

Evolution scenarios for PRACE operational and procurement model

PRACE-1IP	PRACE 1st Implementation Phase Project
PRACE-2IP	PRACE 2nd Implementation Phase Project
RI	Research Infrastructure
SME	Small and Medium Enterprise
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	Supercomputers hosted by national or topical HPC centres

Executive Summary

This deliverable is the first of two deliverables on the evolution scenarios of the organisational and procurement model of the PRACE AISBL. The focus of this deliverable is on the requirements and constraints for possible evolution scenarios. We start by analysing the extreme models – Cycles and Operator model – and their advantages and disadvantages.

An analysis of the current operation of the PRACE AISBL from the point of view of its legal environment, operation and services to users and internal approaches towards an integrated service is discussed and serves as the basis for the methodology to be used for the design of suitable models for the evolution of the PRACE AISBL. This methodology consists of establishing and analysing the main requirements (strategic principles) and constraints (strategic perspectives of the main stakeholders) in order to perform a draft strategic analysis resulting in a set of directions for a model proposal.

The strategic principles discussed are:

- Capability to reach PRACE AISBL technical and scientific objectives;
- Capability to set up Governance;
- Capability of making use of available expertise;
- Capability to raise funding for long term sustainability;
- Capability to further the objectives of building the European Research Area, or supporting ESFRI projects and other main European policies (or priorities);
- Legal requirements.

The strategic perspectives of the main stakeholders are:

- Perspective of the Hosting Members or their countries;
- Perspective of the non-Hosting Members;
- Perspective of the European Commission (representing all relevant European policies whether defined by the Commission, the Council or the Parliament);
- Perspective of the main Scientific User communities;
- Perspective of the Computer Centres (involved in the operation of the PRACE AISBL);
- Perspective of the Industrial User communities;
- Perspective of other funding entities;
- Perspective of PRACE AISBL.

The draft analysis discusses the major variables which express the main driving forces influencing the possible evolution scenarios of the PRACE operational and procurement model:

- Services to be delivered by PRACE AISBL over the period 2014-2018;
- Assets of PRACE AISBL and its Members relevant to designing and delivering the services;
- Available human resources of PRACE AISBL and its Members;
- Goals and expectations of the PRACE AISBL Members;
- Goals and expectations of the user communities;
- Goals and policies of the European Union and the European commission

The conclusions drawn from the draft analysis indicate that, though the PRACE AISBL is showing very promising results, one of the major issues that need to be addressed is funding sustainability. The deliverable concludes with a reflection on some unusual possibilities that may be explored for defining the evolution scenarios for the operational and procurement model to be presented in the second deliverable due on month 18 of the PRACE-1IP project.

1 Introduction

The PRACE AISBL, created on the 23rd of April 2010, is currently being operated according to the Cycles model. The Agreement for the Initial Period, covering 2010-2014, signed by the PRACE AISBL Members made it possible to initiate the services to users. The formal creation of the PRACE AISBL was a major step for the establishment of the Pan-European HPC Research Infrastructure resulting from the effort of all PRACE AISBL Members during the Preparatory Phase of the PRACE Project.

In this document, the first of a series of two deliverables, a review of the extreme organisational models and the current model used for the PRACE AISBL is given. The requirements (strategic principles) and constraints (strategic perspectives of the main stakeholders) of the PRACE AISBL are discussed in order to produce a draft analysis for designing evolution scenarios for the future operational and procurement model of the PRACE AISBL. This analysis allows identifying the major issues faced by the current operational model of the PRACE AISBL and for proposing topics for discussion by the PRACE AISBL stakeholders to design possible evolution scenarios. This document constitutes a working document, which should be then presented to the PRACE AISBL Council as an input.

The main goal of this deliverable is to draft a work plan for the next 12 months. This includes identifying a set of key factors – called variables in the following – that will be investigated further, and the creation of a political Mirror Group. According to the discussions of this *ad-hoc* “Mirror Group”, it should be considered to update this deliverable by mid-2011.

2 Description of the Cycles and Operator models, including advantages and disadvantages

PRACE AISBL is creating a persistent pan-European high performance computing service and infrastructure. The infrastructure is to be managed by a single European entity. During the PRACE Preparatory Phase Project, a number of operational models for the PRACE AISBL were considered and discussed. The deliverables D2.2.1 (“Report on Analysis of Adequate Governance Structure”) [1] and D2.3.2 (“Usage Model Document”) [2] presented two models - Cycles and Operator model, as the extreme cases of a large range of combined operational models that have potential for implementation in the PRACE AISBL. The main difference between the Cycles and Operator models resides in the entities responsible for procurement, ownership, housing and operation of the systems within PRACE AISBL. These two models are simplified and condensed, and are only intended to help the project partners visualise the interactions and the range of parameters and options. Specific combinations of the two models depend on many external and internal factors, e.g. funding model, strategy of the PRACE AISBL members regarding EC funding and specific tools of the Framework programme, legal constraints, amount of common services, and service level of integration.

2.1 Cycles Model

The Cycles model assumes that the procurement, installation and operation of each Tier-0 system are mainly funded by the hosting state, with some level of contribution from EC and non-Hosting Members made available to the PRACE AISBL. Hosting Members contribute to the PRACE AISBL by giving cycles to the PRACE AISBL. Hosting Members may reserve a certain percentage of the full amount of each system’s cycles for their use within the hosting country resource allocation process. In this model the PRACE AISBL legal entity is responsible for performing the peer review process, managing the interoperation between the various distributed systems, managing the relationship between the Hosting Members and PRACE AISBL users (to ensure the needs of the PRACE AISBL users are met).

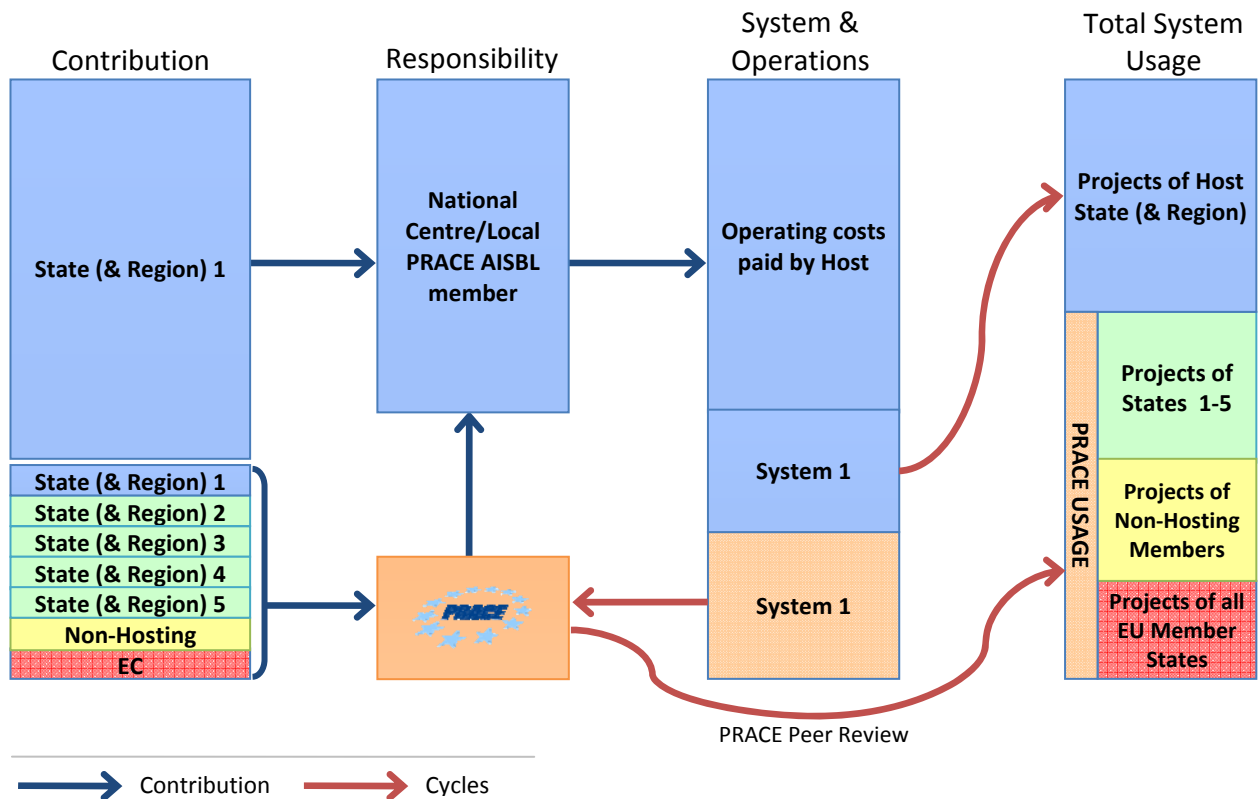


Figure 1: Cycles Model.

Advantages	Disadvantages/Risks
<ol style="list-style-type: none"> 1. Lighter governance structure. 2. Leverages already established processes, facilities and expertise at Hosting Members (e.g. procurement, operation). 3. Funding based mostly on existing relationships with national/regional bodies. So far the PRACE AISBL has secured funding commitments from four Hosting Members. 4. Good match to the PRACE AISBL legal form. 5. This model has been selected by the PRACE AISBL members as a contractual solution for the first 5 years of PRACE AISBL operation. Therefore this solution has been considered feasible and might be fully evaluated towards the end of this period. 6. It will be easy for additional Hosting Members to join the PRACE AISBL. 	<ol style="list-style-type: none"> 1. Distribution of responsibilities between the PRACE AISBL and Hosting Members adds complexity to decision making. 2. Possible conflicts of interest between Hosting Members and PRACE AISBL (e.g. different needs or expectations of local users and PRACE AISBL users). This is mitigated by the fact that all members of the PRACE AISBL need to approve the statutes and the rules for decisions by the PRACE AISBL governing bodies, in particular the procurement plan. 3. Need of rules for funding of operation and upgrades. 4. The effort of some members, mainly based on national/regional funding, may not be sufficient for giving cycles to PRACE resulting from systems of level high enough to fulfill the requirements of the PRACE AISBL .

Advantages	Disadvantages/Risks
	<p>5. The needs of PRACE AISBL may not be fully met by the systems provided by Hosting Members. E.g. PRACE AISBL may want one or two very large systems as opposed to 4 (or more) smaller ones.</p> <p>6. Analysis of funding versus usage will be necessary after some years of operation of the PRACE AISBL. This analysis may have consequences for future funding of the PRACE AISBL.</p>

Table 1: Advantages and disadvantages of the Cycles Model.

2.2 Operator Model

The Operator model assumes that the PRACE AISBL legal entity is responsible for procurement, installation and operation of each system, and also for performing the peer review process, distributed system management and management of the relationship between PRACE AISBL and the users. The infrastructure is fully managed and upgraded by PRACE AISBL based on yearly contributions from all PRACE AISBL partners and EC. The model also allows in kind contributions if agreed upon.

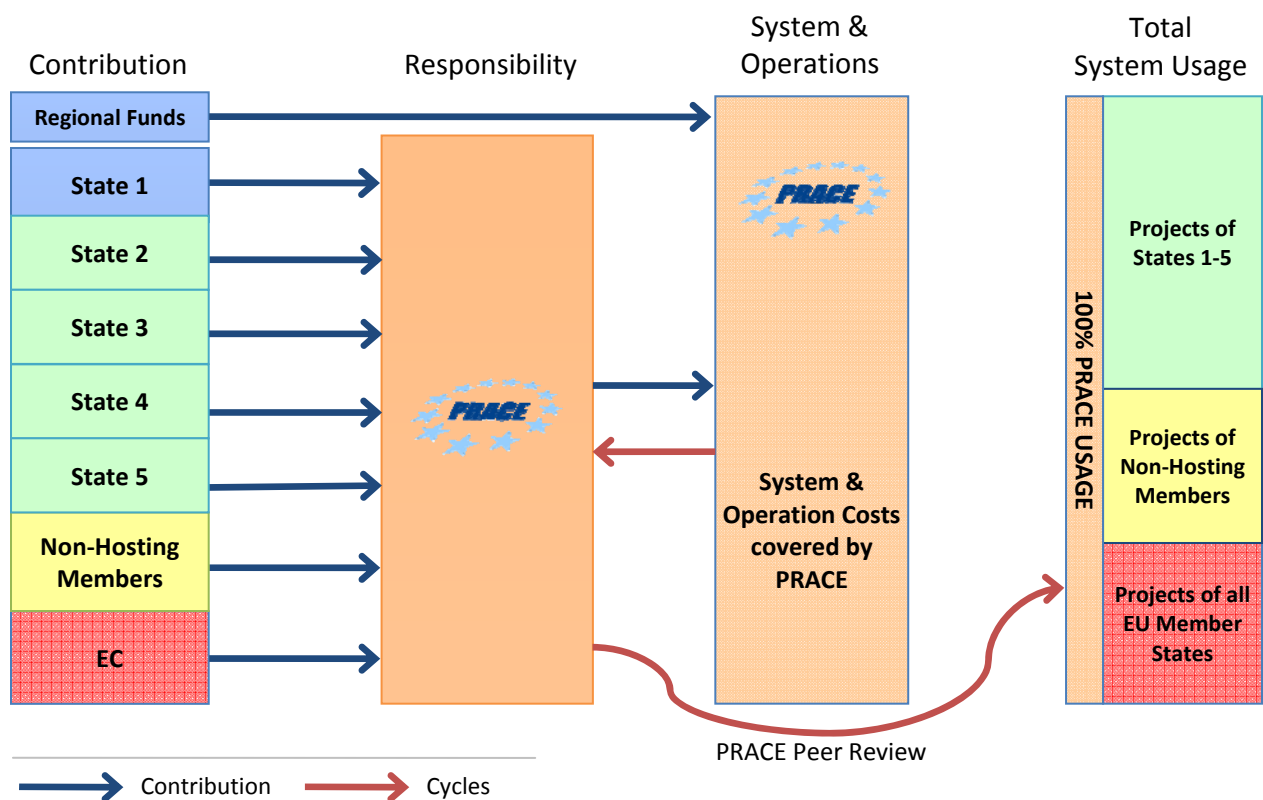


Figure 2: Operator Model.

Advantages	Disadvantages/Risks
<ol style="list-style-type: none"> 1. Clear line of authority and responsibility. 2. Simplified management of users needs (acquisition of systems with new architectures, support, training, etc.). 3. The whole systems fully available to PRACE AISBL users. 4. Joint effort of the PRACE AISBL members and EC. 5. If a Hosting Member cannot meet its commitment, there is a chance that the PRACE AISBL can change the investment of funds to ensure the goals are still delivered. 6. The PRACE budget will be committed by the funding parties on a pluriannual basis, which will ensure that the necessary funds will be available and PRACE AISBL does not have uncertainty of future funding. 7. PRACE AISBL is not seen as a series of separate members but as one single entity. 8. It will be clear that each Hosting Member is contributing the same resources. 	<ol style="list-style-type: none"> 1. Need of establishing funding procedures and strong political support to lower the risk of lack of funding - lack of proved legal form (although there are some early attempts of establishing a ERIC). Some existing funding sources might not have statutory capability to participate in a European joint funding. 2. Commitment from Hosting Members to funding a structure using such an operational model is unknown. 3. Possible heavy governance structure, especially from the point of view of the staff necessary. 4. Need of a strong political commitment of all members to engage in joint operation and procurement. 5. Need to establish new centres with skilled staff.

Table 2: Advantages and disadvantages of the Operator Model.

Remark: it is not clear that such a unified set up would not result in reduction of the total amount of funding for Tier-0 systems. Hosting Member States could consider to be less engaged with the PRACE AISBL, and only be concerned with the operation of a limited amount of Tier-0 resources at the lowest cost.

3 Description of the current PRACE AISBL operational model

During the PRACE Preparatory Phase Project, the partners analysed various operational models. After discussing the advantages and disadvantages of the Cycles and the Operator models regarding the PRACE AISBL and also the legal constraints imposed by the national laws of the member countries, a unanimous decision of creating and operating the PRACE AISBL during the first five years based on the Cycles model was reached. This decision was put forward in the form of the *Agreement for the Initial Period* signed by the PRACE AISBL members (Hosting and non-Hosting Members). This agreement allowed the creation of the PRACE AISBL with the seat in Brussels, Belgium and made it possible to start up the services of the PRACE AISBL to European researchers in the course of 2010.

The Cycles model is expected to regulate the PRACE AISBL for the first five years. In this model, as referred to previously, the Hosting Members are responsible for funding, procurement, installation and management of the Tier-0 computer systems. Apart from national legal constraints, one of the reasons for choosing this model comes from pre-existing agreements between organisations of some member countries regarding funding, installation and management and also from some degree of funding uncertainty, which could jeopardise the sustainability of the PRACE AISBL under other operational models.

At the same time, regarding other issues, the Statutes of the PRACE AISBL, supplemented by the Contributors Agreement allow for an integrated vision (thereby taking into account stakeholders preferences) of the PRACE AISBL. Examples are the single European peer review process that regulates users' access to the PRACE AISBL resources, dissemination and training activities, support for code development, common procurement strategies, etc.

3.1 PRACE legal environment

On February 15, 2010 the Management Board of the PRACE Preparatory Phase Project unanimously decided to establish a temporary PRACE legal entity as an international non-profit association under Belgian law named Partnership for Advanced Computing AISBL (AISBL: Association International Sans But Lucratif) with its seat in Brussels. On October 5, 2010 the PRACE AISBL Council decided to keep Brussels, Belgium for the definitive seat of the PRACE AISBL. The necessary deeds have been signed in Brussels on April 23, 2010 in the presence of a public notary. Publication of the PRACE AISBL statutes in the Annex des Moniteurs Belges under registration number 826.890059 took place and the King (via the Ministry of Justice) signed the documents establishing the PRACE AISBL.

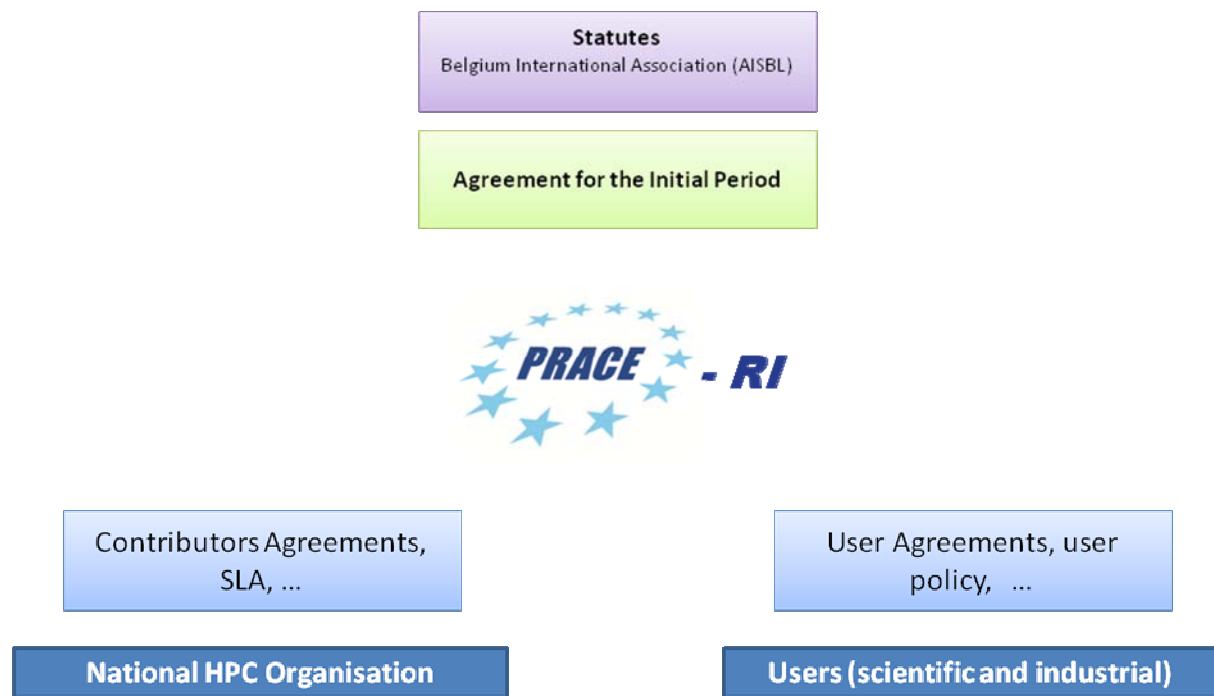


Figure 3: Legal Structure of PRACE AISBL

The set of legal documents of PRACE AISBL consists of the Statutes, the Agreement for the Initial Period, and the Contributors and the Users Agreement.

The **Statutes** describe the internal organisation and functioning of the PRACE AISBL including the composition of the council, and committees and the provisions required by Belgium law. The statutes have been signed by the authorised national HPC coordinating bodies of the member countries. The official French Version and the English translation can be found in the updated version of deliverable 2.1.3 of the Preparatory Phase project. [3].

The **Agreement for the Initial Period** sets up the operation rules of the PRACE AISBL for the first five years and permitted services to start in 2010. This agreement has made possible to obtain funding commitments enabling to create PRACE AISBL and start its operation using the Cycles model for the initial period. The PRACE AISBL headquarters will be fairly small and have a coordinating role during this period. PRACE AISBL will probably not receive significant cash contributions and the Tier-0 systems will be procured mainly or wholly by the Hosting Members. The agreement ensures that these national procurements are coordinated especially in terms of acquisition/upgrading, timing and types of architecture, and that a significant portion of the cycles of each Tier-0 system (adding to a total value of 100 Million € over five years for each Hosting Member) is given over to the PRACE AISBL and made accessible to users through the PRACE AISBL peer review. This constitutes the general strategic plan for the initial period, which will cover the first round of procurements of the HeC equipment of the PRACE AISBL. This agreement is kept separate from the Statutes because it has been found important to allow the PRACE AISBL to adapt to the possible evolution of the requirements for fielding a competitive HPC infrastructure. This may, in turn, necessitate adapting over time the operational model regarding some of its operational aspects, and it would not be appropriate for the Statutes to include articles on this initial period, making them in effect more permanent (or final).

The **Contributors Agreement** regulates the relation between the PRACE AISBL and each Hosting Member. It specifies the rights and duties of the Hosting Member and PRACE AISBL. Very specific provisions of the Tier-0 contribution to PRACE AISBL with detailed technical descriptions are part of this agreement. Each Hosting Member has to sign the Contributors Agreement with PRACE AISBL.

The **Users Agreement** is the agreement between the PRACE AISBL Users and PRACE AISBL. It regulates the usage of Tier-0 resources by the PRACE AISBL User, specifies the rights and duties of both parties. It also regulates IPR (Intellectual Property Rights) and the necessary user acknowledgements to PRACE AISBL and the Contributor(s) (Hosting Members). The amount of CPU hours made available to users and the corresponding allocation time as well as the acceptable use policy (AUP) are also an integral part of the Users' Agreement.

3.2 Operation and services to users

The PRACE AISBL is responsible for the implementation and operation of the services agreed upon among the members. These services are documented in deliverables of WP4 of the PRACE Preparatory Phase Project: D4.3 for the services needed for the distributed systems management of the future PRACE Tier-0 production environment [4] and D4.1.4 for the integration of the European Tier-1 HPC ecosystem [5]. These services include network provision, data services, compute/workflow services, AAA (Authentication, Authorisation and Accounting) services and user services and are essential for the users of the PRACE AISBL compute resources. The PRACE AISBL in its present form assigns responsibilities for specific infrastructure services to the PRACE AISBL Members.

Changes in the PRACE AISBL services like software upgrades, hardware upgrades, new services come under the responsibility of the PRACE AISBL operational teams. These changes must be accepted by the Hosting Members involved in the change or experiencing the consequences of the change. In general these changes must not disturb or have negative consequences for the service offered on the part of the computer systems dedicated to the national users. Also the security impact of a change must be reviewed and accepted. It is necessary to implement a technical operation model to accommodate any possible conflicts of

interests on systems which support both PRACE AISBL and national services. This model may also depend on the operational model for the PRACE AISBL.

Since the Hosting Members (or the technical organisation they delegate to) are responsible for proper and secure operation of the PRACE AISBL services, it is quite natural that they have the right to approve the services and their software implementation.

PRACE AISBL services for users like a helpdesk (with a trouble ticket system), monitoring, documentation, and enabling support will be operated as an integrated service, with support from the PRACE AISBL and the implementation projects:

- A common helpdesk with one single entry point will be operated and managed by all PRACE members who provide services;
- Monitoring information on available products and services will be provided from a common interface ;
- Users are offered a common interface to all sites using the Common Production Environment. Nevertheless differences between sites may always exist, e.g. a certain program library may not be available on a certain architecture or system;
- Usage information is provided through a common interface;
- Direct user support for user start up and enabling support is provided through staff from all members; e.g. a user from country A running jobs in country B can get support from staff from countries A, B, C, etc.

3.3 PRACE AISBL internal approaches towards an integrated service

The PRACE AISBL is at present working according to the cycles model as agreed by the members who signed the Agreement for the Initial Period covering the first 5 years.

In the Cycles model the Hosting Members are responsible for the procurement, acquisition, management and ownership of the supercomputing systems and provide computing cycles to PRACE AISBL. It is important to point out that though in the Cycles model each Hosting Member is ultimately responsible for the computer resources, the PRACE AISBL in many others aspects works in an integrated way and is viewed by most stakeholders as a real Pan-European Research Infrastructure. This is due to the fact that all PRACE AISBL members have consolidated a working methodology leading to integration of the services made available through the PRACE AISBL.

Examples of these services are:

1. **PRACE AISBL website portal.** The PRACE AISBL website portal includes information on the main goals of PRACE AISBL, all activities promoted by PRACE AISBL and by the PRACE Project (training activities, dissemination activities (presentations at conferences, booths at conferences), PRACE workshops and seminars, etc.), user documentation, all public deliverables produced during the PRACE Preparatory Phase Project, information about calls for access to the PRACE AISBL resources, information related to the PRACE AISBL peer review process, information on the projects supported by PRACE AISBL, etc.
2. **PRACE AISBL calls and PRACE AISBL European peer review.** Users can access the PRACE AISBL resources, i.e. the computing cycles given to the PRACE AISBL by the Hosting Members, through the PRACE AISBL calls. The PRACE AISBL has implemented a single European peer review process based on the technical and scientific review of all proposals for access to the PRACE AISBL resources. A large pool of recognised European researchers is responsible for the scientific peer review of all

proposals. The PRACE AISBL peer review is supported by a tool developed specifically for the PRACE AISBL peer review. All information for users, including information on the PRACE AISBL calls, on the peer review process, on how to apply to PRACE AISBL resources and on the projects awarded in each call are published in the PRACE AISBL website. Reports of the projects awarded are also to be included in the PRACE AISBL website.

3. **Dissemination activities.** The PRACE AISBL with funding via the PRACE implementation phase projects organises regular seminars and symposia to create awareness of the PRACE AISBL activities. Important examples of such activities are the PRACE Industry Seminar, the DEISA-PRACE symposium and the user forum (due to be launched in 2011). The stakeholders attending these meetings include scientific researchers, potential industrial users, CIOs of SMEs and large industrial companies, hardware and software developers and vendors, representatives from national and European funding agencies, etc.
4. **Support for code development.** Parallel to the peer reviewed calls for project access, the PRACE AISBL also provides, initially funded through the PRACE projects, expert support for code development, and scalability testing of existing codes. The PRACE AISBL has specific calls, open all year round, dedicated to different types of user support (mainly scalability testing and code development) provided by experts of different countries involved in the PRACE Project.
5. **Procurement and benchmarking.** The PRACE Preparatory Phase Project has created a benchmark suite, consisting of representative codes used in a variety of scientific fields, to be used for future procurement of supercomputer systems. The PRACE AISBL is also collecting best practices and standard procedures to facilitate the procurement of new supercomputer systems.
6. **Training activities.** The PRACE AISBL, again with funding from the PRACE implementation phase projects, organises technical workshops and schools to foster usage of HPC and to train potential new users for usage of the present and future PRACE AISBL supercomputer systems. Besides workshops dedicated to specific HPC issues, the PRACE Project organises 4 training schools per year covering advanced programming, computer architectures, techniques for performance improvement, etc.
7. **Software and hardware survey.** The PRACE AISBL, with funding from the PRACE implementation phase projects, also promotes contacts with software and hardware developers and vendors so as to survey new supercomputer architectures, new hardware components and subsystems (e.g. processors, memory network, etc.), new programming languages and development tool (e.g. compilers, debuggers, etc.), that is all the elements to be used in future supercomputing systems.

All these integration efforts will be pursued in the PRACE AISBL, with the inputs of the PRACE implementation phase projects, in order to fully support the needs of the users of the PRACE AISBL.

4 Analysis of possible evolution scenarios of the PRACE AISBL operational model, towards a more integrated model

In order to design suitable models for the evolution of the PRACE AISBL operational model, WP2 has selected a methodology which consists of establishing first requirements and then constraints. For the purpose of clarity, these are structured as follows:

- a) *Strategic principles for the evolution of the operational model.* These strategic principles stem from the strategic analysis of the mission and vision of PRACE AISBL¹, the operational models described in paragraph 2 above, taking into account particularly the “Advantage/Disadvantage” tables and from the experience gained from the operation of the PRACE AISBL with the Cycles Model. In our definition strategic principles, are principles describing the general and long term collective vision² of the Members concerning the operation of the PRACE AISBL.
- b) *Strategic perspective of the main stakeholders.* It describes the strategic perspective of the stakeholders which are essential for the continued operation and success of the PRACE AISBL. Here we consider the perspective of each of these stakeholders.

Based on this information we then proceed towards performing a Draft Strategic Synthesis, resulting in a first set of directions for a model proposal. This needs to be considered as a draft since many issues need to be worked upon and feedback needs to be gathered from the PRACE AISBL members in order to prepare the deliverable scheduled at Month 18 (D2.2.4 “PRACE operational and procurement model: Analysis of the evolution of the operational and procurement model”).

It should be remembered that the mentioned deliverable may involve some compromise between conflicting considerations. In order to perfect the deliverable at month 18 and to create a suitable framework towards reaching a political commitment for future possible operational models, a work plan has been agreed by the PRACE-1IP Project MB. This involves the appointment of a political Mirror Group to advise and provide feedback along the process for defining the evolution of the operational and procurement framework of the PRACE AISBL beyond the first five year period. Such a group could favour the design and acceptance of a specific operational model for the PRACE AISBL. This group may consult with major stakeholders, including representatives of the EC. The advice of the Mirror Group will be analysed by the PRACE-1IP Project MB before being presented to the PRACE AISBL Council for discussion and possible approval.

4.1 Strategic principles for the evolution of the operational model

This subsection contains an analysis of section 2 “Description of the cycles and operator models”, in order to set up and clarify the Strategic Principles which express the long term collective vision of PRACE AISBL Members concerning the operation of PRACE AISBL. These Strategic Principles are:

¹ The mission of the Partnership for Advanced Computing in Europe (PRACE) is to contribute to the advancement of European competitiveness in industry and research through the provision of a world-leading persistent high-end HPC infrastructure, which includes related support.

The vision of the Partnership for Advanced Computing in Europe (PRACE) is to fully support Europe in attaining global leadership in public and private research and development.

² Therefore expressed by the PRACE AISBL bodies: the Council and/or the Board of Directors.

a) Capability to reach PRACE AISBL technical and scientific objectives

This strategic principle stems from the mission and vision of PRACE AISBL as a world-class pan-European High Performance Computing service for all European researchers. The main goal of the PRACE AISBL is to make state-of-the-art HPC resources available to European researchers from academia and industry for promoting the best science in Europe and its economic impact.

The following sub-goals may be described more precisely:

1. Shared technical roadmap for supercomputers deployment in Europe, ensuring the complementarity of resources and their capacity to fulfil scientific and industrial requirements. Such a technical roadmap should adapt to technology evolution and availability and manage the procurement and technical risks. It should be used as a communication medium towards the user communities enabling them to prepare relevant advanced simulation codes for these new systems.
2. One of the goals is that the PRACE AISBL must provide leading world class resources. This definition must be rendered enforceable by maintaining an agreement between the PRACE AISBL Members regarding:
 - a. the level of performance which pertains to this category;
 - b. the time span of validity during which a particular supercomputer or supercomputer design is a valid candidate for acquisition and fielding;
 - c. the required number of such supercomputers.
3. High quality single process for resource allocation based on scientific merit. This process should accommodate scientific innovation, emerging disciplines, industrial applications based on a single and robust European peer review process as defined in the deliverable D2.4.2 – Final Report on the Peer Review Process of the PRACE Preparatory Phase Project [6].
4. Accessing future innovative technologies and most relevant equipment necessitates to keep several channels to industry suppliers active.
5. Due to the high costs of the computing centres equipment, it is necessary to optimise with regards to several criteria:
 - a. investment in facilities and training of technical personnel,
 - b. design and iterative improvement of green low power consumption facilities,
 - c. architecture choice, etc.
6. High quality service to the users including training, application support and developments, benchmarking of new programming techniques, etc.

As PRACE AISBL embarks on dealing also with some aspects of Tier-1 networking, interoperations and insertion in a seamless e-infrastructure, similar issues will need to be considered regarding Tier-1 and the technical interoperations between Tier-1 and Tier-0.

b) Capability to set up Governance

Another important strategic principle is the capability to set up Governance, i.e. PRACE AISBL will need to coordinate the contributions of the its members and will have to be able to decide on the general policy for governing the association. In general, flattening the organization and developing horizontal connections or simply eliminating layers of middle management are some of the steps that improve communication and decision making. The present PRACE AISBL follows this general rule and has a very light organisation with a flexible communication and decision making process. Regarding this strategic principle, the PRACE AISBL may use the Cycles or the Operation model, or even intermediate models. It should be pointed out that the Cycles model requires a lighter organisation structure in terms

of staff, because some tasks can be outsourced to the members. The important issue being that PRACE AISBL must have a coordinating Governance in order to be able to fulfil its mission and vision.

The governance scheme must express the interest of a set of major stakeholders:

1. All participating members.
2. Hosting Members which may have made funding commitments as well as large investment in facilities, personnel, housing, etc. in order to accommodate PRACE AISBL Tier-0 systems.
3. Scientific communities which are represented through the PRACE AISBL Scientific Steering Committee.
4. Funding entities, notably national/regional and European.

c) Capability of making use of available expertise

Capability of making use of available expertise is very important for the success of the PRACE AISBL strategy:

1. PRACE AISBL should profit from being a Pan-European RI, with a large number of members, and as such should profit from key expertise available in the various member countries. This expertise is available through all PRACE AISBL member organisations and networks.
2. Also, the Hosting Members are contributing key expertise in deploying and operating world class systems. The operation of PRACE Tier-0 centres and equipment will permit to further develop skills and hands on experience. It is deemed important to adopt an operation principle that will permit to capitalise on such knowledge and experience.
3. PRACE AISBL also builds upon external projects or interest groups, notably STRATOS concerning future technologies. PRACE also has connections with several FP7 funded projects such as EESI which aims at creating an European exascale roadmap.
4. PRACE is building links with international HPC groups such as INCITE, TeraGrid, etc.

A set of factors dealing with Human resources will be essential, regarding especially:

1. Local employment of specialists in a computer centre belonging to a different organisation of the same country;
2. Mobility resulting of employment of specialists in a computer centre belonging to an organisation of a different country;
3. Highly mobile scientists who need nevertheless to spend an extensive period of time at a site different from their home organisation. The mobility patterns may show quite frequent travel;
4. Careers of young researchers specializing in HPC.

While these issues are complex, the success of a site may ultimately depend on the quality of the personnel it can recruit. Success of cooperation may also depend in some cases on the possible mobility of key personnel between sites of different cooperating partners.

d) Capability to raise funding for long term sustainable operations

This is one of the most critical strategic principles. At present funding comes mainly from the Hosting Members, and their contributions are key to ensuring the feasibility of PRACE AISBL.

Several criteria need to be considered:

1. It is critical that all PRACE AISBL members highly value the European access to a world-class HPC infrastructure through a single peer review process. Furthermore, a sustainable approach and long-term commitment is needed since HPC modelling and simulation need a long term vision and sustainable availability to researchers. For instance development of a competitive simulation application may require five to ten years and this can only be justified if the expected scientific exploitation lasts for a similar time window.
2. Concerning the Hosting Members, their acceptance of sharing the major part of the funding may result:
 - a. of their commitment to developing the ERA,
 - b. of their considerations of the worldwide scientific competition notably with regards to USA, China, etc.,
 - c. of their expected return in terms of national scientific excellence and industrial competitiveness. Moreover, the Hosting Members permit the PRACE AISBL to benefit from some level of mutualisation of the infrastructure (buildings, facilities, network, services) allocated to PRACE AISBL.
3. Non-Hosting Members benefit from access to the shared infrastructure, their expertise and know-how.
4. All members of PRACE AISBL will expect return on investment in terms of Intellectual Property (development of new world class application codes) and the ability to recruit and train highly skilled scientific and technical personnel. Access to PRACE AISBL resources may give a competitive advantage to cooperative projects using simulation.

We need also to consider the key factors which motivate the EC to fund the project:

- Development of the ERA by providing world class HPC resources to the European scientific communities;
- Development of the European competitiveness and its societal impact;
- Support the EC Framework Programme objectives by providing access to key funded projects;
- Improve competitiveness of key pan-European RIs which can rely on the PRACE AISBL resources;
- European participation in world level scientific networks and cooperation;
- Support of world-class scientific research across Europe via a robust peer review process.

Various issues may also influence the motivation of funding members:

- Balance within members in terms of funding level, voting rights in the governance, members of scientific or technical bodies, etc.
- Capacity of funding members to commit: this may be dependent on national budgetary rules (for instance the budget is decided annually in some countries). In general, long-term funding commitments may be made in intergovernmental agreements.

- Substantial support from the EC may also facilitate the national decisions regarding funding of the PRACE AISBL by helping national policy makers of these funding countries to recognise the value of the PRACE AISBL for the European development and for minimising the economic differences between European countries.
- EC funding for HPC should be directed to the PRACE AISBL and not to specific projects, otherwise the PRACE AISBL can be faced with multiple peer review processes with different criteria. This may compromise the PRACE AISBL mission of promoting the best science in Europe and may create some frustration between the PRACE AISBL users. The selection of funding mechanisms for the EC (direct funding or project related) should be discussed with the EC, preferably under the auspices of the PRACE AISBL Council.

Involvement of several EC research programmes for PRACE AISBL funding is also important to create a common research policy for Europe covering all scientific fields that cannot achieve their present and future goals without the HPC resources made available by PRACE AISBL. This may imply a bundling of funding efforts from various directorates inside the EC for covering scientific fields as diverse as Economics, Fundamental Physics, Chemistry, Material Science, Medicine and Life Sciences and even Humanistic and Social Sciences.

Care must be taken when proposing evolution of the funding scheme:

- Unless other sources are available, it is important to maintain the commitment of the Hosting Members to fund the PRACE AISBL, and therefore address their requirements.
- When looking at EC funding, it is required to keep in mind that most likely EC will only accept to fund a fraction of the costs, and therefore PRACE AISBL members (and/or Hosting Members) will be called upon to complete the round of funding. Here too, the requirements of all funding entities must be kept in mind.
- EU funding comes from European Members. Both this and the Hosting Member contributions are in danger of being affected by the current downturn in the economic climate.
- Some marginal funding can be contributed to the PRACE AISBL by its own activities (e.g. training). This funding may help to cover for the running costs of the PRACE AISBL organisation, but cannot be considered as a major source of income.

e) Capability to further support the objectives of building the European Research Area, or supporting ESFRI projects and other main European Policies or Priorities

Another important strategic principle is the support of PRACE AISBL to the objectives of building the European Research Area and supporting other main European research projects and/or future policy decisions for European research. At present the PRACE AISBL receives advice from the Scientific Steering Committee, formed by prominent European scientists from various countries and covering all fields of science, regarding the access to the PRACE AISBL resources. Once again it is important that this advice is directed to a single organisation with a full pan-European character – the PRACE AISBL – instead of being spread through various committees and organisations that in some cases may issue contradictory advice on European research priorities.

f) Legal requirements

Legal requirements, mainly regarding the management of PRACE AISBL funding (either from member countries and/or the EC) need to consider a common strategy for taxation and exchange of funding and services between the member countries. This strategic principle

results from the distributed character of the PRACE AISBL, with supercomputers distributed through various countries and the possibility of various countries contributing with their expertise to the various services provided by PRACE AISBL. The full set of PRACE AISBL services (not only supercomputing access, but also training and user support, testing of new architectures in prototype systems, etc.) implies a distributed model for acquisitions and exchange of services between PRACE AISBL members and between the PRACE AISBL and its members. This model does not exist yet and its implementation will request an agreement between the PRACE AISBL members. Here once again, the EC can have an important role to create the suitable regulations and possibly the legal framework to permit the necessary legal agreements between the member countries of PRACE AISBL.

4.2 Strategic perspectives of the main stakeholders

This subsection describes the Strategic perspective of the main stakeholders, inasmuch as the selection of an operational model is relevant for their decision of participating in the PRACE AISBL or allocating funding commitments to the PRACE AISBL.

a) Perspective of the Hosting Members or of their countries

So far the Hosting Members are responsible for the largest part of the PRACE AISBL funding. In the Agreement for the Initial Period it was decided that the Tier-0 machines already (or to be) installed in the countries of the Hosting Members, will give part or totality of the cycles of the machine to PRACE AISBL. Any remaining cycles can be used as a national resource. This model is almost completely based on funding from national and/or local organisations of the countries of the Hosting Members.

If difficulties in soliciting funding arise in the hosting countries, or if a sufficient number of hosting countries cannot be found, PRACE AISBL funding may be compromised. Concerning the Hosting Members' investments in the PRACE AISBL, the following should be considered:

- Investment in facilities which would normally be paid back over several procurement cycles: building, facilities, electrical supply.
- Investment in human resources including training and team building.

Hosting Members may also use various indicators to assess their success in using the PRACE AISBL facilities including number of allocations, value of the allocated computing time, number of publications or patents, scientific and economic impact, etc.

b) Perspective of the Non-Hosting Members

The contribution of non-Hosting Members to PRACE AISBL funding is currently somewhat limited and covers mainly the costs for running the organisation of PRACE AISBL and their contributions to the implementation phase projects, without any direct contribution of compute cycles. This reduced funding is also reflected in the voting rights of the non-Hosting Members in the PRACE AISBL Council and may be seen from the point of view of non-Hosting Members as a limitation of their influence on the Governance of PRACE AISBL. Non-Hosting Members may see the EC contribution to PRACE AISBL funding as common European funding and as having their own share on the EC contribution through the global contributions of their country to EC. Their capability to match the funding to cover their part of the operation must be investigated, including their possible monetary contribution. It is also important to make sure that non-Hosting Members do not see PRACE as being entirely managed by the Hosting Members. Although, it must be recognised that due to their high level of investment, Hosting Members should have more influence, there is a need to keep

non-Hosting Members engaged in order to have a fully European organisation. This will be a challenge for PRACE Council and the PRACE projects' Management Boards to ensure.

The non-Hosting Members may also value:

- their participation in a world-class RI and the possible gain in expertise and know-how;
- the possibility to value their expertise and know-how;
- access for their own researchers to a world-class HPC infrastructure.

c) Perspective of the European Commission (representing all relevant European policies whether defined by the Commission, the Council or the Parliament)

The EC has a major interest in the PRACE AISBL, because almost all scientific fields need top-class computer resources to solve the most challenging problems. The EC has so far supported the implementation of PRACE AISBL through funded FP7 projects. It has not yet decided on its possible direct contribution to the funding of the PRACE AISBL, and therefore on a participation to the acquisition and operation of computing resources made available to users through the PRACE AISBL. Nevertheless, this situation shows the recognition of the importance of PRACE AISBL for European research but does not match the expectation of the EC regarding PRACE AISBL support to the ERA program, other ESFRI initiatives and European research in general. This support of the ERA rests mostly on the funding by the Hosting Members.

Long-term EC funding for PRACE AISBL will make sustainability more independent of the policy decisions of the Hosting Member countries and will somehow alleviate the funding responsibilities of the Hosting Member countries not only for their national researchers but also for all European researchers. EC funding can be also seen as direct European interest in the success of the PRACE AISBL and may facilitate funding from present and possible new Hosting Members.

However, if EC funding does only cover a fraction of costs, for instance in agreement with current practice in the Framework Programme, the matching funds by PRACE AISBL members or Hosting Members still need to be considered, together with the requirements of these parties.

Under FP7 Capacities programme, the EC has developed a specific scheme to support the use and the development of the best research infrastructures existing in Europe and also to help the creation of new research infrastructure of pan-European interest. The European scientific community needs these tools to stay at the forefront of the advancement of science. Industry can also benefit from these European infrastructures by strengthening its base of knowledge and technological know-how.

Furthermore, Europe has taken a major step forward in the development of a more coordinated approach for policy-making in the field of research infrastructure with the establishment of the European Strategy Forum on Research Infrastructure (ESFRI) in 2002. ESFRI releases a first roadmap in 2006, identifying 35 new research infrastructures or major upgrades of existing ones of pan-European interest. This list has been updated in December 2008 with the identification of a set of 10 additional research infrastructures to be developed by 2015-2020. ESFRI will follow the implementation of the roadmap by providing regular reports.

Different types of projects are being funded through the Capacities programme: support to existing research infrastructures, support to new research infrastructure and accompanying measures. It has to be noted that for the support for existing infrastructures, EC funding is

limited to 10% of the total running cost of the research infrastructure. An exception is GEANT, for which a continuous project funding scheme is used to allow for an EC contribution of 50% of the running costs.

d) Perspective of the main Scientific User communities

The user communities are not very much aware of the organisational model of PRACE AISBL, and do not need to be, but since the first PRACE AISBL services were made available to them, there has been an enormous demand of PRACE AISBL Tier-0 resources. There is a danger that the user communities will begin to assume that availability of these resources is not only a certainty but the resources will increase according with their demand. This assumption is not correct because the sustainability issues are not yet solved and the resources may not grow at the same pace as the demand of the user communities.

One other issue to be addressed by the PRACE AISBL Council should be to investigate the expectations of the European scientific community concerning the desirable level of support by the PRACE AISBL for FP7 funding projects. This is quite independent of the operational model, since this relates either to the funding model or the scientific evaluation. Further elaboration on this topic could be initiated by the PRACE AISBL Council if it is so decided.

The funding and therefore the capacity of the PRACE AISBL resources relative to user demand raise policy issues for the PRACE AISBL and its funding members. Such long-term funding policy has not been decided by the PRACE AISBL Council at this point in time. It is anticipated that the success of PRACE will result in a large demand by scientific users and as a consequence a robust and highly selective peer-review process based on scientific excellence is necessary.

This is not a specific problem for Europe, but also of other countries such as USA, Japan, China and South Korea, where nevertheless long-term sustainability seems at present to be more settled than in Europe. If the sustainability issues of PRACE are not solved, the user community may see their expectations for the near future being not completely fulfilled. If this is the case, Europe will see their research suffer from lack of top-level compute resources and there is a strong risk that the most prominent European researchers will move to countries outside Europe.

Because of the limited PRACE AISBL resources available to researchers, it is essential that the PRACE AISBL peer review process is seen by the scientific community to be fair, transparent and robust.

Scientific users may also expect some interoperability between the various layers of HPC capability, especially between different Tier-0 and between Tier0 and Tier-1 resources. This type of interoperability is being addressed in the framework of the PRACE implementation phase projects and may need to be taken into account in future operational models of the PRACE AISBL.

e) Perspective of the Computer Centres involved in the operation of PRACE AISBL

The computer centres involved in the operation of computer resources of the PRACE AISBL may also suffer from lack of funding. A long-term perspective for PRACE AISBL will be important to keep the know-how in the computer centres and also to attract new hardware and software experts. At present, the computer centres may see a small horizon for their future perspectives, especially if no upgrades and/or acquisition of new machines are planned.

This is where the engagement of non-Hosting Members could become more important as the expertise in their national computing centres could be utilised in building a wide network of experts in hardware and software.

There is an additional interest from Hosting Members who contribute their own centres to PRACE as part of their relationship with PRACE AISBL.

f) Perspective of the Industrial User communities

At present, industrial users are only able to access PRACE AISBL resources through collaborations with academia. This preliminary access is giving the opportunity to industrial users to become familiar with the possibilities opened up by PRACE AISBL and to plan how to interact with PRACE AISBL. On the other side, PRACE AISBL is developing specific models for access to industry, taking into account their specific needs such as security, IPR rights, etc. Like the other user communities, industrial user communities have also high expectations from the possibility of using the PRACE AISBL resources.

Industrial communities may have a secondary effect on PRACE AISBL in that the areas where they are exploiting research often leads to a drive to develop certain areas. Therefore, even though industry itself may not be leading PRACE AISBL projects, it may be driving the priority areas of the PRACE AISBL.

g) Perspective of other funding entities

To complement national and European funding for ensuring PRACE AISBL sustainability and their own possibility of using the PRACE AISBL resources, other funding entities, such as other EC funded projects, DG – Research, industrial funding, regional funding may show an interest in participating in the PRACE AISBL Governance and funding. In such a case, further studies of their motivation and requirements need to be done. Evolving from this situation towards accepting complementary funding sources would need a decision of the PRACE AISBL Council, and the completion of successful negotiations.

h) Perspective of PRACE AISBL

The PRACE AISBL is a legal entity with the mission of making top-class compute resources available to all European researchers. The PRACE AISBL organisation is based on this mission and the PRACE AISBL Council with representatives from all members is in charge of fulfilling this mission. The PRACE AISBL aims to represent the common interests of all its members and whilst fulfilling its mission and vision, and also its own interests as a European RI: image, credibility, long term sustainability, strong relationships with users and suppliers, fulfilling legal agreements and legal responsibilities, etc.

The different types of organisation of the members including computing centres, national funding agencies and Government bodies, leads to a wide range of expertise and interests which can be exploited to provide the best expertise for the PRACE AISBL.

4.3 Draft synthesis

We shall now expose the major variables which express the main driving forces influencing the possible evolution of the PRACE AISBL operational and procurement model. Once the possible trends for each of these variables is well understood, we will be able to proceed towards extracting a small set of possible scenarios which would attempt to map the entire area of possible evolutions for the PRACE AISBL. This would be followed by the detailed analysis of these scenarios, thus giving the basis for a decision process to be performed by the PRACE AISBL Council.

The WP2 work plan foresees that the analysis of the scenarios will be the major subject of Deliverable D2.2.4 “PRACE operational and procurement model: analysis of the evolution of the operational and procurement model”, to be completed at Month 18. This analysis should

contain the descriptions of the trends for each of the variables, the scenarios to be considered and their analysis.

In the sequel, together with describing the scenario variables, we shall attempt to give an indication of the work required to fully understand the relevant possibilities concerning each of them. In each of the scenarios, the variables will be determined and therefore the scenarios will permit to examine their coherency and the consequences of the variable selection. The selection might be made for reasons of:

- Expressing the influence of external factors, for example budget level, technology options.
- Attempting to produce a specific outcome, for example satisfying specific scientific needs, training specified number of specialists.

We wish to remind the reader that some variables describe forward looking events or trends and therefore unexpected events or the advice of the Mirror Group may force to reconsider some of our analyses.

From the previous discussion we can conclude that the major variables influencing the scenarios to be considered can be summarised as follows:

1. Hardware and associated services to be delivered by PRACE AISBL over the period 2014-2018.
2. Assets of PRACE AISBL and its members relevant to designing and delivering the services.
3. Availability of human resources of PRACE AISBL and its members.
4. Goals and expectations of PRACE AISBL members.
5. Goals and expectations of the user communities.
6. Goals and policies of the European Union and the European Commission.

Each possible scenario will need to address all variables defined against the strategic principles of PRACE AISBL. In order to initiate the work for defining possible scenarios we elaborate on these variables and point some of the present status, the future directions and some issues regarding these variables.

Hardware and associated services to be delivered by PRACE AISBL over the period 2014-2018

The trends to be assessed for Tier-0 supercomputers deal with:

1. Tier-0 capability range. This is partly documented by the work done around the different Exascale roadmaps provided by the HPC vendors or by several EC funded initiatives. However, at this time the desirable capability range of a Tier-0 supercomputer in the considered period is not yet sufficiently understood. The output of WP8 and WP9 will contribute here.
2. Tier-0 architectural scope. It would be desirable to understand whether a small (e.g. 3) or larger (e.g. 6) number of architectural options are needed to guarantee access to European scientists to a sufficient diversity of supercomputers. On one hand, it is counterproductive to disperse efforts and funding, on the other hand, one does not wish the European efforts to become irrelevant which would happen if intellectual investment on the most promising architecture has been impeded.
3. Tier-0 operating mode. While today Tier-0 supercomputers are operated in batch, the question might be raised to couple Tier-0 supercomputers with quasi-real time events. With that respect, experiments concerning the medical domain should be followed [7], while public policies might be more concerned by the mitigation of natural disasters

and epidemics. Technical development in the software and scheduling area should be followed [8] further building on the experience of DEISA, and the questions of interoperation of Tier-0 and Tier-1 might also be a precondition to define the expected functionality.

4. Ease of operation. Multiple supercomputers would permit delivery of services in several categories: a) very flexible access to scientific communities for theoretical and experimental simulations; b) highly secured access for industries. Other concerns might be added here by Computer Centres as Stakeholders. Considerations regarding interoperation within the Tier-0 and Tier-1 part of the European HPC pyramid may also contribute here.

Variable	Trends	Work required/Comments
Tier-0 capability range	Needs further work	Link with WP7, WP8, WP9
Tier-0 architectural scope	Needs further work	Link with WP7, WP8, WP9
Tier-0 operating mode	Desirability should be assessed	Tier-0–Tier-1 – Stakeholders scheme
Ease of operation	Desirable	Need to be presented in terms /desirability categories of cost/feasibility

Table 3: Analysis of the trends that need to be assessed regarding Tier-0 supercomputers

Assets of PRACE AISBL and its members relevant to designing and delivering the services

1. Computer centre facilities. Requirements are very stringent in terms of capacity (housing, electrical power, cooling), physical security, and power efficiency. It is clear today that with respect to power efficiency the community is engaged currently in a rather steep learning process. This requires designing, evaluating (measuring) and making both continuous and radical improvements.
2. Supercomputers. Requirements are very stringent. Top level equipment should not be considered “off the shelf” and therefore requires precise study to prepare procurement and systems engineering to integrate in a working computer environment. The Hosting Members, both at their individual computer centres and through their cooperation set up by PRACE AISBL or resulting from their joint participation in PRACE AISBL, have demonstrated and also plan to maintain important know-how for solving these issues.
3. Networking, data storage and archival equipment, network security. These are highly valuable assets that are mostly developed in the computing centres. Access to large data sets in a distributed way is becoming an important characteristic for many application areas (input data, visualization of results). So besides providing the needed network capacity and data storage, also availability of the data to the end users must be guaranteed.
4. Intellectual property: optimised libraries, tools, training material. These are accrued in the long term.
5. Established relations with vendors. Accessing the most competitive and innovative equipment may require establishing long term relationship with vendors. This needs to be well articulated with procurement policies at the level of PRACE AISBL. The current experience of PRACE AISBL is that it has been useful that several centres of

the Hosting Members, on their own initiative, have embarked in projects with vendors (CEA-BULL, FZJ–IBM Gottingen for eQPACE, etc.). The STRATOS entity will allow for further direct relations between vendors and the PRACE AISBL regarding advanced technologies.

6. Reputation with user communities. While the user community access PRACE AISBL through a single and high quality peer review evaluation, their utilisation of the supercomputers will depend on the quality of the equipment and of all services around it. It is essential for PRACE AISBL that a good reputation be established and maintained; this means managing the key contributing professional groups with a long term view and ensuring that the community has confidence in the peer review process.

Concerning items 1), 2), 3) above, the issues of ownership and funding may be discussed if required to fully understand or differentiate scenarios. This would also entail considerations of ownership, procurement regulations and taxes; other legal issues might be discussed if found relevant to this study.

Variable	Trends	Work required/Comments
Computer centre facilities	It is desirable to further pay back the investments of the Hosting Member facilities	Rather long lived assets (e.g. 15 years)
Networking, data storage and archival equipment, network security	It is desirable to further pay back the investments of the Hosting Member facilities	
Supercomputers	Needs continuous assessment of new technologies	
Intellectual property: optimized libraries, tools, training material	Needs further assessment	
Established relations with vendors	It is desirable to build on the very positive dynamics started during the PRACE Preparatory Phase Project	Most profitable relations need long term vision, mutual gains. Risk sharing aspects could be further investigated
Reputation with user communities	Needs to be established in the first years of PRACE operation	Important for policy makers: benefits will be brought by the long time investment of users: credibility is paramount

Table 4: Analysis of the assets of PRACE AISBL and its members

Available human resources of PRACE AISBL and its members

1. Technical staff. It is important to recruit, train and retain technical staff. Notably, the supercomputers centres of the Hosting Members have made significant investment, most often leveraging their experience as a national or topical supercomputer centre. Several aspects of the operational and procurement models are significant here: i) retaining computer centres for a rather long duration favours good working conditions; ii) assigning personnel to the PRACE AISBL or recruiting personnel for the PRACE AISBL allows the sharing of their expertise over multiple sites; iii) having common Tier-0– Tier-1 centres, or evolving centres between the two categories, permits to

mutualise skills and to provide a secure career path to individuals in a very competitive environment.

It might also be appropriate to discuss the benefits of the mobility of such personnel, either to provide career evolution paths, or as a driver of dissemination of HPC skills in the industry. Such mobility might be geographical, therefore oriented towards building the ERA, or local and benefiting local clusters. Several stakeholders may therefore have different views of the desirable features with respect to this category.

2. Application and user support. Much of the above discussion is valid here, however the views of the stakeholders may vary.

It should be emphasised that application developers and scientists involved in the design and maintenance of key applications are critical resource for making simulation and HPC computation available in the public and private sectors. Their mobility should therefore be considered as a factor for enhancing European competitiveness and contributing to several goals of targeted policies: competitiveness and clusters, innovative manufacturing, enhancing product innovation, etc.

The PRACE AISBL organisation model may therefore influence:

- a. The availability of a pool of skilled “PRACE AISBL” personnel to participate in targeted projects;
 - b. The setting up a resource network catering for the needs of several categories of users;
 - c. The availability of resources capable of leading highly visible Open Source software projects (of scientific or economical interest).
3. Dissemination and outreach. Much of the above discussion applies.
 4. Liaison with scientific communities and industries. Much of the above discussion applies. However, it seems very desirable to develop the links with industry and it might be the case that the “central” PRACE AISBL is better suited to liaise with industry groups each spanning all actors in a specific domain, whereas the PRACE AISBL members or their computer centres might be able to establish and sustain deeper and more strategic relations with particular companies.

Regarding scientific communities their concern when planning to rely on PRACE AISBL for projects or experiments should encompass issues like guaranteed availability to strategic projects and funded experiments. In practice, working arrangements must be made concerning the availability of the data to be processed, and scheduling of jobs needed for project progress, experiment configuration and planning, etc. Whenever the funding or the organisation is European, it might prove simpler to be able to cater to all aspects through the centralised PRACE AISBL. The concept of “Virtual Community” proposed by the European Commission might be of interest. Here also, it might be effective that Hosting Members or their computer centres establish working relationships with selected communities although regular access to the machines would still be through the central peer review process.

A complete discussion of this topic needs to address common interests, applicable policies regarding public-private ventures and the relevant European – or national – regulations (procurement, state aids, policies regarding SMEs and innovation).

Variable	Trends	Work required/Comments
Technical staff	Highly desirable: good recruitment opportunities, retaining, good work conditions	Desirable: mutualisation of „star players“ through PRACE AISBL, building on skills available in all Tier-0 and Tier-1 centres, leveraging Hosting centres experience
Application and user support	Very competitive area worldwide. Obtain a deeper understanding of "Virtual Communities"	Need further study of industry needs
Dissemination and outreach	Highly desirable, facilitated by pooling resources	
Liaison with scientific communities and industries		Desirable to establish long term relations, long term credibility

Table 5: Analysis of available human resources of PRACE AISBL and its members

Goals and expectations of PRACE AISBL Members

1. Competitiveness of research. All PRACE AISBL members and the Governments they represent work towards this common goal, expressed by the European document "2020 Vision for the ERA". Furthermore, High Performance Computing at the highest level has been recognised as a priority in the "ESFRI Roadmap" since its first edition. This has been taken into account in the Governance of PRACE AISBL, in particular in the design of the PRACE AISBL Council decision procedures, the Scientific Steering Committee and the peer review process based on scientific excellence.

All evolution scenarios need to take this priority into account when evaluating new operational models; in particular it is important to foresee the adequacy of proposed measures and structures to satisfy the needs of the scientific communities and enabling innovative scientific directions.

Open access to scientists based on scientific excellence is an essential characteristic; however, its provision must use methods that are not averse to satisfying funding country requirements of efficient utilisation of their contribution. This is generally evaluated in terms of "national return", which is a somewhat limited viewpoint.

2. Economic growth. Furthering the policy goal expressed in the Lisbon Strategy for Growth. This includes making use of HPC for industrial competitiveness, support of innovation, support of "Green development".

This needs to be translated in the operation scheme, for instance to facilitate usage for industry, and in the Governance to ensure a good prioritisation of these policies.

The design of PRACE AISBL tools and methods to address industries and SMEs may also be pursued in order to obtain further funding for the PRACE AISBL, possibly jointly with public subsidies. This may influence the Governance and operation aspects. For instance some sites may offer security schemes or job scheduling schemes better fitting industry needs.

3. Externalities. Most countries supporting PRACE AISBL members, and particularly Hosting Members, may expect positive externalities: HPC skills development, trickle

down effect promoting Tier-1 centres, local industries and start ups, etc. This will be factored in their decision of funding the PRACE AISBL at the rather high level sought from Hosting Members.

4. Risk sharing between Members. Risk sharing concerns: access to several types of supercomputers without the requirement to fund each of the alternatives; possibility to access, train and value HPC skills at the highest level for Hosting and non-Hosting Members and countries.

Variable	Trends	Work required/Comments
Competitiveness of research	Central in the design of PRACE AISBL	
Economic growth	It is desirable to carefully design the operation framework to work with industries	Build on the expertise of PRACE AISBL members
Externalities	Implicit in Hosting countries funding decision	Difficult to fully assess, needs further work
Risk sharing	Needs further work: methods and organisation to be put in place, relation to mobility of personnel	

Table 6: Analysis of goals and expectations of PRACE AISBL members

Goals and expectations of the user communities

1. Predictability of strategic implementation. Scientific communities are engaged in HPC for the long term; they may invest over multiple years into advanced simulation tools or may design complex experiments which rely on access to HPC. These activities span multiple years (typically 5–20), and therefore it is important for them to sense a predictable, sustainable and politically supported RI. Inter governmental agreements and EC involvement are important in this respect.
2. Appropriate performance and architectural characteristics. This means that the user communities should be involved in the definition of the overall roadmap, and also in expressing requirements for equipments and computer centres.
3. Good service. This spans a large number of concerns. At the high level: single point of contact for most transactions (submittal of proposal, training, user support), effective hardware and software products, effective training and support. This in turn translates into the operation model and the decisions of PRACE AISBL, notably concerning “centrally provided”, delegated or subcontracted functions.
4. Fair allocation procedure. The peer review process needs to be seen as a robust process and be trusted by the user communities.
5. Good support of practices. In particular, it is important to provide seamless access to users at their work place and/or make common tools available (eg. grid environment, high-speed network, etc.). Also, the huge amount of data needs to be addressed, for storage, transfer, shared analysis, etc. This relates to the operations model, both concerning the definition of services and available skills.

Variable	Trends	Work required/Comments
Predictability of strategic implementation	Needs to be addressed	Further work needed for ensuring sustainability
Appropriate performance and architectural characteristics	To be addressed by PRACE-1IP through the creation of the User Forum	
Good service	To be addressed by PRACE-1IP	
Fair allocation procedure	In place	
Good support of practices	Some issues to be addressed by PRACE-1IP	Further work needed, in particular address key communities (large data, other constraints)

Table 7: Analysis of goals and expectations of the user communities

Goals and policies of the European Union and the European Commission

1. Worldwide visibility and excellence. The European Union has expressed these priorities in several documents or directives:

- a. The European Competitiveness Council Conclusions, 25–26 November, 2004 which mandated ESFRI to define a roadmap for research infrastructures.
- b. The decision to setup the “European Research Council” (ERC) as a pan-European funding body set up to support investigator-driven frontier research. Its main aim is to stimulate scientific excellence to go beyond established frontiers of knowledge and the boundaries of disciplines.

This priority does not translate directly into an operation or procurement model, however, it is clear that dispersion of efforts is an impediment to achieving such ambitious goals.

- a. This concern is already taken into account by operating under the PRACE AISBL several bodies, processes and policies: i) the Scientific Steering Committee; ii) the Tier-0 peer review and resource allocation process. This process has been applied, so far, to the PRACE Early Access call and for the First PRACE Regular call; iii) services to users as described above in sections 3.2 and 3.3. This includes services targeted at a wider community such as training, outreach and dissemination of results.
 - b. European wide cohesiveness will be extended by work currently planned under the PRACE 2nd Implementation Phase Project (PRACE-2IP) proposal which would pave the way towards closer relations between PRACE AISBL and the Tier-1 national centres involved in the DEISA suite of FP projects. It should be noted that the interoperation with Tier-0 supercomputers may be facilitated by the fact that several Member sites are also participating to the Tier-1 network set up by DEISA.
2. Support of strategic FP orientations. This includes the support of ESFRI RIs and Virtual Communities. It must be noted that supercomputing has been given a higher priority in FP7 documents and calls. In particular, under “Topics opened in Call FP7-INFRASTRUCTURES-2011-2” of the FP7 Capacities call N° 9, the following is stated:

“In line with the ESFRI roadmap, this supercomputing infrastructure should address the ever growing computational and simulation requirements of

advanced scientific communities to allow them to stay at the forefront of research; as well as those of industry to boost its innovation capabilities. “

The main goal is stated as:

“Expected impact: *The deployment of a state-of-the-art HPC capability in Europe (at petascale level as of 2010, moving to exascale by 2020). This new infrastructure will help Europe stay at the forefront of scientific breakthroughs, strengthen its international position in computational sciences and intensify the exploitation of the benefits of computing by its scientific and industrial communities. The emphasis on the early porting of applications to the new machines/architectures will ensure the most efficient and effective use of the machines and the highest benefit for the researchers.”*

Several issues, that PRACE AISBL would need to address inasmuch as they contribute to this main goal, are also mentioned:

- *effective mechanisms for joint procurement and joint ownership of machines;*
- *articulation of the European supercomputing infrastructure with national HPC installations and their evolution in time;*
- *financial and environmental sustainability ("green computing");*
- *and any other issue deemed essential for the long term success and sustainability of this infrastructure.*

3. Adequate repartition of funding between EC and Member States.

This scenario variable is essential, in particular in connection with:

- Funding regulations, whether national or European, as well as expectation of the funding parties.
- Ability to apply a European vision, concerning for instance openness to all researchers, scope of access to industry.

It must also be noted that this is somewhat related to the legal structure of the PRACE AISBL.

The EC position with regard to this issue is expressed in the “FP7 Capacities call No 9“ document as follows:

“While Member States remain central in the development and financing of most infrastructures, the EU can and should via FP7 play a catalysing and leveraging role by helping to ensure wider and more efficient access to, and use of, the infrastructures existing in the different Member States. The EU actions should also stimulate the coordinated development and networking of these infrastructures, and foster the emergence of new research infrastructures of pan-European interest within a medium to long term vision.“

4. Support of EU policies. In particular, the following expressions of EU policies are taken into account and will be translated in scenarios.

- a. The Communication from the Commission “EUROPE 2020 A strategy for smart, sustainable and inclusive growth”, which describes several “flagship” priorities, including the "Innovation Union" goal to improve framework conditions and access to finance for research and innovation so as to ensure that innovative ideas can be turned into products and services that create growth and jobs.

- b. The “Digital Agenda for Europe”, another flagship initiative of Europe 2020, highlights the role of the e-Infrastructures for building Europe innovative advantage. The further development and adoption of e-Infrastructures are explicitly addressed by the Framework Programme.
- c. In 2008, Member States agreed to implement a new partnership with the Commission on researchers the “European Partnership for Researchers”. Progress towards its goals is described in the “Report by the ERA Steering Group on Human Resources and Mobility (SGHRM) 2009 Report on the Implementation of the European Partnership for Researchers (EPR) by Member States and Countries Associated to FP7” [9].

Making competitive infrastructures available to researchers contributes to the objectives of excellence, good working conditions and attractiveness of the ERA.

Variable	Trends	Work required/Comments
Worldwide visibility and excellence	Major strategic goal of PRACE AISBL already	Several scenarios differentiated by positioning of competition, available resources, etc. need to be built
Support of strategic FP orientations. This includes the support of ESFRI RIs and Virtual Communities	Further work needed	
Adequate repartition of funding between EC and Member States	Further work needed	This study will eventually permit the PRACE AISBL Council to engage in the required discussions. Several scenarios needed.
Support of EU policies	Major strategic goal of PRACE already	

Table 8: Analysis of goals and policies of the European Union and the European Commission

5 Conclusion

This document describes:

- The conceptual framework used by PRACE AISBL to discuss issues concerning the operational model.
- The current PRACE AISBL operational model.
- The first step towards building an analysis of evolution scenarios of the PRACE AISBL operational model. This part concentrates on the strategic perspective of the relevant stakeholders and then proceeds to identifying key variables influencing the scenarios that should be considered.

As part of the work to be done in this task it has been considered necessary to create a political Mirror Group to assess the feasibility of the concepts to be developed for defining the evolution of the operational models of the PRACE AISBL. As expected, much work remains to be done and the second deliverable will report on the progress of this work, including the vision and advice of the Mirror Group. The present document gives hints for the selection of the subset of scenarios to be pursued during a detailed analysis and gives preliminary results of the analysis of these hints.

The work to be done should start with obtaining all the information regarding the variables and their components, as identified in the tables in section 4.

At present, the following conclusions may be reached, concerning feasible scenarios:

1. Hosting Members have committed essential contributions to PRACE RI: investment, participation of very competent personnel, launch of HPC services, experience and practices validated by serving a wide pan-European community. They have also contributed to the FP projects (Preparatory Phase and Implementation Phase), in a fashion conducive to a highly networked and cooperative collaboration between all PRACE AISBL members.
2. Non- Hosting Members of PRACE AISBL have contributed important functions and skills to the PRACE projects and the PRACE AISBL in a fashion conducive to a highly networked and collaboration between all PRACE AISBL members. They are experiencing the positive aspects of pan-European openness of resource allocation through the PRACE AISBL peer review process. Together with Hosting Members, they also benefit to the much enhanced network of HPC experts in Europe, which is now recognised worldwide (see IDC study [10]).
3. The distributed nature of the HPC RI, its ability to provide the sustained operation of the Tier-1 exchange and interoperation network developed by DEISA, have been confirmed as important orientations.
4. The recent start of operations of Tier-0 services of the PRACE AISBL implies that much experience is still to be gained by all PRACE AISBL members.

As the PRACE AISBL shows very promising results, it becomes very clear that an important issue concerning the PRACE AISBL is funding sustainability. The present model used by the PRACE AISBL is based on the funding from the Hosting Member countries. The risks with regard to this issue are elaborated above and permeate the discussions of many of the main variables.

In order to explore the solution space widely, the document – and the forthcoming M18 scenarios – might envision unusual possibilities:

1. Extended EC funding. The corresponding requirements from the EC would still need to be understood more completely. This might be made easier if either a) the EC issues some statement concerning its extended involvement in the PRACE AISBL; or b) enhanced experience of the ERIC structure [11] is available; or c) the PRACE AISBL Council decides upon opening talks (or delegates this action to the Mirror Group) with EC representatives to make progress relative to this issue. In the latter case, it is hoped that this document and its M18 follow on might be found useful.
2. Industrial funding. Inclusion of some costs related to HPC in FP proposals, thereby permitting co-funding of the PRACE AISBL either by the projects or through the DG – Research. One could proceed similarly concerning international scientific organisations that require HPC resources. Other entities, which could use collaboration frameworks participating in the co-funding of the PRACE AISBL, could be also identified.