SEVENTH FRAMEWORK PROGRAMME

Model for Public Authority — Research Infrastructure Interaction

The business models for ICT Research Infrastructures

FP7-ICT-248295/CSEM/R/PU/D4.1

Project Number: FP7-ICT-2007-4 248295

Project Title: Towards an Open and Sustainable ICT Research Infrastructure Strategy (OSIRIS)

Contractual Date of Deliverable: 31/03/2012

Actual Date of delivery: 30/03/2012

Work package contributing to the Deliverable: WP4

Nature of the Deliverable: R

Dissemination level of the Deliverable: PU

Editor: CSEM / Arno Hoogerwerf

Contributors:

IBBT / Rosette Vandenbroucke

IBBT / Piet Demeester

CSIR / Colin Wright

INFN / Antonio Candiello

IWT / Luc De Ridder

TUBITAK / Musa Cağlar

Tyndall Institute / Alan Mathewson

CSEM / Arno Hoogerwerf

Abstract:

Funded by the European Commission under FP7 the OSIRIS project started on January 2010. The OSIRIS consortium is composed of participants involving several institutes, Public Authorities and National Champions across 13 EU Members States and Associated Countries and regions with direct links to existing and future ICT European research infrastructures (RIs), i.e., High Performance Computing, Grids, Networks, Micro/Nanoelectronics and Future Internet.

The main aim of the OSIRIS project is to build the platform, mechanism and models required to secure the efficient involvement of Member States, Associated Countries and regions in developing cross border public-public partnerships and to establish a coordinated approach to future large scale investments in international European ICT RIs. For this reason, a thorough analysis of the business models of current international ICT RIs is required. This analysis will be presented in this report.

Each international ICT RI has many aspects, many of which are hierarchically related. The consortium has opted for a visual way of representing these aspects. This allows an overview of the different aspects to be gained much more effectively than would be possible from a text description. The visual representation that has been chosen is that of a mind map. Mind maps have been found to be very useful during discussions within the consortium and are regarded as a good means of communicating the different aspects of the international ICT RIs.

The aim of this report is to provide a source of information on the possible business models of how ICT RIs can be managed and supported once a need for them has been identified and the RI has been founded.

Once the RI has been founded, there are four important aspects that describe the RI business model:

- Governance;
- Sustainability;
- Access Policies;
- Operational principles.

These aspects are described in detail in this document. Governance describes the control of the RI, in other words who determines the direction the RI will take in the future. Sustainability describes the future of the RI and how it will continue to operate. Whereas the arguments prior to the founding define whether an RI will be created, sustainability defines whether the RI will continue to exist. Access policies describe the interactions of the international ICT with one of its most important stakeholders: namely its users. Operational principles describe how the sustainability, the governance, and the access policies are implemented at an operational level.

These four aspects are analysed together with their detailed sub-levels by visualization with the help

of mind maps. Considerations and opinions are given at the end of each detailed level.

Keyword list:

Research Infrastructures (RI), Information and Communication Technologies (ICT) , Infrastructure Strategy, Business Model, Mind Map,

Clarification

Nature of the Deliverable

R	Report
P	Prototype
D	Demonstrator
O	Other

Dissemination level of Deliverable:

PU	Public
PP	Restricted to other programme participants (including the Commission Services)
RE	Restricted to a group specified by the consortium (including the Commission Services)
CO	Confidential, only for members of the consortium (including the Commission Services)

Disclaimer

*The information, documentation and figures available in this deliverable, are written by the OSIRIS (“*Towards an Open and Sustainable ICT Research Infrastructure Strategy”*) – project consortium under EC co-financing contract FP7-ICT-248295 and do not necessarily reflect the views of the European Commission*

List of acronyms

AUP	Acceptable Use Policy
CEA	Commission pour l'Energie Atomique: the French nuclear research organisation
CSEM	Centre Suisse d'Electronique et de Microtechnique SA: the Swiss MNT RI
DANTE	Delivery of Advanced Network Technology to Europe
DCI	Distributed Computing Infrastructure
EGI	European Grid Initiative
ERIC	European Research Infrastructure Consortium
EU	European Union
HPC	High Performance Computing
HUC	Heavy User Communities
IBBT	Instituut voor BreedBand Technologie: the Flanders (B) ICT RI
ICT	Information and Communication Technologies
IMEC	Interuniversitair Micro-Electronica Centrum: the Flanders (B) MNT RI
IPR	Intellectual Property Rights
LETI	Laboratoire d'Electronique et de Technologies Intégrées: the French MNT RI, part of CEA
MNT	Micro- and Nano-Technologies
MoU	Memorandum of Understanding
NREN	National Research and Education Networks
PRACE	PaRtnership for Advanced Computing in Europe
RI	Research Infrastructure
VO	Virtual Organisation: the implementation of a VRC
VRC	Virtual Research Community

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1 Introduction

Funded by the European Commission under the Seventh Framework Programme for Research and Development (FP7,) the OSIRIS (towards an Open and Sustainable ICT Research Infrastructure Strategy) project started on January 1st 2010. The OSIRIS consortium is composed of participants involving several institutes, Public Authorities and National Champions across 13 EU Members States and Associated Countries and regions with direct links to existing and future ICT European research infrastructures (RIs), i.e. High Performance Computing, Grids, Networks, Micro/Nanoelectronics and Future Internet.

The main aim of the OSIRIS project initiative is to build the platform, mechanism and models required to secure the efficient involvement of Member States, Associated Countries and regions in developing cross border public-public partnerships and to establish a coordinated approach to future large scale investments in European ICT RIs. For this reason, a thorough analysis of the business models of current European ICT RIs is required.

This document aims at describing the non-technical aspects of European ICT RIs. The goal is to gain a better understanding of the business model of RIs in general. Each RI differs from the others in its scientific and technical objectives and operation. However, many commonalities can be found when analysing the non-technical aspects of the RI, such as governance and sustainability. Each RI has to address these issues and many similar solutions have been found by RIs which span widely different scientific fields. The analysis of these common aspects will help to develop the instruments needed for better interaction between Public Authorities and RIs and will support the actors that are interested in the establishment of new ICT Research Infrastructures.

This analysis of these different non-technical aspects of RIs was carried out as a task of the OSIRIS project. The members of the project read the more than forty reports on research infrastructures cited in the references of the project. They also interviewed eight key persons representing different ICT research infrastructures in Europe and analysed more than 30 ICT Research Infrastructures from publicly available information. The results of the analysis carried out by members of the consortium were discussed in ten days of face-to-face meetings and a dozen telephone conferences. The results were described in this deliverable by multiple persons and the resulting document has been edited in order to achieve a unity of style and content.

The present document is one of the Deliverables of the OSIRIS project. Other Deliverables of the project include:

- A report on the results of a survey that was submitted to key people in ICT RIs and Public Authorities in Europe;
- The result of the analysis of 30 ICT RIs or projects that were evaluated for the different aspects of the mind map;

- The results of interviews held with key people in European ICT RIs.

The information that has been obtained for these different deliverables has been used in the elaboration of this document.

This document presents extensive information about the business model of European ICT RIs that is useful for different types of readers. The most effective way to seek the information in this document is to first read the introductory chapters 1 and 2 and then follow the mind map to the branches of interest and read the relevant sections on these branches. This is also possible through the use of the interactive tool available on the OSIRIS website (http://www.osiris-online.eu).

1.1 Analysis methodology

The business model of each European ICT RI has many aspects, many of which are hierarchically related. The way of representing these aspects preferred by the consortium is a graphical one. This allows an overview of the different aspects to be obtained much more effectively than with a text description. The graphical representation that has been chosen is a mind map.

A mind map is a diagram used to represent words, ideas, tasks, or other items linked to and arranged around a central key word or idea. Mind maps are used to generate, visualize, structure, and classify ideas, and as an aid in studying and organizing information, solving problems, making decisions, and writing. The elements of a given mind map are arranged intuitively according to the importance of the concepts, and are classified into groupings, branches, or areas, with the goal of representing semantic or other connections between portions of information[1]. Mind maps have been very useful during discussions within the consortium and are considered to be a good means of representing the different aspects of European ICT RIs in an efficient manner.

The use of a mind map has defined the structure of this report. The mind map will be presented and explained in Chapter 2. In the subsequent chapters of this document, the different branches of the mind map will be documented. The documentation of the mind map generally follows a standard pattern. First, a definition of the branch will be presented, and then an explanation of the branch will be given, followed by general considerations of the branch. For some branches, considerations for a particular type of RI will be presented. The definitions, explanations, considerations, and RI specific considerations are all defined by a separate font style, and by the words “definition”, “explanation”, or “considerations” at

[1] http://en.wikipedia.org/wiki/Mind_map

the start of that particular section. With respect to RI specific considerations: these will start with the naming of the type of RI for which the consideration has been made. Example:

Definitions (bold)

Explanations

Considerations (italic)

RI specific Considerations (bold italic)

2 Overall Mind Map

The overall mind map of the business model of a European ICT RIs is presented in Figure 1. The top level subject of the mind map is the European ICT RI shown in the ellipse in Figure 1.

Figure 1: The overall mind map representing European ICT RIs

Definitions:

The word “European” means in this context: of, relating to, or affecting two or more nations which belong to the European Union or the Associated States. This implies that a given ICT RI extends beyond the national borders of a single country.

According to the EC[2], the term ‘research infrastructures’ refers to facilities, resources and related services used by the scientific community to conduct top-level research in their respective fields, ranging from social sciences to astronomy, genomics to nanotechnologies. Examples include singular large-scale research installations, collections, special habitats, libraries, databases, biological archives, clean rooms, integrated arrays of small research installations, high-capacity/high speed communication networks, highly distributed capacity and capability computing facilities, data infrastructure, research vessels, satellite and aircraft observation facilities, coastal observatories, telescopes, synchrotrons and accelerators, networks of computing facilities, as well as infrastructural centres of competence which provide a service for the wider research community based on an assembly of techniques and know-how.

Information and communications technology or information and communication technology, usually called ICT, is defined in [Impacts, 2008] as consisting of three levels:

- **Technology – The materials, processes, and technical principles that create the basic hardware elements (electronic, photonic, mechanical component layer)**
- **Equipment – The combination of basic hardware elements and software which creates a functional system or device (product layer)**
- **Services – System-based applications of hardware and software with content (content layer)**

[2] http://ec.europa.eu/research/infrastructures/index_en.cfm?pg=what

By combining the definitions above, a European ICT RI can be defined as an ICT facility, resource and / or related services that extends beyond the borders of a single country and is used by the scientific community to conduct top-level research.

Explanation:

A Research Infrastructure is used by the scientific community to conduct top-level research. This implies that the RI itself does in general not perform the research itself, but rather acts as a facilitator of the research.

By looking into the definition of ICT, one can distinguish different types of European RIs. These types are:

- Data communication networks. In Europe, the vast majority of European academic and institutional sites are linked through the GÉANT network. GÉANT, in several generations, and over ten years of existence is effectively the only non-commercial European network.

- Distributed Computing Infrastructures (DCI). These infrastructures are also known under the heading of grid computing. In Europe the largest non-commercial organisation in DCI is the European Grid Initiative (EGI) that includes more than 300 computing and storage Resource Centres in Europe for which it coordinates general access and sharing of services.

- High-Performance Computing (HPC) infrastructure is targeted towards providing the highest sustained parallel peak computing capacities for the benefit of scientific research communities. The Partnership for Advanced Computing in Europe (PRACE), which has already commenced operation, will maintain a pan-European HPC computing infrastructure consisting of up to six top of the line leadership systems (Tier-0) which are well integrated into the European HPC ecosystem as a single European entity.

- Data repositories and the data handling of instruments. Data repositories store large amounts of (scientific) information. Instruments are typically RIs that help to improve our understanding of complex problems. They often generate large amounts of data for later analysis. The handling of these large amounts of data represents problems that are similar to those of data repositories. Data repositories in Europe are sometimes accessible through the European Grid Initiative (EGI).

- Remote instruments. As noted in [ESFRI, 2010], European RIs' instruments and facilities – such as synchrotrons, telescopes, sensor networks, and biomedical facilities – are an unrivalled asset. In Europe there are more than 500 such facilities, of which at least 300 have strong international visibility, attracting world class researchers. The remote instrument model permits researchers in one place, using advanced computer and communications technologies, to undertake experiments on such facilities remotely, in real time.

- Test beds for future internet. This is a multidisciplinary research environment for investigating and experimentally validating highly innovative and revolutionary ideas for new networking and service paradigms. In Europe, the Future Internet Research and Experimentation - FIRE - Initiative is addressing this need.
- Laboratories for Micro- and Nanoelectronics and Micro- and NanoTechnology (MNT). These laboratories are cleanrooms containing very capital intensive equipment to fabricate wafers in which devices with extremely small features are created.

The European ICT Research Infrastructure business model mind map has six branches that were identified by the OSIRIS consortium. These branches represent the non-technical and non-scientific aspects of the RI:

- Arguments;
- Historical Background;
- Governance;
- Sustainability;
- Access Policies;
- Operational principles.

The arguments and historical background are the most important aspects that arise prior to the founding of the European ICT RI, whereas the latter four aspects are most important once the RI has been founded. Since they become the most important aspects once the RI has been founded, they of course have to be considered prior to the founding of the RI.

The arguments are very important prior to the founding of the RI, because they represent the motivation for establishing the RI.

The historical background describes the process of how the RI came into being. Arguments alone do not suffice to create an RI: the enthusiasm of the people involved certainly plays a key role. These and other aspects are treated in the historical background.

Governance relates to decisions that define expectations, grant power, or verify performance. Governance relates to consistent management, cohesive policies, guidance, processes and decision-rights for a given area of responsibility.

Sustainability can be defined as the potential for long-term maintenance by providing the necessary means to reach this goal.

Access policy can be defined as a high-level overall plan to enter or to communicate between the users and the RI.

Operational principles describe how the sustainability, the governance, and the access policies are implemented at an operational level.

Considerations:

When analysing laboratories for Micro- and Nanoelectronics and Micro- and NanoTechnology (MNT), the OSIRIS consortium found that their characteristics are different from those of other ICT RIs. First, the MNT RIs appeared to be working mainly nationally, with typically one RI having one cleanroom in one country. Second, the facilities of the RI were mainly used by the personnel of the RI, with only restricted access for the research community outside the RI. This contrasts with the other ICT RIs that are managed and kept operational by the RI, but that are used mainly by researchers outside the RI. Third, the industry involvement in MNT is much larger than in any other ICT RI. Whereas, other ICT RIs typically have at most 10% industrial income, the MNT RIs can have more than 50% industrial income [OSIRIS-D3.3, 2012].This in turn affects many policies of the RI, particularly in terms of confidentiality and IPR. Therefore, many commonalities that are present amongst different ICT RIs are not present in the case of MNT RIs.

3 Arguments

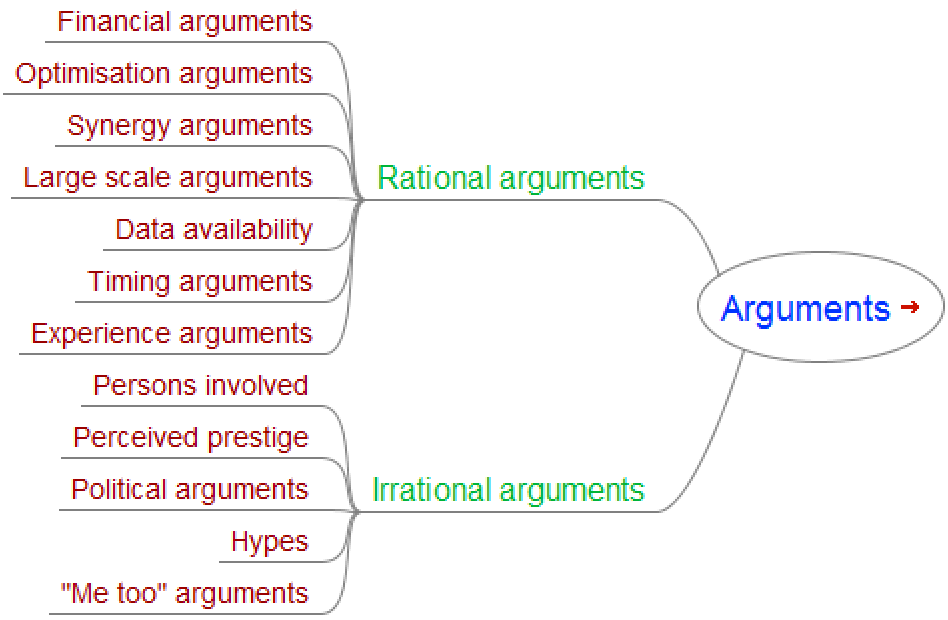

Figure 2: The arguments part of the mind map

Definition:

The most appropriate definition of the word "Argument" is[3]: a coherent series of statements leading from a premise to a conclusion.

Explanations:

For any European ICT RI, the first and foremost arguments will be technical and scientific ones. These arguments are specific to each RI and were not analysed by the OSIRIS consortium, which has focused on all other arguments. These other arguments can be categorised into two groups: rational ones and irrational ones.

Considerations:

[3] http://www.merriam-webster.com/dictionary/argument

The founding of a European ICT RI is a major undertaking and is generally preceded by many years of preparation. The decisive arguments for the creation of an RI generally continue to be important for the continuation of the RI once it has been created. They are therefore often important arguments to maintain the sustainability of the RI.

The arguments also present the unique explanation why certain types of European ICT RIs do not exist. For these RIs, the arguments against must have been more important than the arguments in favour. An overview of the different arguments for the founding of a European ICT RI is therefore important for the understanding of why certain RIs exist and why certain do not exist.

3.1 Rational Arguments

Definition:

Rational arguments are arguments that can be defended on the basis of principles of logical reasoning and facts.

Explanations:

The main non-technical and non-scientific rational arguments that play a role in the creation of a European ICT RI are presented below. Most of the arguments are taken from [OECD-GSF, 2010]:

- Financial arguments. The implementation of an RI can exceed the funding capacity of an individual country. The possibility of sharing the financial burden amongst different countries is therefore an argument favourable to the creation of a European RI. If the RI does not exceed the funding capability of a single country and is expected to yield local financial benefits (spin-off creations, attraction of high-tech industry, etc.), it can be a good financial argument for keeping a prospective RI at the national level.
- Optimisation arguments. The optimisation argument in favour of European RIs is certainly that it reduces unnecessary duplication and enhances complementarity. Rather than having national RIs that duplicate each other’s work, a European-wide RI could eliminate these duplications in large measure and permit different groups in the RI work on complementary subject. The flip-side of the coin is the risk of creating a large bureaucratic, self-perpetuating organisation, because of the lack of competition. This risk should be kept in mind when defining the governance of the RI.

- Synergy arguments. Bringing together the best scientists, engineers, technicians, and administrators in a single RI environment can create a very creative and energetic scientific environment in which many new ideas can flourish. The risk of exclusion or isolation of certain national scientific communities whose countries are not part of the collaboration should be addressed when defining the access policies of the RI.

- Large scale arguments: the ability to process more data in the same time or obtain results in a shorter timeframe is a positive argument for the creation of a European ICT infrastructure.

- Data availability: the availability of data on a European scale can open new horizons for the concerned science discipline.

- Timing arguments. The timing argument against a European RI is that it creates delays and expenses associated with protracted international negotiations.

- Experience arguments. A European RI can provide international experience for young scientists and engineers.

Considerations:

The financial arguments always play a role in the business model of European ICT RIs. In general, a RI represents a major capital expenditure and it is of interest to study whether the financial burden of this investment cannot be shared between countries. ESA and CERN are typical examples of RIs that exceed the funding capabilities of a single country. The benefits of sharing the financial burden must be balanced against the benefits of keeping a national RI. In the case of Micro- and Nanoelectronics and MNT laboratories, the technical know-how gained is intimately related to the laboratory environment. The results of the work performed in these laboratories can also have a strong economic impact in the short to medium term. It is therefore expected that these laboratories will generate local value in the short to medium term. This can be achieved through the creation of spin-offs of the RI, but also through the attraction of industry facilities to the vicinity of the RI. As an example, the placement of the ST Microelectronics facilities in Crolles (F) can be explained by their close proximity to the CEA-LETI research infrastructure in Grenoble.

The major optimisation argument in favour of a European ICT RI is the enhancement of the complementarity. The value of a national computer network is enhanced if it becomes connected to the national network of another country. The national networks of each country are entirely complementary to networks of other countries, so this is a strong incentive to work together on an international basis. A corollary to this argument is the reduction of unnecessary duplicates. If one RI in a European collaboration already has a piece of equipment or a service that is not intensely used, another RI in the collaboration can refer to the first RI for this equipment or service. The funds it saved by not offering this service then become available for the provision of an additional capability.

The synergy arguments play a much smaller role in the case of ICT infrastructures that are mainly of a distributed nature.

The timing argument often plays a role against the European ICT RIs. The creation of such an RI is often the result of international negotiations spanning many years. For example, by the time the negotiations have come to a conclusion, the technical relevance of the RI may have diminished. This risk is especially important in the rapidly changing field of ICT. The creation of an ERIC legal framework by the EU attempts to address this argument.

The experience argument almost never plays a role with ICT RI, as many of them are of a distributed nature.

3.2 Irrational arguments

Definition:

Irrational arguments are arguments that cannot be defended or based on principles of logical reasoning.

Explanations:

Irrational arguments can be in favour of or against the creation of a European ICT RI. They can be very strong at certain moments, but these arguments tend to change over time, as the persons related to these arguments become more or less involved in the creation process. Irrational arguments that can be distinguished are:

1. Persons involved. The creation of a European ICT RI requires the involvement of a large number of people, with a smaller group that have key roles in the creation of the RI. These people can be the chief executives of the national ICT RIs that will be merged into a bigger European one, or they can be heads of funding agencies that will share the major part of the financial burden of the new RI. The affinities or antagonisms between these key people will have a major influence on the progress towards the creation of the European ICT RI.

2. Perceived prestige. The perceived prestige of a European ICT RI, especially when a major part of the RI will be physically located in a particular host country will have a major influence on the creation process. The perceived prestige will make the politicians in the host country eager to attract the RI as quickly as possible, which will typically be done by making more funds available in the host country.

3. Political arguments. Political arguments are arguments that are unrelated to the European ICT RI being created, but that have an influence on the process. Examples of political arguments are:

    - The wish to create closer ties to a particular country by means of the European ICT RI.

    - The wish to offset the disadvantage of a particular country in recent attributions by granting it the hosting of the European ICT RI.

4. Hypes. In the public opinion, certain subjects can, all of a sudden, be perceived as extremely important. Addressing this public opinion through the creation of a RI in this field can create problems in the long term. Fortunately, the time needed to create a European RI exceeds the typical life time of a hype.

5. “Me too” arguments. If a RI is created somewhere in the world, it creates a desire to do something similar in Europe too.

Considerations:

The irrational arguments listed above can play a very important role at certain stages of the creation of the European ICT RI. However, if they are predominant during the entire creation process, they will endanger the sustainability of the European ICT RI. The changing of the circumstances will then remove the major reason for the existence of the RI, which is of course a very dangerous situation.

4 Historical background

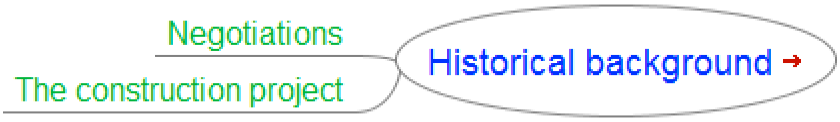

Figure 3: The historical background part of the mind map

Definition:

The most appropriate definition of the word "History" is[4]: a chronological record of significant events (as affecting a nation or institution) often including an explanation of their cause. The most appropriate definition of the word background is[5]: the circumstances or events antecedent to a phenomenon or development. The historical background can therefore be defined as the chronological record of significant events antecedent to the creation of the European ICT RI.

Explanations:

"The drive to create a new multi-stakeholder RI arises from the scientific aspiration and the technical ability to achieve collectively that which cannot be achieved individually. Action follows when the funding capacity of the interested parties reaches a critical mass." This quote from the EIROforum document [EIROForum, 2010] elegantly describes the starting point of the creation of a European RI. The process between this starting point and the founding of the RI forms the history of the creation of the RI.

The history is made by the acts of the persons involved in the creation of the RI. It is their task to keep the momentum going, to keep the parties interested and to align actors and actions [EIROForum, 2010]. There are first experiences at trying to work together on some topics. Sometimes, cooperation projects are started to gain experience in working together. Then, the official negotiations are started to create the European ICT RI. Finally, the construction of the RI presents the culmination of the efforts prior to the founding of the RI.

[4] http://www.merriam-webster.com/dictionary/history

[5] http://www.merriam-webster.com/dictionary/background

Considerations:The persons involved in the creation of the European ICT RI often take leading positions in the RI once it has been created. As a result, the history of the RI creation will be remembered by these persons, which can have an influence on their decisions.

GÉANT: The European Research Network, for the moment known as GÉANT, is the result of an intensive study undertaken under the auspices of the European Commission (COSINE Study) and the push of large countries to create a research network that was comparable to that of the US and that did not depend on proprietary solutions (like EARN or DECnet). Political discussion, showing the importance of strong personalities as mentioned above, lead to the founding of two organisations, namely TERENA and DANTE, to manage all the diverse aspects of the European Research Network.

EGI.EU has been founded to formally define a sustainable European Grid Infrastructure so taking care of most of the aspects of an ICT RI presented in this document. The negotiations for the founding of this ICT RI were carried out during the third phase of the series of EGEE projects (3 successive EC Framework projects). It can be said that in this case the European ICT was founded after a large scale "limited bottom up" trial (initiated by one scientific discipline in quest of a solution for future data handling and data processing).

A typical example of an ESFRI initiated RI is Lifewatch. In 2002 the EU Member and Associated States established the European Strategy Forum on Research Infrastructures (ESFRI) as an incubator for new large-scale research infrastructures. In its 2005 document "Towards new research infrastructures for Europe", ESFRI identified the opportunity to strengthen biodiversity research in Europe.

Life Watch, demonstrating not only the need but also the feasibility of building this kind of robust infrastructure, has been selected for the 1st ESFRI Roadmap. In 2008 the European Commission granted financial support for a three-year preparation of Life Watch. The preparatory project provided the detailed information needed by interested countries before they can decide on their investment, and on the construction and operation of the infrastructure. The preparations started in February 2008 and the work was finished early 2011. The construction phase of LifeWatch started in Jan 2011.

4.1 Negotiations

Definition:

The word negotiations stems from the verb "to negotiate" which means[6]: to confer with another so as to arrive at the settlement of some matter.

Considerations:

The negotiations involved in the creation of an RI are often very long, spanning a period of several years. The negotiations can in general be kept shorter if the initial consortium is kept small. This initial consortium should foresee its future enlargement. On the other hand, a larger consortium can give more support and funding, ensuring the sustainability of the infrastructure. In this case it might be desirable to have lead members in the consortium that have more leverage on the formation process [EIROForum, 2010].

The choice of negotiators is also very import. On one hand, high level people are required, who can take decisions without requiring approval from higher echelons. On the other hand, the negotiations will often need to go into considerable detail, which is not compatible with the agendas of high-level persons. It might therefore be beneficial to have two groups of people involved in the same negotiations: namely a group of higher level people who will negotiate the contentious points and will monitor the progress of the negotiations and a second lower level group of people who will finalise all the details. This lower level group of persons will in the beginning consist mainly of scientific people. As the negotiations progress, the scientific people will become less involved in the negotiations and lawyers will come in to draft the documents [OECD-GSF, 2010].

The language of the negotiations and the agreement also needs to be determined early on in the process. It is in general easier to set a language early on in the process than at the time that results of difficult negotiations have to be put on paper. The language of the host country of the RI also needs to be taken into account, as often at least a part of the documents have to be written in one of the official languages of the host country. [OECD-GSF, 2010].

The negotiation agreement must cover at least the major items of Governance, Sustainability and Access Policies of the RI. The implementation of the Operational principles is best left to the governing board of the RI, once it is founded. This simplifies the negotiations and therefore diminishes the risk of additional delays in the negotiations.

4.2 The construction project

[6] http://www.merriam-webster.com/dictionary/negotiate

Considerations:

A new RI will often push the frontiers of science. However, this does not take away from the fact that the construction of an RI has many similarities to a large civil or industrial project. Project management tools and experience from such projects will be very beneficial to the RI construction project. It might therefore be beneficial to have an experienced project manager with senior experience of such types of projects in charge of the construction project. A generic project plan for the construction of an RI can be found in [Cost-control, 2010].

5 Governance

Figure 4: The governance part of the mind map

Definition:

Governance is the act of governing. It relates to decisions that define expectations, grant power, or verify performance. [...] [...] governance relates to consistent management, cohesive policies, guidance, processes and decision-rights for a given area of responsibility.[7]

[7] http://en.wikipedia.org/wiki/Governance

Explanation:

"Governance covers the balance of powers within an entity, including the management structure – the basic hierarchical structure – and the relationship between the different organs of the entity. The rules of governance should be defined in a convention or a comparable founding document. A sound convention is paramount to good governance and management. It should have the capacity to adapt the structure and policy in response to scientific developments and operational needs. It should be forward-looking, allow for flexible solutions, ensure that the interests of the members are kept in balance, and should encourage optimal operational efficiency. It should reflect the members' input and interests whilst serving the scientific and technical requirements of the facility. It should make clear and transparent the division of roles and responsibilities between management and the governing and advisory bodies.

The convention is the basis for all other important elements needed for the operation of the infrastructure: staff policy, access policy, IPR issues, data management, the definition and evaluation of research programmes, rules for introducing new members, the applicability of law and the conduct of external relations. It underpins the committee structure and determines the hierarchy of decision making so that rights and responsibilities are transparent. It deals with voting rights that have a direct influence on the balance of powers.

Governance and control of issues such as policy and finance is exercised by the members and associates, represented on the main governing bodies of the organisation. In addition, provision for ad personam appointments to scientific committees ensures the protection and promotion of scientific excellence." [EIROForum, 2010]

As with the founding of any organisation, it is essential to:

- Define its mission;
- Define its governing structure;
- Involve its stakeholders;
- Choose its legal form;
- Set its rules.

Considerations:

The report [OECD-GSF, 2010] advises on establishing large international research infrastructures and deals with aspects such as legal and administrative issues.

DCI, HPC, Networks

NRENs that do not have representation of key stakeholders in their governance structures should consider including these stakeholders in their governance structures, allowing all key stakeholders to have an input into the decision and policy-making processes of the NREN. [EARNEST-GOV, 2007]

5.1 Mission

A mission statement is a […] statement of the purpose of a […] organisation. The mission statement should guide the actions of the organisation, spell out its overall goal, provide a sense of direction and guide decision-making. It provides the framework or context within which the company's strategies are formulated[8].

Explanation:

Vision and Mission statements are often confused with each other, and some organisations even use them interchangeably. In simplest terms, the mission is the organisation's reason for existence, and the vision is what it wants to be.[9]

The mission of the RI will often be defined precisely during the negotiations that precede its founding.

5.2 Governing structure

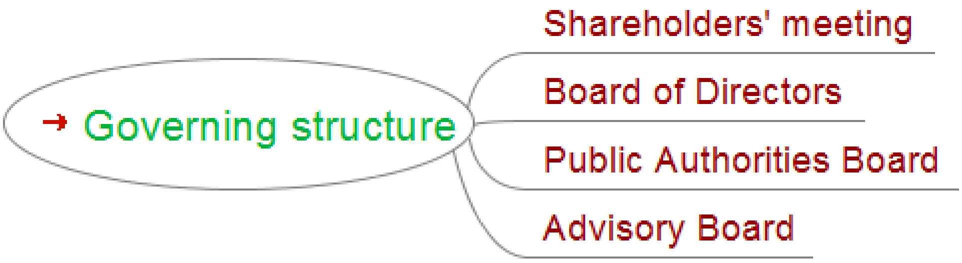

Figure 5: The governing structure branch of the governance part of the mind map

[8] http://en.wikipedia.org/wiki/Mission_statement

[9] http://en.wikipedia.org/wiki/Vision_statement#Mission_statements_and_vision_statements

Definition:

The governing structure defines the top level organisation of the European ICT RI by which the owners yield their influence.

Explanation:

A Research Infrastructure needs a governing structure of boards, each with a specific role and a defined relationship with the other boards.

Typical boards are:

- The Shareholders' meeting;
- The Board of Directors;
- The Public Authorities Board;
- The Advisory Board.

A typical organisational chart representing this structure is depicted in Figure 6.

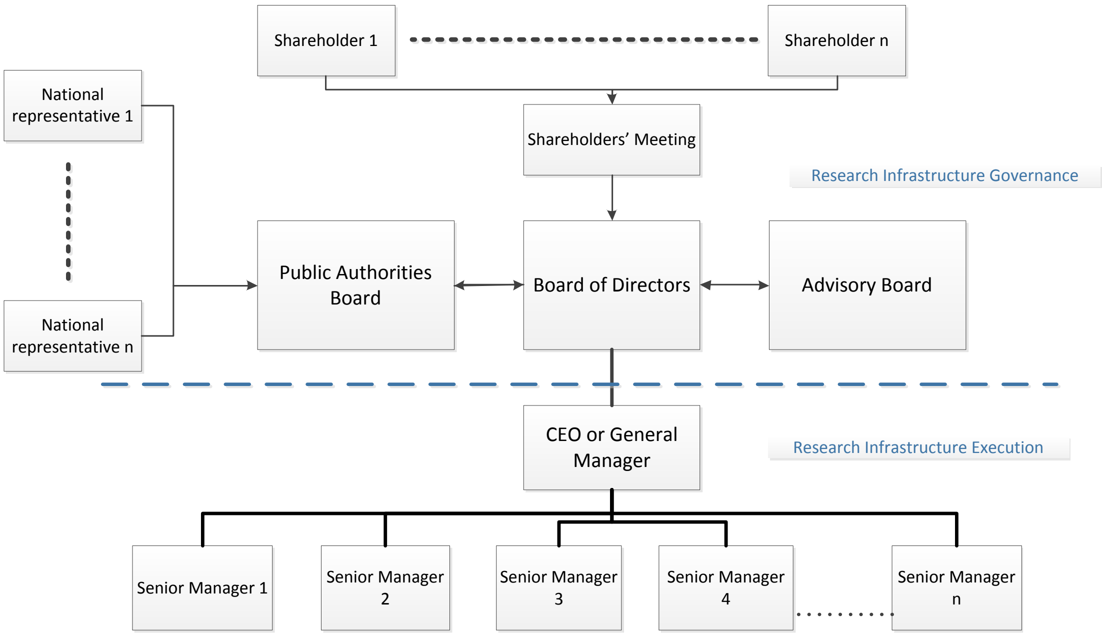

Figure 6: The typical governing structure represented as an organisational chart

MNT:

Most MNT organisations do not have a Mirror group as they are national organisations. Almost all do have a (scientific) Advisory Board that assist them in setting technical and scientific strategic directions. [IMEC, 2011][LETI, 2011][Tyndall, 2012][CSEM, 2012]

DCI, HPC, Networks:

A majority of NRENs (66%) are legal entities or part of a larger legal entity, and 62% of NRENs are controlled by a committee of stakeholders, who could be government representatives and/or representatives from the research and education communities. Very few NRENs have a 'normal' company structure where the NREN company is controlled solely by its senior officers such as directors. A significant minority of NRENs are part of a government department or are controlled by a government department (31%).

Some NRENs do not have any stakeholder representation from the research and education communities in their governance structure. It may be perceived that this is not required if there is government representation in the NREN governance structure. However, to follow best practice, it is desirable that all NRENs have representation from all key research and education stakeholder groups, so that those groups (who often provide funding) can have an input into the management and decision-making processes of the NREN. [EARNEST-GOV, 2007]

Possible models for effective NREN governance are:

Model 1

- *The NREN is a legal entity with a supervisory board. In the Anglo-Saxon legal system, where there is no legally required separation between the Board of Supervisors and the General Managers, this would be a Board of Directors including both supervisors and managers.*
- *The board is comprised of members who represent key stakeholders from the research and education communities and from the government (e.g., the government departments for education, for research etc.). In the Anglo-Saxon system, the General Manager(s) of the NREN will be members of the board as well.*
- *Other, minor stakeholders are represented on a committee of stakeholders, and the chair of that committee is a member of the board.*
- *The Chief Executive Officer or General Manager of the NREN chairs the NREN management team, which consists of the senior managers of the organisation.*

Model 2

- ***The NREN is not a legal entity but has a board.***
- ***The board comprises members who represent key stakeholders from the research and education communities and from the government (e.g., the government departments for education, for research etc.). In the Anglo-Saxon legal/organisational culture, the General Manager(s) of the NREN will be members of the board as well.***
- ***Other, minor stakeholders are represented on a committee of stakeholders, and the chair of that committee is a member of the board.***
- ***The Chief Executive Officer or General Manager of the NREN chairs the NREN management team, which consists of the senior managers of the organisation.***

Variations of models 1 and 2 can be developed to meet the requirements of the national government or other influential stakeholders. For example, if the government does not want many, or even any, representatives of the research and education communities to sit on the board, the models can be adapted so that all stakeholders are represented in the committee of stakeholders. [EARNEST-GOV, 2007]

5.2.1 Shareholders' meeting

Definition:

The Shareholders' meeting (annual general meeting) is held every year to elect the Board of Directors and also to inform members of previous and future activities. It is an opportunity for the shareholders and partners to receive copies of the company's accounts as well as reviewing fiscal information for the past year and asking questions regarding the directions that the business will take in the future.[10]

Explanation:

The shareholders' meeting represents the owners of the RI. The owners of a European ICT RI are typically national governments or funding agencies.

[10] http://en.wikipedia.org/wiki/Shareholders%27_meeting

5.2.2 Board of Directors

Definition:

The Board of Directors, "a body of elected or appointed members which jointly oversees the activities of a […] organisation. […][11]. Other names include supervisory board (in Europe, with a separation between supervisory board and executive board), board of governors, board of managers, board of regents, board of trustees, and board of visitors.

Explanation:

The Board of Directors is elected by the Stakeholders Meeting.

Typical duties of Boards of Directors include:

- Governing the organisation by establishing broad policies and objectives;
- Selecting, appointing, supporting and reviewing the performance of the chief executive or even the entire Executive Board;
- Ensuring the availability of adequate financial resources;
- Approving annual budgets;
- Accounting to the stakeholders for the organisation's performance;
- Setting their salaries and compensation."[12]

In most European Union and many Asian countries, there are two separate boards, **an executive board for day-to-day business** and a **supervisory board (the Board of Directors) (elected by the shareholders) for supervising the executive board**. In these countries, the CEO (chief executive or managing director) presides over the executive board and the chairman presides over the supervisory board, and these two roles will always be held by different people. This ensures a distinction between management by the executive board and governance by the supervisory board. This allows for clear lines of authority. The aim is

[11] http://.wikipedia.org/wiki/Board_of_directors

[12] http://en.wikipedia.org/wiki/Board_of_directors

to prevent a conflict of interest and too much power being concentrated in the hands of one person.[13]

[13] http://en.wikipedia.org/wiki/Board_of_directors

HPC (PRACE):

Regardless of the model for the organisation PRACE will need to be able to:

- *Define and implement a strategy* ***for providing a world class HPC infrastructure in Europe***
- ***Manage the formation of a suite of complementary Tier-0 systems in Europe***
- ***Manage the*** *contributions* ***of partners***
- ***Operate an open and fair access system based on*** *peer review* ***to the Tier-0 services***
- ***Manage the interaction with*** *industrial organisations* ***wishing to access PRACE systems***
- ***Perform training and computational science R&D activities***
- ***Interact with multiple stakeholders in order to promote HPC in Europe with a long term and sustainable approach***
- ***Deliver appropriate accounting, administration, human resources, marketing and communication activities***
- ***Provide a*** *secretariat* ***to PRACE governance bodies.***

Some of the important decisions that will have to be taken by the governing board include:

- ***Transforming a common vision into a coherent strategy, which is compatible with the long term goals of the infrastructure, its stakeholders and in particular the RI partners***
- ***Decisions on the Tier-0 performance level objectives, type of Tier-0 architecture needed and the locations where the systems should be located***
- ***Decisions on timing and extent of upgrades***
- ***Decisions on the use of resources according to research areas***
- ***Decisions concerning the evolution of the legal entity and its relations with its partners, including:***
- ***Modifications of the statutes***

- ***Decisions on the change of status of partners from general to principal and vice versa, and on the entry of new partners into PRACE***

[PRACE-D2.2.1, 2008]

5.2.3 Public Authorities Board

Definition:

In European research organisations, e.g. Joint Technology Initiatives, it is common to have a Public Authorities Board (or "states representative group", "National States Representatives Group", or "Mirror group") in which the participating Public Authorities are represented.

Consideration:

The reason for this separate board is to eliminate conflict of interests. Public Authorities are often not allowed to participate in a Board of Directors of private companies that are funded by these Authorities. The legal structure of a European ICT RI is often that of a private company under national law, thus preventing Public Authorities from participating in their Board of Directors. A Public Authorities Board circumvents this constraint and allows a proper representation of the interests of the Public Authorities.

Explanation:

With publicly funded Research Infrastructures, the Mirror Group is a means of representing the national funding agencies.

5.2.4 Advisory Board

Definition:

An advisory board is a body that advises the board of directors and management of a corporation but does not have authority to vote on corporate matters, nor a legal fiduciary responsibility. Many new or small businesses choose to have advisory boards in order to benefit from the knowledge of others, but to not encumber them with the rigors of a more formal board of directors.[14]

[14] http://en.wikipedia.org/wiki/Advisory_board

Explanation:

Advisory boards typically consist of scientific experts and/or industry representatives. They advise the Board of Directors on the strategic goals.

EGI:

EGI, in its model of a Memorandum of understanding with a Virtual Research Community (VRC) may require representatives of the VRC to participate in its advisory group.

5.3 Stakeholders

Figure 7: The stakeholders' branch of the governance part of the mind map

Definition:

A […] stakeholder is a party that can affect or be affected by the actions of the business as a whole. […] It defined stakeholders as "those groups without whose support the organisation would cease to exist[15].

Explanation:

The concept of Stakeholder goes beyond that of Shareholder. The shareholders together are the owner of the organisation through a financial transaction. The stakeholders do not necessarily have a financial involvement in the organisation.

In the context of European ICT RIs typical stakeholders are:

- National governments;
- Intergovernmental organisations;
- Government laboratories;
- Academic institutions;
- Research institutes;
- Industry (possibly with a focus on SMEs);
- User Communities;
- Others.

In the context of strategic management, there are different techniques for stakeholder analysis and management in the literature. These techniques provide for a means to classify stakeholders such as leader, partner, strategic partner, supplier etc. and defining the relationship types between the stakeholders and the founding organization.

[15] http://en.wikipedia.org/wiki/Stakeholder_%28corporate%29

MNT:

The stakeholders of MNT RIs vary widely. Some MNT RIs are a part of larger research organisations (LETI-CEA, Fraunhofer VμE-Fraunhofer Gesellschaft) and their stakeholders are the executive board of the research organisation. Other MNT RIs (Tyndall) are closely related to a nearby university and this university is the major stakeholder. Other MNT RIs (CSEM) have shareholders. However, the shares of CSEM are not publicly traded, but are held by local industry and Public Authorities. [IMEC, 2011][LETI, 2011][Tyndall, 2012][CSEM, 2012]

DCI, HPC, Networks

NRENs should consult with all key stakeholders when taking very important strategic decisions. [EARNEST-GOV, 2007]

HPC (PRACE):

The PRACE organisation will have numerous stakeholders and a balance should be achieved between return on investment for stakeholders who financially contribute on the one hand, and a guarantee that the best European scientific and engineering projects will have access to the Tier-0 systems on the other. [PRACE-D2.2.1, 2008]

5.4 Legal Form

Definition:

The legal form of the European RI defines the civil law framework under which it will operate.

Explanation:

The choice of the legal form of the organisation fixes the responsibilities and, hence, its relationships with the outside world.

Depending on the law of the state in which the RI is set up, it can have one of many different legal forms. The selection of the legal form has to serve the purpose of the RI as well as possible.

Independent states can decide to establish an international/transnational/European organisation, but in the end the organisation has to be established in one of the states according to the law of that state. Decisions on the organisation have to be approved by each individual participating state.

An organisation (e.g. a RI) can be established according to public law or private law. If according to public law, it is constituted by a Governmental act; if according to private law it is constituted by free agreement between two or more parties.

[PRACE-D2.1.1, 20008] provides an extensive overview and comparison of legal forms for ICT RIs.

The ERIC framework is a method for a European RI to achieve the advantages of a European organisation without the necessity to elaborate ad hoc treaties.

Considerations:

The European Research Infrastructure Consortium (ERIC) framework is a method for a European RI to achieve the advantages of a European organisation without the necessity to elaborate ad hoc treaties [ERIC-Council, 2009]. The ERIC framework requires the RI to be established in a Member State or Associated State of the EU. If it meets certain requirements, it can apply to become recognised as an ERIC according to a well-defined procedure. Once established, it benefits from some of the advantages (tax exemption, for example) of a European organisation.

The legal form will have implications for the many aspects of the RI, which are listed below [PRACE-D2.1.1, 2008]:

- *Time to Implement*
- *Non Profit Objective*
- *Recognised Legal Personality*
- *European Character*
- *Limited Liability*
- *Suitable Governance*
- *Ownership and Share Transfer*
- *Compatibility with Funding Model*
- *Flexible for Usage*
- *Tax Exemption*
- *Flexible Procurement*
- *Cost to Set up*
- *Personnel*

- *Staff Privileges*
- *Designed for Research.*

The choice of a legal form and legal host country presents a plethora of options each of which has an impact on all the aspects listed above. Preparing an overview of the legal forms and the impact on the different aspects of an RI is beyond the scope of this project.

MNT:

The legal form of MNT RIs is always national. Some MNT RIs have the legal form of a Limited Liability company, some with a retained profit feature (CSEM). The large research organisations to which some MNT RIs belong (CEA, Fraunhofer, etc.) are often organised as foundations under national law. [IMEC, 2011][LETI, 2011][Tyndall, 2012][CSEM, 2012]

DCI, HPC, Networks:

The study has concluded that there are many different governance models in place for the different NRENs, and that the funding and charging mechanisms and the methods of making decisions are also diverse. [EARNEST-GOV, 2007]

The current governance models of European NRENs vary widely, but the most common model is that the NREN is a legal entity or part of a larger legal entity. This model is a sound model: it has proven to work for NRENs and also works for many other types of organisations. By law, a legal entity is able to take decisions autonomously. Nevertheless, when taking decisions the views of key stakeholders have to be taken into account carefully. [EARNEST-GOV, 2007]

HPC:

The report [PRACE-D2.1.1, 20008] describes and compares the different options for a legal form for the PRACE research infrastructure (RI), which is to be established after the successful completion of the PRACE project.

5.5 Rules

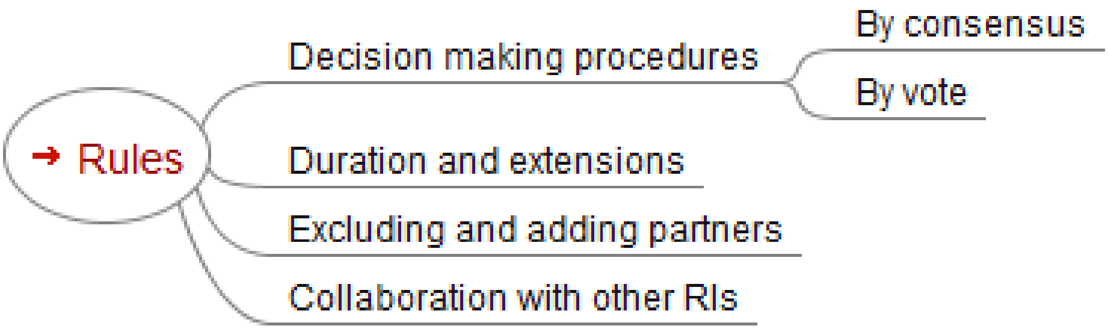

Figure 8: The agreement rules branch of the governance part of the mind map

Definition:

The rules define how the different boards of the governing structure operate and interact.

Explanation:

The agreement that defines the European ICT RI defines the rules by which it will operate. These rules include:

- The decision making procedures;
- The duration of the operation of the RI and possibilities for extending this duration;
- The rules to add or exclude RI partners;
- The collaboration with other RIs.

5.5.1 Decision making procedures

Definition:

The decision making procedures define how decisions should be arrived at.

Explanation:

There are two ways to arrive at a decision:

- By consensus;
- By vote.

5.5.1.1 Consensus-based decisions

Definition:

Consensus decision-making is a group decision making process that seeks the consent, not necessarily the agreement, of participants and the resolution of objections. Consensus is defined by Merriam-Webster as, first, general agreement, and second, group solidarity of belief or sentiment. It has its origin in a Latin word meaning literally feel together. It is used to describe both the decision and the process of reaching a decision. Consensus decision-making is thus concerned with the process of reaching a consensus decision, and the social and political effects of using this process.[16]

5.5.1.2 Vote-based decisions

Definition:

Vote-based decisions are based on the results of a vote on the subject.

Explanation:

The vote is a purely numerically procedure that allows only one interpretation. The vote requires two parameters to be defined in the rules of the RI:

- The weighting of the votes;
- The majority required.

The weighting of the votes can be based on the principle of one partner-one-vote or based on a parameter such as the contribution of the partner. In the latter case, the more the partner contributes, the more its vote weighs. A definition of the way to convert the parameter(s) into the voting weight needs to be established.

In the literature, one of the most used methods to determine weights is the Analytic Hierarchy Process (AHP). In this method, relative weights are expressed by pairwise comparisons such as partner a's contribution is three times more important than partner b's contribution and a matrix is constructed. The AHP method then calculates the relative weights of each partner in accordance with the consistency index. The following matrix shows the relative importance of the partners and the weights calculated according to the

[16] http://en.wikipedia.org/wiki/Consensus

AHP method are also depicted (the yellow part is the pairwise comparison and the white part is the inverse of each of them).

	Partner a	Partner b	Partner c		Weights of Partners
Partner a	1	3	2	a	0,5
Partner b	1/3	1	2	b	0,3
Partner c	1/2	1/2	1	c	0,2

Figure 9: AHP method for determining the relative weights of partners

The majority is the fraction of the total votes minus abstentions that is required to accept a proposed decision. A simple majority requires 50% of the votes minus abstentions, unanimity requires 100%. Simple or 2/3 majorities are the most common majorities.

5.5.2 Duration and extensions

Explanation:

The organisation can have a predefined limited duration. Possibly the duration can be extended. The way to extend the duration is defined in the Agreement.

European ICT RIs often have a long or unlimited duration or else a possibility for extension exists.

Considerations:

The funding outlook could influence the duration for which a Research Infrastructure is foreseen.

5.5.3 Excluding and adding partners

Explanation:

The number of partners that participate in a European ICT RI can vary over time. A certain number of partners sign the agreement that establishes the RI and after it has become operational other partners may wish to join. On the other hand, partners may not meet their obligations. The rules of the agreement should describe if and how partners can be added to the RI (financial conditions, IPR, etc.) and when and under what conditions partners are excluded.

DCI, HPC, Networks:

Many NRENs have expanded the communities that connect to their network or are in the process of doing so. NRENs have moved away from connecting only universities and research establishments and may connect schools, hospitals, commercial science parks etc., or they have plans to connect such new communities of users. In such cases, an explicit decision to connect a particular new user community has to be made. This decision could be contentious if the current NREN user base is not happy with the NREN expanding its activities into other areas and thereby possibly diluting its support effort. The way decisions are made about connecting new communities of users is therefore important. In the survey, 64% of the NRENs indicated that they are planning to connect new types of user institutions. The other NRENs have already connected new types of institutions and have no further plans for connecting others, or they still only support the research and education communities and have no plans yet to connect new types of user institutions. [EARNEST-GOV, 2007]

5.5.4 Collaboration with other RIs

Explanation:

The agreement should include rules that govern the interactions of the European ICT RI with national RIs in the same field. If European RIs exist that are working in fields that have some synergy, the collaboration with these RIs should also be defined in the agreement.

DCI, HPC, Networks:

It is clear that the majority of NRENs that responded want to be involved in the development and setting of European research and education networking policies, but only wish to implement European policies when they are in line with existing and/or future policies of the NREN. In other words, the majority of the responding NRENs do not wish to be subservient to European research and education network policies, even though they themselves have an influence on the development and setting of European research and education networking policy through bodies such as the NREN Policy Committee. [EARNEST-GOV, 2007]

6 Sustainability

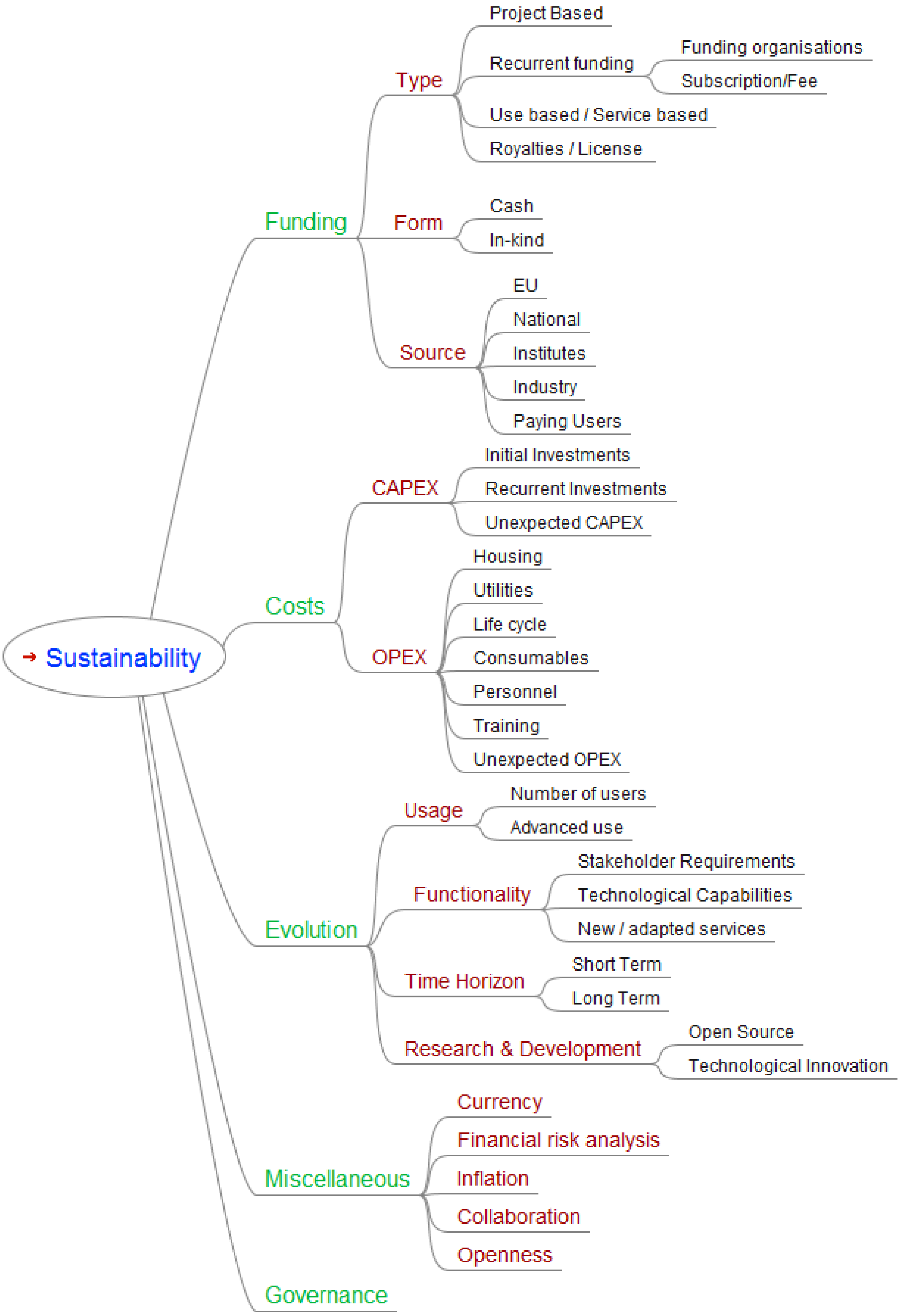

Figure 10: The sustainability branch of the mind map

Definition:

Sustain is a synonym for maintain and support. Sustainability can be defined as the potential for long-term maintenance by providing the necessary means to reach this goal. Sustainability of an e-Infrastructure can be defined as the potential to maintain that e-Infrastructure for a long period of time. A collection of parameters has to be taken into account at the stage of the founding of that e-Infrastructure and/or at a later stage to ensure this sustainability.

Explanation:

The sustainability parameters mentioned in Figure 10 have been defined by using available literature on founding and sustaining e-Infrastructures. Funding, costs, evolution and the choice of a governance structure are seen as the mainstream parameters for building a sustainable e-Infrastructure. Establishing the funding model of an e-Infrastructure is a difficult exercise. Costs have to be well known or carefully estimated in order to be able to know how much funding is needed. Adequate governance should facilitate the funding process, convince and assure stakeholders of the sustainability of the e-infrastructure. Evolution of an e-Infrastructure is imperative to ensure sustainability and needs to be realized at the technical level, the service level and the usage level.

Considerations:

Sustainability is a very important aspect to consider when founding an e-Infrastructure. Founding and operating an e-infrastructure is an expensive task both in CAPEX and OPEX. This effort cannot be justified if the e-infrastructure cannot be sustained. Sustainability is also an essential element for user take-up. Users will not make the effort of starting to use a new e-infrastructure if they do not have the guarantee that this e-infrastructure will exist for a number of years, e.g. the time needed to prepare a PhD thesis or the term of a project. This holds true even if it is advantageous to the user to use the new e-infrastructure. All components of sustainability mentioned above apply to all ICT infrastructures but some infrastructures, such as data infrastructures, might add requirements on contents and content management to that list. The latter may also have an inherent demand for a very long lifetime sustainability with inclusion of adaptations to technology changes during that lifetime.

DCI, HPC, networking and data infrastructures:

"The sustainability of e-Infrastructure services must be guaranteed if user communities are to rely on them in the long term." [e-IRG-RMP, 2010]

Data infrastructures:

"The various stakeholders - administrations, the scientific, education and learning communities, the private sector and the general public – should have well-founded confidence that the infrastructure is reliable, delivers value for money, can adapt to change as technologies and science move on and that it continues to collect and preserve securely Europe's great scientific heritage and core information (which plays an increasingly critical role this century, as we face critical threats such as climate change and biodiversity loss).The repositories should have a capacity or associated framework to support the long-term sustainability of collections, be trusted, and to guarantee the authenticity of stored materials and cope with changing levels in demand." [e-SciDR , 2008]

"Sustainability of repositories, data collections, indeed of our wider information infrastructure and heritage depends on good collection management and responsible stewardship. It will be impossible to keep everything. Collections policies, management of these policies, and co-ordination of policies and stewardship over the appropriate dimensions, and underpinned by far-sighted collections governance, are of critical importance, both for the quality of collections and for the sustainability of collections and repositories (in the short term, and over time). Aside from geography, both the compound nature of many e-Science objects and the increasing capability to span over the various stages of an information bundle, from data to processed data to publication, mean that collections policies and management will need to be conducted across what are at the moment multiple organisational and professional levels." [e-SciDR , 2008]

6.1 Funding

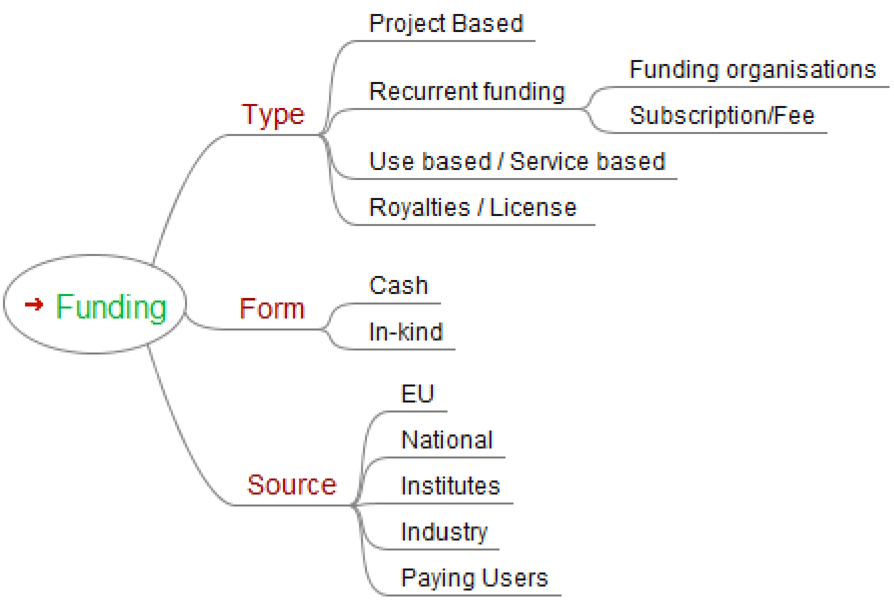

Figure 11: The funding branch of the sustainability part of the mind map

Definition:

The definition of a fund in the context of this project can be taken from the Webster's Dictionary as: "a sum of money or stock of convertible wealth employed in, set aside for, or available for a business enterprise or other purpose".

Explanation:

Funding and income are used almost interchangeably in most ICT Research Infrastructures. Although, income is technically the most applicable term, the term funding will be used throughout this Section as it is more widely used.

The set-up of an e-Infrastructure requires a study about how its funding can be realized (type), what form the funding can take and which sources of funding (source) are available. The funding model will be an essential part of the business model of the e-Infrastructure. For international e-Infrastructures funding at national as well as funding at European level has to be considered.

Considerations:

The funding model will be an essential part of the business model of the e-Infrastructure. For European e-Infrastructures funding at national as well as funding at European level has to be considered.

Funding, and especially stable long term funding, is essential for the sustainability of an ICT infrastructure. A funding mechanism is the basis for any business model for which an ICT infrastructure may opt. Several types of funding exist and in most cases the business model will combine those different funding types. Experience with setting up and maintaining ICT infrastructures has shown that project based funding alone is not sufficient to guarantee sustainability and that long term recurrent funding is necessary for sustainability. Moreover it will be easier to found an ICT infrastructure if the funding mechanisms are well thought through and well defined at the start. For European e-Infrastructures, funding at national as well as European level has to be considered. However, as can be deduced from the quotations below, it is often very difficult to get guarantees for multi-annual funding.

Users and users' communities contribute explicitly (with fees, as occurs for network RI) or implicitly (by sharing efforts, as occurs in grid/cloud RI) or do not contribute at all (as in the current scientific excellence model in PRACE); the responsibility for the contribution is generally left to the Research Institution they belong to or their National Representative (NREN, NGI).

Networks, DCI, and HPC:

Funding should be sufficient to enable efficient performance and service in distributed environments. [e-SciDR , 2008]

The funding should cover the development and maintenance of services and tools to support easy, rich use of the repository holdings. [e-SciDR , 2008]

Funding for quality: The funding should cover provision for curation of holdings, where appropriate, and other quality measures. [e-SciDR, 2008]

MNT:

Industrial funding alone is never sufficient to maintain a state-of-the-art MNT technology base. Public funding is needed to develop new technologies and processes. [IMEC, 2011], [LETI, 2011]

DCI, HPC, Networks and data infrastructures:

"If one wants NRENs to develop in a cost-effective and efficient way, then the ability of NRENs to plan ahead is very important. Many NRENs are only setting annual budgets. It is recommended that all NRENs set multi-annual budgets covering a period of at least three years, even if their funding organisations do not guarantee a budget over this period. If NRENs are not provided with multi-annual guarantees of funding, they should enter a dialogue with their funding organisations in an attempt to improve the budget planning and commitment process, so that longer-term (multi-annual) budgets can be agreed and set." [EARNEST-GOV, 2007]

"The study has concluded that there are many different governance models in place for the different NRENs, and that the funding and charging mechanisms and the methods of making decisions are also diverse. Many NRENs do not have budget planning in place for more than one year ahead, which potentially could lead to problems when planning medium- and long-term programmes for network service developments and upgrades." [EARNEST-GOV, 2007]

"European funding policies may need to be adjusted to enable research e‑Infrastructure services, and the applications using them, to more readily adopt new architectures and programming techniques, without compromising stability and reliability." [e-IRG-RMP, 2010]

"The financial stability of the EIROs derives from the long-term funding models laid down in their founding agreements. The two pillars are adequate funding and stability of funding. Stable funding enables prudent and economically sound choices and long-term planning". [EIROForum, 2010]

"Due to the interdependencies within the EGI ecosystem, this new direction offers a unique opportunity for creativity and flexibility to keep cash flowing between the EGI community, who could serve as both consumers and providers. By implementing a combination of business models and the necessary tools to support them, the relevant products and services needed by the user community will inevitably be brought to the surface. Consequently, any unnecessary ones will automatically be streamlined through exploiting free market forces. Ultimately, these practices will not only reduce costs and effort, but also create opportunities to meet the needs of new users, expand and refine products and services, forge new relationships and review current practices. A challenge to any business model discussion will be the difficulty in changing the mentality around charging for a service that has been 'free' to its user community for the last decade. Either way, a realistic discussion needs to take place now, especially given the complexities of the infrastructure and ecosystem, in order to properly position itself in market for the long-term." [EGI-D2.7, 2011].

"The EU has invested heavily in e-Infrastructures over the past decade. In fact, due to the e-Infrastructure's community dependence on public funding sources, further change is being forced upon it. It is clear that public funding of all activities is coming under increased scrutiny in the current economic climate and dependency for maintenance and general operations is expected to decrease with each passing year. As coordinating and maintaining high-quality infrastructure costs money, the focus in the EGI-DS and now EGI-InSPIRE projects has been to move towards ensuring sustainability, therefore transferring recurring operational costs to the communities that benefit from it is the logical next step. Users (or their NGIs or institutions) will eventually need to pay in some form or another for the resources they currently use for 'free'. As the community shifts to a more service oriented model, the pressure on the providers to ensure that the services offer 'value for money' will certainly increase, as will the community's ability to compare costs to commercial cloud providers and evaluate the value that e-Infrastructures provide. The revenue gained from charging for service use will make it easier for those services to be maintained sustainably, and for user communities to focus on research rather than being involved in running the services they use. Opportunities will also arise for the community members to provide the necessary services as well." [EGI-D2.7, 2011].

"We recommend that the European Commission urge member states and their agencies to provide funding for e-Science digital repositories, which is specific to their role and function as digital repositories. This funding should be stable and rolling, and of a duration to match the duration of the repository's role or of its holdings. The funding should be sufficient to support and maintain the repository holdings, individually and as collections, to provide quality services and support to users, and provide good management at repository level, which can deliver continued, efficient, rich, easy-to-use access to trusted, quality materials. This will entail the provision of funding at levels beyond the repositories themselves." [e-SciDR , 2008]

"The e-IRG notes the importance of the steps undertaken by the EGI and PRACE initiatives to promote sustainability of the computing-related e-Infrastructure such as the development of policies, business models and funding schemes for the new required structures. e-IRG recommends that adequate levels of funding should be granted by the EC and Member States for the development of the new structures both on national and European level." [e-IRG-WP, 2009]

"For the successful launch of EGI initial co-funding by the European Commission will be necessary. The major purpose of this co-funding is to bring all the players—NGIs—together, not to substitute for national funding which is the basis of EGI financial stability and sustainability. Full sustainability of the EGI operations should be eventually achieved using national funding only, helped by the expectation that effort to operate the grid can be gradually decreased thanks to streamlining and automation. However, in the highly dynamic environment of distributed computing, EC funding for innovation has to continue — most logically on a project basis." [EGI-BP, 2008]

"The e-Infrastructure should support easy and reliable submission of materials for science, research and learning into known, trusted repositories through the whole science, research and education cycle, providing confidence that the materials will be well and securely stored, maintained, and not abused. Scientists with data to deposit should be able to do so with ease, supported by timely guidance and tools to help create sufficient quality metadata. They should be assured of their prior right to recognition and a defined period of privileged use (where applicable).

_ The repository infrastructure should be funded adequately for service provision and sustainability.

_ Europe's infrastructure of repositories should deliver services equally across the whole of Europe and participate as (a) partner(s) in the wider global e-Science information infrastructure. "[e-SciDR , 2008]

"Funding structures for services and shared facilities: Services to support access to data, efficient retrieval and use of objects in repositories, may be built and/or maintained independently, in coordination with, or by, the repositories. In other words, the funding beneficiary might not be the digital repository itself, but an external expert and/or grouped supplier. The study's findings also show examples of and opportunities for grouped or centralized development and provision of services, where funding goes to a single unit, servicing many." [e-SciDR , 2008]

6.1.1 Type

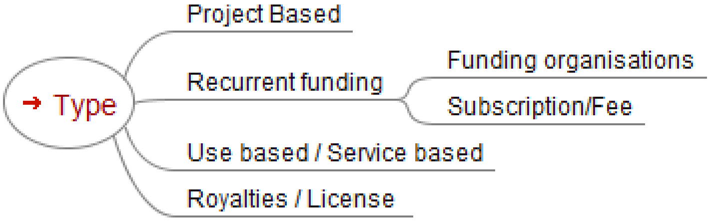

Figure 12: The 'Type' branch of the sustainability part of the mind map

Definition:

In the scope of this document we will define “type of funding” as the contract model that is used for granting funding to an e-Infrastructure.

Explanation:

Funding of an e-Infrastructure can be done in different ways. We identified project based funding, program based funding, use based funding and income from royalties and licences as the main possibilities. Weighting of contributions is an aspect that needs to be considered when defining sustainable funding of a European e-Infrastructure.

Considerations:

The four main funding types, project based, recurrent funding, usage based, royalty/licence funding, shown in Figure 12, all have their advantages and disadvantages. Most often a combination of these funding types is needed to arrive at a balanced business model. Main directions in the choice of these funding types are that stable recurrent funding is aimed at paying the exploitation and normal running costs of the e-Infrastructure while project funding is asked for innovation purposes and user or user community fees are charged for anything other than basic services. Project based funding and use based funding have almost equal disadvantages in that they are difficult to estimate for the yearly budget. Royalty/licence funding is only applicable in a limited number of cases (but it could provide a stable income) and is more long term than the other sources of funding mentioned.

DCI, HPC, Networks and Data infrastructures:

"The initial stages of international discussions about a large European infrastructure will focus on the scientific nature of the project, the general characteristics of the project site, and a preliminary cost estimate. As the discussions advance and a seriously committed set of potential Partners emerges, an accurate cost will have to be agreed on, as well as the details of the financial rules and procedures. The goals of these advanced discussions concerning funding and contributions will be: [….]:

6. To decide on how the operations of the completed infrastructure will be financed, including the handling of external income, if any (e.g., in the case of a user facility, payments received for services provided to private enterprises)." [OECD-GSF, 2010]

6.1.1.1 Project Based

Definition:

Project based funding means that the corresponding money is granted on the basis of a project at national or European level and is regulated by a description of work, distributed among partners, that has to be executed in a certain timeframe. The partners of the project are paid relative to the amount of work they have to do. In principle it is possible that there is only one partner in a project; however project funding rules in the European research environment often require the participation of several partners.

Most project based funding is won after competitive bidding. This means that the funding organisation has a fixed budget and invites project proposals for funding. Only projects that best meet the criteria of the funding organisation will be funded. This makes it difficult to consider project funding as a stable form of funding.

Explanation:

Most European countries have national (and/or regional) agencies that fund research or research oriented activities. Those agencies often realise funding through a project procedure. This is also the case for the European Commission where calls for projects take care of the budget allocation (such as the framework programmes). The different programs of the Commission (framework programmes, the ERA net, etc.) are handled by different departments that can for, for all intents and purposes, be considered as independent agencies.

Considerations:

Project funding at national and/or European level can be used during the foundation of a research infrastructure or an e-Infrastructure. However such funding will not be sufficient to guarantee sustainability of the infrastructure because they are limited in time. Dependence on the prolongation of the project or a follow-up project cannot be considered as a good basis for sustainability. In addition to realising the start of an e–infrastructure, project funding can be a solution to realise innovation and follow-up of technological improvements. Project funding is also an additional motivation for all stakeholders to contribute to the infrastructure so providing extra collaborators who can take part in innovations and access new services.

It has happened in the past that project funding was so specifically targeted that in practice only one applicant/consortium could apply (e.g. some projects for Géant, and PRACE). In practice, these projects were awarded on an almost non-competitive basis and had the characteristics of recurrent funding.

DCI, HPC, Networks and Data infrastructures:

"Therefore, almost all of these infrastructure projects had to repeatedly request supplementary support grants to continue operating, administrating, and maintaining the e-infrastructure. Although this process has some advantages, it also comes with considerable overhead costs for both researchers and funding organisations, which not only decreases the efficiency but also put these projects at jeopardy. In order to overcome this and create self-sustainable projects, some of the e-infrastructures introduced a membership-fee business model, seeking to cover the operational and upgrade costs, and to secure continuous, long-term revenues." [ANNTEL, 2010]

"This is a model frequently used by public funding bodies (e.g. research councils) that are willing to commit expenditure for a specific activity for a defined duration. In considering this model, it is essential to identify the initial stakeholder(s) willing to pay for the work and how the general community and its investor would benefit from the work. It also opens up opportunities for commercial involvement through pre-competitive research through joint collaborations or development of specific products or services ultimately driving innovation and economic stimulus." [EGI-D2.7, 2011]

MNT:

The competitive project based funding is essentially the only source of EU funding available in the field of MNT.

The project type of funding is totally incompatible with the operational mode of a MNT RI that has very high fixed OPEX costs and whose equipment lifetime well exceeds the duration of an EU project. This latter incompatibility also means that the RI has to pay for a proportion of the equipment lifetime beyond the duration of the project. With a typical project duration of three years, this means that the RI has to pay for the equipment for the lifetime period even when it is no longer state-of-the-art. The situation is even more problematic as the EU has concluded that MNT is a mature field of technology and therefore will not support development projects in this field. It has therefore become extremely difficult to find EU projects that contribute to the support of the high operational costs of existing MNT RIs. [CSEM, 2012]

6.1.1.2 Recurrent funding

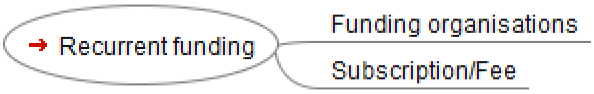

Figure 13: The recurrent funding branch of the sustainability part of the mind map

Definition:

Recurrent funding is defined here as funding provided as a fixed budget line item that is often regulated by an agreement, contract, Memorandum of Understanding (MoU) or other document that specifies the modalities and duration of funding.

Explanation:

Recurrent funding is considered as the most important funding of a sustainable e-Infrastructure. It comes mainly from funding organisations or partners of the ICT RI infrastructure who pay a subscription or a fee on an annual or multi-annual basis. The subscription or fee can be equal for all contributing parties or can be based on a system of "weighted contributions". In this latter case the fee is calculated following a certain key that is parameter based. For example if a subscriber is a country, GDP or a GDP related formula is often used as the parameter for calculating the level of contribution.

Considerations:

As explained above, project funding is not sufficient to make an e-Infrastructure sustainable at the financial level. Recurrent funding on a long-term basis is essential. Certainly for a European e-Infrastructure the recurrent funding does not have to come from one source. Recurrent funding can or even has to be provided by stakeholders of the infrastructure. The funding levels recurrent funding programs are by no means guaranteed, but any changes of funding level will be announced well in advance. Ideally, the recurrent funding time horizon should extend beyond the next investment for a major technical upgrade

6.1.1.3 Use based / Service based

Definition:

A use based or service based funding model depends on assigning a cost to the use of a resource or service made available by the infrastructure directly or indirectly via particular groups (real or virtual).

Considerations

Usage of the e-infrastructure or of a service can be on a "pay as you go " basis or on a freemium basis where the user gets a basic use for free and pays for additional service. Use or service based funding is not applied in most of the existing ICT RIs with the exception of MNT. The whole context of use based/service based funding is detailed in section 6.1.3.5.

6.1.1.4 Royalties / License

Definition:

The royalties or license income is the income that comes from the valorisation of the Intellectual Property Rights of the European ICT RI.

Considerations:

Apart from the field of MNT, this type of income is almost non-existent for European ICT RIs. The major reason is that other European ICT RIs in general do not perform research that could generate IPR. These infrastructures perform more operational and short term development activities.

MNT:

The business model of LETI is to have its largest and most stable source of income from royalties and licence income. Their target is to have more than 50% of their income from royalties and licenses. In order to achieve this, LETI tries to maximise the number of patents that can be deposited by its people. The number of patents deposited is the most important key performance indicator of LETI. A customer that works with LETI almost inevitably has to make use of one of the patents in LETI's large portfolio. So, when this customer wants to go into production it has to agree to royalties or license fees in order to be able to continue to use this patent. [LETI, 2011].

IMEC acting on various phases along the R&D life cycle uses a financial model being adapted for each of such phases. Briefly, one may state that for early life cycle (precompetitive) activities, the financial compensation is a mix of margin, overhead and direct costs and an upfront fixed payment for IP rights. For later life cycle activities (development on demand, technology transfer and even IP monetization), shifting the background payment, in a delayed payment scheme (e.g. royalties) is possible. The key features of the valuation policy is to be consistent over the entire portfolio of contracts, compensation for know-how access and a realistic estimate of the risk on deferred payments. While today focus is on early life cycle activities wherein only a portion of the financial retribution is IP based, the tendency towards another balance early versus late activities (and hence a more IP centric valuation) is present. IMEC therefore invest in further strategic value oriented development of its patent portfolio. [IMEC, 2012]

6.1.2 Form

Explanation:

The form in which the funding arrives can be either cash or in-kind.

Considerations:

For most ICT Research Infrastructures cash is the preferred funding form. In kind contributions in the funding algorithm can become very difficult to implement, especially for the usage/service based funding as a service might be used occasionally or irregularly so that bartering becomes nearly impossible. In kind funding for personnel that are located at the funder's site can also become a problem especially when the corresponding tasks are not well defined or control of the executed work is not possible.

6.1.2.1 Cash

Definition:

Webster's dictionary defines cash as "current money in hand or readily available". In the context of funding of e-Infrastructures we define "cash funding" as the money that is made readily available to the e-Infrastructure project partners regulated by the project contract.

Considerations:

Cash is the most used payment type in project funding. Each project partner receives a well-defined sum of money to execute well-defined tasks. In international projects fluctuations in currency values can result in a shortfall in the partners' real budget.

6.1.2.2 In-kind

Definition:

In-kind contributions are contributions that are not paid in money or money equivalents.

Considerations:

The 'in kind' model is in fact a barter based model where individuals exchange services when the value of the services is defined dynamically by the parties involved in the transaction of comparable value or mutual interest on a trust basis. Neither party is "paid", but receives something that would only have had to be converted to physical currency. Clearly the parties concerned need to identify services that they are willing to exchange and define a way of ensuring that the values of the services exchanged are equal – either in a single transaction or over the longer term as part of a series of transactions. Such a barter model is not always ideal for the sustainability of an ICT RI because it is a funding source that does not give the possibility to the ICT governance of using the funding as they see best fit. This also needs a very detailed and well thought through contract to minimize the malfunctioning of this funding form.

DCI, HPC, Networks and data infrastructures:

"In-kind contributions: These fail to compensate for membership fees and never cover the full costs of the infrastructure. They are therefore insufficient to operate a large infrastructure and impair operational flexibility. However, in the right circumstances, in-kind contributions can serve useful functions in enabling technical upgrades and broader international support for the RI." [EIROForum, 2010]

MNT:

In the case of MNT, equipment can be an in-kind contribution. This happens when an equipment vendor places a piece of equipment at the site of the MNT RI at no cost; sometimes even providing technical support as well. In exchange, the MNT RI will use this piece of equipment in the development of the newest fabrication technologies and will communicate the results of the equipment performance to the vendor and possible clients.

6.1.3 Source

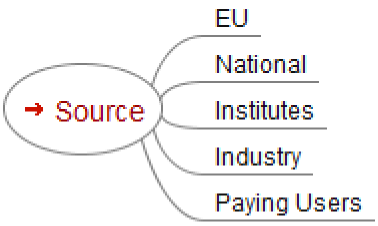

Figure 14: The source branch of the sustainability part of the mind map

Definition:

Source in this context can be defined as: "the initiator of a payment".

Explanation:

The source of funding can be manifold; possibilities are the European Union, countries, institutes, industry and users. At the EU as well at the national level several funding schemes exist.

Considerations:

Experience shows that European e-Infrastructures most often use a combination of these sources to guarantee their sustainability. Much debate is on-going as to how much should be funded by each of these different sources and for which part of the e-infrastructure a particular source should pay, e.g. the EU pays for innovation, the national government pays for the recurrent costs, the user or the user community pays for a particular service. At EU level, as well as at the national level, several funding schemes exist. National funding schemes can be very different-- including the conditions attached.

Users or user communities paying for the use of an e-infrastructure or even for the set-up of an e-infrastructure is subject to a lot of debate about funding, innovating, etc. in ICT RIs. When the source of funding is the user or the user community, these users are often in turn funded by public funding. The argument for this discussion is to give a voice to the user in the operation and evolution of the RI.

Funding from industry is in general restricted to the case of MNT where it is very important (up to 60%). Although other European ICT RIs are also increasingly considering this as a minor source of extra funding, it is still marginal (typically less than 5% of the funding).

6.1.3.1 EU

Definition:

EU stands for European Union.

Considerations:

The e-Infrastructures activity, as a part of the Research Infrastructures programme, focuses on ICT-based infrastructures and services that cut across a broad range of user disciplines. It aims at empowering researchers with an easy and controlled online access to facilities, resources and collaboration tools, bringing to them the power of ICT for computing, connectivity, storage and instrumentation. Funding for e-infrastructures can be obtained via the 7th Framework Programme (FP7) and in the future Horizon 2020. Under FP7, the e-Infrastructures activity is part of the Research Infrastructures programme, funded under the FP7 'Capacities' Specific Programme. It focuses on the further development and evolution of the high-capacity and high-performance communication network (GÉANT), distributed computing infrastructures (grids and clouds), supercomputer infrastructures, simulation software, scientific data infrastructures, e-Science services as well as on the adoption of e-Infrastructures by user communities. E-infrastructures, such as Géant, EGI and PRACE have reserved calls under this programme. The funding in this programme focuses on innovation and new services and will not fund operational tasks and in most cases not the hardware (computers, etc.). The EU does not have any special support programs for MNT, as it considers this technology to have reached maturity. This argument overlooks the fact that MNT OPEX is very high, even without new technology developments. The operational MNT RIs are continuously fabricating new devices that are often enablers of larger systems.

There is also the European Regional Development Fund, the so-called structural funds which can be accessed by national public bodies and used for the funding of e-infrastructures.

6.1.3.2 National

Definition:

National means “at the country level”

Considerations:

Information obtained from the OSIRIS partners shows that national funding programs dedicated to ICT infrastructures do not exist. Often, national funding for ICT infrastructures has to be found in programs that fund research infrastructures in general and/or large funds that are available for supporting universities and research organisations. The funding does not always cover the whole cost of the infrastructure, we see a variation of between 75% and 100%. Sometimes the funding only allows a one-shot capital investment, while others propose 75% for initial investment and 25% for recurrent investment. Sometimes personnel to install the infrastructure can be paid for from the funding but not personnel for the daily operations. International participation is sometimes allowed.

MNT:

For almost all MNT RIs, national funding is the most important source of public funding. Without national funding, most of today's MNT RIs would not have existed.

6.1.3.3 Institutes

Definition:

According to Webster's Dictionary, an institute is an established organisation or society pledged to some special purpose and work.

Considerations:

Certainly, at the national level individual institutes have often directly contributed to national, and thus often indirectly to international, infrastructures. For example, universities and research organisations pay a fee or participate in the connection costs to the National Research Infrastructure. Universities and research centres provide the computing resources for the National Grid Infrastructures. Less often, institutes directly fund international ICT infrastructures. An exception is the PRACE infrastructure, where large centres provide resources directly to the supercomputing infrastructure, albeit as a contribution of a national delegation from their country. Although in many cases the money from the institutes comes from the government, we still consider this as institute money because the institute decides on what to do with this government money as it has the freedom to use it for other purposes (not related to ICT RIs).

6.1.3.4 Industry

Definition:

Industry is a special branch of productive work.

Considerations:

Direct investment of industry in ICT infrastructures is very unlikely in many cases. In the classical e-Infrastructures, such as networks and computing infrastructures, the ICT industry is eager to get into these environments, but only as a supplier. Industrial research is often not interested in using e-infrastructures (e.g. computing resources), with their lack of security being one of the main reasons given for not using them. However, this is different for the micro- or nanotechnology infrastructures where intensive industrial cooperation is the rule.

MNT:

Industry is likely to be the largest single source of income for an MNT RI. Most of the income from industry comes in the form of development projects, in which the industry pays for the development of new technologies and devices. LETI uses a model in which it tries to patent all its technological capabilities, so that the industrial customer has to pay royalties or license fees once it wants to produce a device or technology developed at LETI. Other RIs valorise their patents through increased margins on development projects. [IMEC, 2011][LETI, 2011][Tyndall, 2012][CSEM, 2012]

6.1.3.5 Paying users

Definition:

Paying user refers here to the user of an e-infrastructure who contributes to the funding of that e-infrastructure by paying for his/her use.

Considerations:

The discussion of users paying for their consumption of network bandwidth, computing cycles or bytes of storage and related service has recently been held at the management boards of several e-infrastructures and at the meetings of policy bodies related to e-infrastructures. However, this discussion is not new and has been on the agenda in the past. It is also likely that this possible source of funding is addressed at times of economic crises that often have, as consequence a reduction in national and/or international funding. One of the arguments for having users pay for e-infrastructure services is that users who are given the possibility to pay for a service can choose the service that best fits their needs, at the best price. A paying user could also request participation in the governance of the e-infrastructure and thus have the possibility to adapt or change the e-infrastructure. It is however not an easy task to deploy such accounting practices at the individual level. The technical and administrative overhead that will have to accompany such a policy might exceed the financial gains. Furthermore, the funding programs are not adapted to such an approach. Instead of having an individual researcher paying for e-infrastructure services it might be more interesting to have a user community partly funding the e-infrastructure, for use by its community members. This might be a good solution at all levels: easier to charge than individual users, easier to incorporate in a funding policy and easier to integrate in the e-infrastructure governance. Moreover the establishment of well recognised user communities would foster international collaboration at research level as more researchers would be glad to enter such a user community.

DCI, HPC, Networks:

"Where possible, NRENs should aim to simplify user-institution charging models, while maintaining transparency and fairness of charging." [EARNEST-GOV, 2007]

"A well-known debate is the question of central funding (direct financing by the government or a government agency) versus user charging (i.e., payments by the connected institutions). It has been argued that at the early stages of the establishment of a national research and education network it is essential that the activity is almost entirely centrally funded. Once the research and education networking organisation and its services have become well-established, the organisation can be positioned more at arm's length from the government and a certain amount of user-institution funding can be introduced, thereby also giving the connected institutions more influence on decision making. EARNEST indeed found a trend towards a higher proportion of user-institution funding in a few countries, but in most countries the funding models, although mutually very different, seem quite stable. In one country, the plan was to slightly reduce the proportion of user-institution funding. "[EARNEST-chal, 2008].

"Partial funding by connected institutions is a viable model, but it needs to be treated carefully. For upgrades of the network and for the development and deployment of innovative services, a certain amount of central funding is often indispensable." [EARNEST-chal, 2008].

6.2 Costs

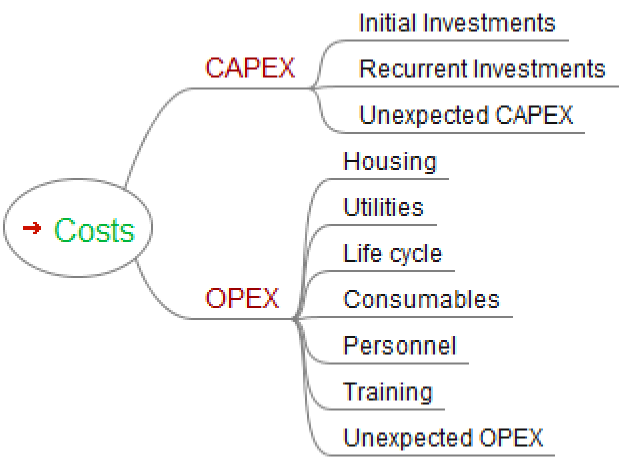

Figure 15: The cost branch of the sustainability part of the mind map

Definition:

Cost in the context of this document can be defined as “to be priced at”, “transfer of funds required as the price of possession”.

Explanation:

The costs needed to run an e-Infrastructure have to be estimated as accurately as possible. Capex (Capital expenditure) and Opex (Operational expenditure) are the main components of those costs. Capex consists of the initial capital expenditures needed to set up the e-Infrastructure and of the recurrent capital expenditures that will be needed to upgrade the e-Infrastructure. The procurement of software should also be considered as capital expenditure. Unexpected Capex needs to be estimated in order to be able to react for example, to a situation when a quick uptake of the e-Infrastructure demands upgrading the equipment in a shorter timeframe than foreseen. Opex includes housing and energy, maintenance of the e-Infrastructure, consumables and personnel. It is also safe to foresee some unexpected operational costs.

Considerations:

CAPEX and OPEX are important factors to consider when setting up an e-Infrastructure. These are key in defining the required level of initial and recurrent funding and key to a sustainable infrastructure. They need to be very carefully considered and agreed when founding an ICT RI.

All ICT RIs:

To agree on the total cost of the infrastructure: It is likely that the definition of what constitutes the "total cost" will differ significantly from country to country, so it will be important to arrive at a common understanding of the cost model, and to recognize the practices, requirements and constraints that apply among the partners. The issues that will need to be discussed could include: whether to include the effects of inflation over the anticipated time span of the project (which can increase the total amount to a very significant extent); whether a contingency factor should be included to cover unanticipated expenditures (a difficult matter to reach agreement on, given that it is treated quite differently in various countries); whether to consider separately "new expenditures", as opposed to items like in-kind contributions of already-existing equipment, or the salaries of persons who will work on the project, but who are employed by national laboratories or universities, and are already budgeted for. [OECD-GSF, 2010]

Networks:

"From an economic point of view, and assuming that there is a competitive market supplying the network elements, telecommunications networks are characterised by having very high capital costs, relatively moderate operational costs and quite granular incremental costs. In this context, granular means that the changes in network capacity are not smooth; increases in capacities come in discrete 'chunks'." [EARNEST-ECO, 2007]

"Transmission costs. These are the costs of circuits to interconnect the nodes on the GÉANT2 network as well as the costs of connections between Europe and other world regions. In GÉANT2, many of these are provided via fibre that has been acquired and lit by the GN2 project. Where this is the case, the investment in the DWDM transmission systems that are necessary to provide capacity is regarded as a hardware cost. However, there remain high-speed connections (2.5 Gb/s and 10 Gb/s) that are leased from telecommunications operators as well as lower-speed connections for which leasing on an annual basis is the only practical way of implementation; typically, such connections incur hardware costs only for routing and switching." [EARNEST-ECO, 2007]

"Cost analysis could be used as tool for designing different levels of services associated with different costs for the user. Moreover, cost information could be used as a proper input for ROI models assessing the Grid long-term economic impact." [e-IRG-D4.3, 2011]

6.2.1 CAPEX

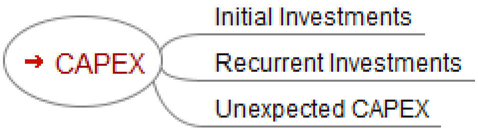

Figure 16: The CAPEX branch of the sustainability part of the mind map

Definition:

Capital expenditures (CAPEX or capex) are expenditures creating future benefits. A capital expenditure is incurred when a business spends money either to buy fixed assets or to add to the value of an existing fixed asset with a useful life extending beyond the taxable year. CAPEX is used by a company to acquire or upgrade physical assets such as equipment, property, or industrial buildings.[17]

Explanation:

Three types of capital expenditure have been taken into consideration, namely initial investments, recurrent investments and unexpected CAPEX. Initial investments and recurrent investments are thought to be the main factors in defining the required start and recurrent investment capital whilst a provision of funds should be foreseen in case of unexpected investment costs.

[17] http://en.wikipedia.org/wiki/Capital_expenditures

Considerations:

CAPEX and its subtypes can be very different from e-infrastructure to e-infrastructure. If an e-infrastructure is distributed, there can also be important differences in the sum of money needed in different countries. Attention should be paid to the fact that capital investment is not only needed for equipment but that housing maintenance, energy utilisation and software are also items that should be taken into account in certain cases.

MNT:

The cumulative investment for a state-of-the-art nanoelectronics production cleanroom is in the multiple billions of Euros range. For a research cleanroom with less equipment duplication, the required investment is in the 500 to 1000 M€ range. This investment requirement doubles approximately every three years. Recurrent CAPEX is in the tens to hundreds of millions of Euros range. The lifetime of a state-of-the-art nanoelectronics cleanroom is typically 7 to 10 years. This implies that a Nanoelectronics facility needs to invest funds in the billion Euro range every 7 to 10 years.

The financial burden is somewhat lightened by the fact that equipment manufacturers are very interested in placing equipment for free or at very low cost at the RI. In return, they get very useful data about the performance of their equipment in a complex environment. Moreover, their equipment will be used in the development of new state-of-the-art fabrication technologies so that when such technologies are transferred to industry, their equipment will be used by industry. [IMEC, 2011][LETI, 2011]

Networks:

Hardware costs. These are the costs associated with the acquisition and ownership of the hardware that provides the network service to NRENs. They consist of the costs of routers and switches as well as DWDM transmission systems. They are generally based on a capital investment that is amortised over several years [EARNEST-ECO, 2007]

6.2.1.1 Initial investments

Definition: Initial investments are the capital that is needed for the purchase of all elements relative to the set-up of the e-Infrastructure.

Considerations:

Initial investments very often require a large sum of money be acquired. This investment can include housing, utilities, equipment, software and other items depending on the type of e-infrastructure. Certainly, in the case of a distributed e-Infrastructure the necessary expenditure for the same kind of installation or equipment can be different from country to country and should be an accepted phenomenon.

6.2.1.2 Recurrent investments

Definition: Recurrent investments are the capital that is needed on a regular time basis to maintain a state-of-the-art e-infrastructure.

Considerations:

Every e-Infrastructure will regularly need to be updated to cope with new technology and new user requirements. The type of e-Infrastructure will for a large part determine how much capital is needed for the recurrent investments. For example, a supercomputer might need to be replaced in its whole after three years whilst in a distributed high throughput computing environment it might be sufficient to replace only part of the equipment. The availability of recurrent investments is vital to ensuring sustainability.

6.2.1.3 Unexpected CAPEX

Definition:

Unexpected CAPEX is the capital needed to provide for unexpected purchases that are needed and are not included in the regular financial planning.

Considerations:

If the funding allows, it might be beneficial to provide for some unexpected CAPEX. In a well-defined e-infrastructure, major unexpected CAPEX should not occur but it can happen if an e-infrastructure experiences a strong take-up as a consequence of which it no longer performs well and risks becoming a victim of its own success.

6.2.2 OPEX

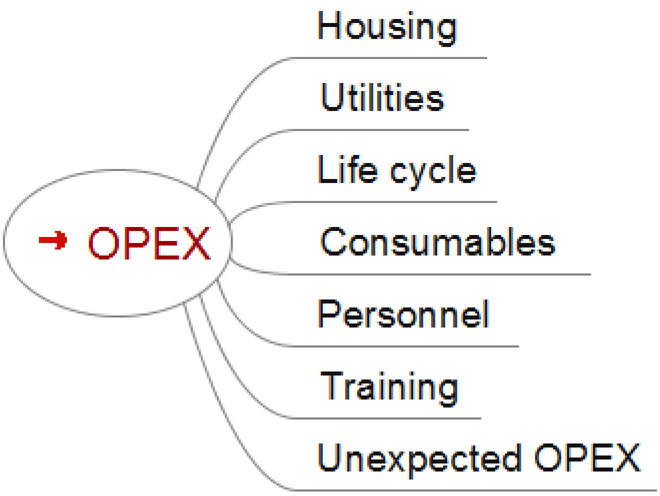

Figure 17: OPEX branch of the sustainability part of the mind map

Definition:

OPEX stands for operational expenditures and is the money that will be needed to keep the e-infrastructure "up and running".

Explanation:

Six categories of OPEX have been considered in the context of e-Infrastructures: housing, energy, maintenance, personnel, consumables and finally unexpected OPEX.

Explanation:

"Infrastructure *operating costs* can be very significant: for large research facilities, a typical "rule of thumb" is that the annual cost of operations is about 10% of the total construction cost. It includes:

- the Staff of the Collaboration, including their benefits (most notably, pensions which must be provided for in some way, if only by explicitly making employees responsible for their own arrangements);
- the "non-scientific" infrastructure: buildings/offices and their maintenance, vehicles, roads, grounds-keeping, insurance;
- utilities, notably electricity (for some facilities, this can be a very high cost indeed), expendables, and replacement components;
- maintenance and replacement of defective equipment;

- R&D for new instruments, prototyping and upgrades;
- educational and outreach activities." [OECD, 2008]

After considering the operational cost items mentioned above, "R&D for new instruments, prototyping and upgrades" was eliminated as it was considered in the OSIRIS consortium as being an element of the scientific and technical objectives of the RI. By re-phrasing some of the elements, the following seven items for the OPEX of a European ICT RI were highlighted:

1. Housing;
2. Utilities;
3. Life cycle;
4. Consumables;
5. Personnel;
6. Training;
7. Unexpected OPEX

Considerations:

Housing and energy have for a very long time been neglected in operational costs, mainly because they were provided for by the institute where the equipment was installed. In parallel with the rise of energy prices concern has arisen about the energy costs pertaining to the power consumption as well as to the cooling needs. Personnel cost has always been a major item in the operational expenditures. Attention should be paid to personnel that are provided "in kind" and tend to be forgotten in the costs with an inherent risk of a shortage of funds when the in kind provision of personnel stops. In certain cases, consumables are also very important in the overall OPEX (e.g. MNT).

All ICT RIs (probably with the exception of point 2: vehicles, roads, grounds-keeping):

Infrastructure operating costs can be very significant: for large research facilities, a "rule of thumb" is that the annual cost of operations is about 10% of the total construction cost. It includes: (1) the Staff of the Collaboration, including their benefits (most notably, pensions, which must be provided for in some way, if only by explicitly making employees responsible for their own arrangements); (2) the "non-scientific" infrastructure: buildings/offices and their maintenance, vehicles, roads, grounds-keeping, insurance; (3) Utilities, notably electricity (for some facilities, this can be a very high cost indeed), expendables, and replacement components; (4) maintenance and replacement of defective equipment; (5) R&D for new instruments, prototyping and upgrades; (6) educational and outreach activities. [OECD-GSF, 2010]

Data repositories & Instruments:

Information technology costs (including computing services, data distribution and archiving) have to be considered in some detail, especially for data-oriented infrastructures (e.g., computing grids, supercomputer centres). Agreement must be reached on who provides the services (the Partners? the Collaboration?) and who pays the associated hardware, software and operational costs. [OECD-GSF, 2010]

Networks:

Operations costs. These are the costs associated with the day-to-day running of the network. They include the network operations functions, maintenance costs of equipment, and the planning and support of network development. Operations costs are generally relatively insensitive to network capacity, because they are characterised by a high fixed element that covers the provision of operations services and the maintenance of the hardware platforms. It is important to note that operations costs are directly related to the technology operated. [EARNEST-ECO, 2007]

MNT:

The operations cost of a MNT RI typically runs in the tens of millions of Euros. First, there is the cost of air treatment to keep the cleanroom clean. This cost must be paid, even if the cleanroom is not used. Then, the consumables (high purity gases and chemicals, wafers) are also very expensive. Finally, the personnel count needed to operate and maintain all the equipment in the cleanroom operational is also very high (dozens of persons).

6.2.2.1 Housing

Definition:

Housing is the act of storing equipment in a house or building. The housing of an RI considers all the housing that is not specifically related to the scientific instruments of the RI. Typically, the housing consists of offices and workshops related to the scientific and technical activity of the RI.

Considerations:

The housing can be donated by the host country of the RI.

An ICT infrastructure often requires an adapted housing. The space needs to have adequate air-conditioning, electricity connections and, most often, high speed network connections. Attention should also be paid to the quality of the building to minimize costs. ICT infrastructures like micro- or nanotechnology can even put a heavier burden on the housing, e.g. the installation of a state-of-the-art clean room.

6.2.2.2 Utilities

Definition:

Utilities in this context mean: electricity, heating and cooling, water, and sewage.

Considerations:

Energy and energy consumption is a very important factor in the operational costs. In the past this cost category was rather neglected because it was hidden in the operational costs of the institute, these days it is an item that should attract attention as the e-infrastructures are most often asked to pay for these costs themselves. Therefore, utmost effort should be made to select equipment that consumes as little energy as possible, that the housing of the equipment is adapted to the energy saving requirements and that, if possible, energy recuperation mechanisms are used.

If the housing is donated to the RI, its thermal isolation might not always be optimal and could require investment in order to reduce the heating costs in the long term.

HPC:

The electrical power consumption and cooling water needs for a Tier-0 supercomputer are in the order of several MW.

MNT:

The air handling cleanrooms consumes several kW of electricity plus the heating and cooling requirements to obtain an air condition of 21°C, 45% R.H. (relative humidity). This translates into an electricity and heating bill of several millions of Euros per year, depending on the size of the RI. [IMEC, 2011], [LETI, 2011], [Tyndall, 2012], [CSEM, 2012]

6.2.2.3 Life Cycle

Definition:

***Life cycle*s are evolution of a system, product, service, project or other human-made entity from conception through retirement[18]. The life cycle management in the context of a European ICT RI means the management of all the material in the RI from its procurement, through its maintenance, until its proper disposal.**

Considerations:

In most ICT RIs, the ICT material that needs to be disposed of is similar to consumer ICT materials for which proper disposal techniques are now being developed.

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18 [ISO12207, 2008]

Maintenance of equipment is a traditional cost category in any operational budget. Indeed, the e-infrastructure equipment needs to be maintained so that effective exploitation can be realised: defective parts should be replaced and software should be updated. Costs for maintenance should be clearly defined and categorised in addition to recurrent investments costs.

The very short product cycles in ICT cause a maintenance problem, as replacement parts rapidly become difficult to find.

MNT:

A typical MNT maintenance team is in the range of five to forty persons, depending on the size of the facility. [IMEC, 2011], [LETI, 2011], [Tyndall, 2012], [CSEM, 2012]

MNT equipment for non-critical processes can have lifetimes in the order of ten years. However, the computer control of the equipment becomes obsolete in two years' time. This causes many problems with the maintenance of such equipment. [CSEM, 2012]

The decommissioning (closing down) of a MNT cleanroom requires the services of specialised companies, as many toxic gases and chemicals are used in cleanrooms.

6.2.2.4 Consumables

Definition:

The Webster definition of "consume" is rather negative: to destroy (as by burning), to expend wastefully, squander or use up, as money or time. Consumable is the adjective derived from this verb.

Considerations:

This category of costs can be very broad. It extends from the traditional pencil and paper to smartphones and even laptops. But it can also cover insurance fees, travel, etc. In MNT consumables are typically chemicals and process gases and represent a considerable amount of money.

MNT:

The consumables in the field of MNT are typically specialty chemicals and process gases. Their cost ranges from the hundreds of thousands to millions of Euros per year. [IMEC, 2011][LETI, 2011]

6.2.2.5 Personnel

Definition:

Personnel are the persons employed in a business. The cost of personnel should at least include salaries, pension contributions and accident insurance.

Considerations:

Depending on the type of e-infrastructure and the offered services, personnel might take a more or less important place in the operational budget. Personnel are certainly required to set up, maintain and operate the e-infrastructure. Additionally, personnel could be needed to follow up customer requirements and accordingly update services and/or define new services. Furthermore, training users on the infrastructure is a cost that is easily overlooked. A helpdesk could also be people intensive and the number of personnel and corresponding costs can be considerably larger if a 24/7 service has to be offered. Attention should be given to hidden personnel costs when partners contribute "in kind" to the e-infrastructure by providing personnel for operational tasks.

It often happens that a RI is associated with a university and the employment conditions are those of the associated university. This can be a serious problem, since most universities grant only limited-term contracts to many of their staff (except the professors). This induces a large turn-over of personnel which hampers the long-term operation of a RI.

6.2.2.1 Training

Definition:

Training in the context of European ICT RIs means the training of the users to be able to properly use the infrastructure.

Considerations:

In many ICT RIs, the training is often overlooked in the OPEX of the RI. However, it often turns out to occupy several people full time.

MNT:

The extremely long training required for MNT infrastructure is generally circumvented through the use of an "access to service" model.

6.2.2.2 Unexpected OPEX

Definition:

Unexpected OPEX is the money needed to cover those costs that were not foreseen in the operations planning.

Considerations:

Unexpected operational costs could occur due to circumstances that could not be predicted in the operational plan of the e-infrastructure and for which a total coverage by other funds could not be guaranteed. Examples are: a flood or a thunderstorm catastrophe that could not be fully covered by the insurance.

6.3 Evolution

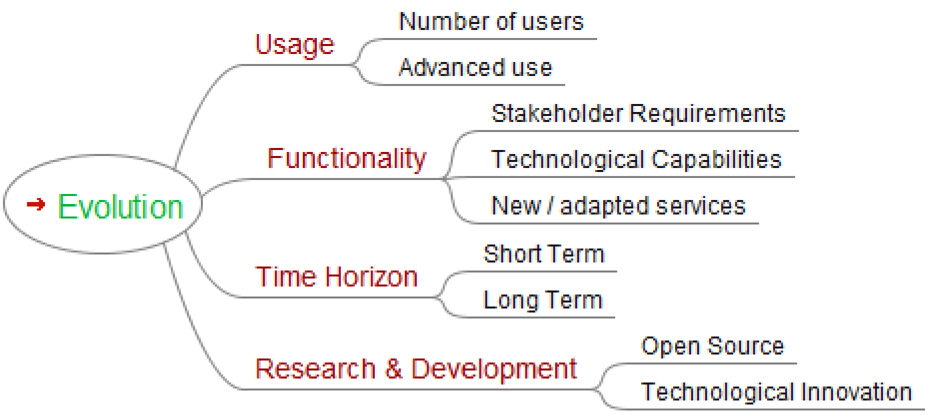

Figure 18: The evolution branch of the sustainability part of the mind map

Definition:

Evolution in this context means the change over time of the ICT infrastructure.

Explanations:

The change of the ICT infrastructure can be a change of usage or functionality. These changes happen over time, so a time horizon of the change is also important. An ICT infrastructure can also attempt to anticipate its evolution through R&D projects with the goal of developing the changes to be implemented.

Networks:

NRENs must ensure that charging mechanisms do not discourage the uptake and use of networking services that support collaborative research and education. [EIROForum, 2010] [EARNEST-chal, 2008]

6.3.1 Usage

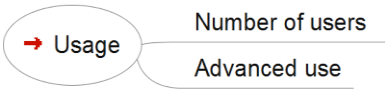

Figure 19: The usage branch of the sustainability part of the mind map

Explanation

Two items are considered crucial for the sustainability of the e-Infrastructure, namely the uptake of the use of the e-infrastructure and the offer of advanced services that are not commercially available.

Considerations:

To ensure sustainability of the e-Infrastructure a critical mass of researchers will need to use its services. It is thus very important to have user communities adopt e-Infrastructure as a main tool in their research. In order to realise such an adoption, it is necessary that user requirements are taken into account as soon as an e-infrastructure is planned. European and national e-infrastructures for research need to provide advanced functionality in order to give researchers the possibility of performing advanced research.

6.3.1.1 Number of users

Definition:

Number of users is a measure of the take up of the RI infrastructure. Users often belong to a user community. User communities are (international) groups of researchers that are collaborating in the same field (or subfield) of science. Hence, the number of different user communities can also be a measure of the success of the infrastructure.

Considerations:

A successful e-Infrastructure at national and European level needs to be used by a large percentage of the targeted research community. Note that this targeted research community might be relatively small in its number of researchers (e.g. in HPC).

The way an e-Infrastructure has grown or evolved can be of importance to the usage. A top-down driven setup of an e-infrastructure is often favourable to funding sustainability but it can be a danger for the usability of that e-Infrastructure. Such an e-Infrastructure might not be suitable for the requirements of the user communities. A bottom-up approach to set up an e-Infrastructure could cope with the above challenge but then there is a risk that the e-Infrastructure will be suited to only one community and/or that finding recurrent funding proves to be difficult. The best solution is to set up an e-Infrastructure in collaboration with as many user communities as possible, take their requirements into account and allow them the possibility of having their place in the governance structure of the e-Infrastructure. It is also necessary to attract new users and new user communities in order to be able to attract new investments and to have good arguments for ensuring on-going recurrent funding. It might be impossible to set up one e-Infrastructure that fits all researchers, but specific portals and/or a mix of supported technologies can pave the way for a successful e-Infrastructure. Experience within e-Infrastructures tells that actions are needed to bring national user communities together to form a European user community that can better exploit the e-Infrastructure.

Very specialised RI infrastructures might not have the number of users or user communities as a measure of success. In these cases scientific output, to which the use of the ICT RI was an important contribution, is taken as performance key indicator.

DCI, HPC, Networks:

"The e-IRG recommends the funding of activities that help national user communities to cooperate with corresponding user communities in other countries in order to foster the European research activities in using the e-infrastructure." [e-IRG-WP, 2009]

HPC:

In the field of HPC, the number of users is less important than the quality of the work carried out on the infrastructure. The quality of the work is measured in terms of scientific publications. [PRACE-Interview, 2011]

MNT:

The user base of MNT RI has a tendency to shift from a small number of large companies to a larger number of smaller companies. The average size of the development projects has a tendency to diminish as well. [IMEC, 2011][LETI, 2011]

6.3.1.2 Advanced use

Definition:

With advanced use is meant the use of emerging technologies that are not yet available on the commercial market.

Considerations:

Although users adopt an e-infrastructure because it suits their daily requirements concerning networks, computing, data necessary for their research, they also turn to e-Infrastructures for advanced use of new ICT technologies that are not yet offered on the commercial market or that are commercially available but at too high a cost to perform research. This means that an e-Infrastructure needs to stay ahead of commercial offerings in order to give the researchers an advantage in their research possibilities.

6.3.2 Functionality

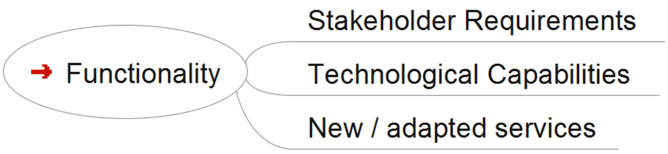

Figure 20: The functionality branch of the sustainability part of the mind map

Definition: In the information technology context, functionality can be defined as the set of functions or capabilities associated with computer software or hardware. In the context of ICT RIs we can add the functionalities and capabilities of the provided services.

Explanation:

Three items have been identified that influence the functionality of e-infrastructures:

1. Stakeholder requirements that are important to set up and maintain a useful environment;
2. The full exploitation of technological capabilities to offer value added services to the user and;
3. The ability to adapt existing services and add new services as required.

Considerations:

An e-Infrastructure needs to evolve in answer to technical innovation and in answer to stakeholder needs. These adaptations are necessary to retain users and also to recruit new users and user communities. Services are becoming more and more important. The innovation of the raw e-Infrastructure will not be sufficient to guarantee sustainability. The need for new services must be understood and those new or adapted services have to be continuously implemented. These services include ease of use and training. A lack of taking both new technologies and new requirements into account and adapting the e-Infrastructure accordingly, may lead to user desertion and a collapse of the e-Infrastructure. It is also essential that the governance body of the e-infrastructure leads the whole process of functionality improvement.

DCI, HPC, Networks:

"E-Infrastructures and the innovative technologies that power them and the demanding researchers that use them are a strong and ever-present mechanism enabling researchers, developers, and technology and resource providers to all work toward a common goal. It is essential EGI.eu uses every means available, on behalf of the community, to communicate and collaborate in these strategic areas (i.e. establishing MoUs, etc.) in order to answer the needs of the current users and to continue building new communities. Forming and maintaining these communities will be how the EGI and its stakeholders will survive, thrive, and evolve." [EGI-D2.6, 2011]

"Technology will always be evolving therefore it is essential that EGI.eu takes on its coordination responsibility in leading the evaluation of emerging technologies and facilitate the adoption of best practices where it makes sense and streamline efforts and resources where possible." [EGI-D2.6, 2011]

"Increasingly, new and diverse user communities are relying on e‑Infrastructure services; as such, the common e‑Infrastructure must cater to new and updated requirements. This junction between leading-edge research and the e‑Infrastructure that supports it is an area where considerable socio-economic benefits can be realised. "[e-IRG-RMP, 2010]

"The growing requirements of new and existing user communities compel continual reassessment of all components of the e‑Infrastructure service portfolio, including the structure of interactions between users and service providers. As e-Infrastructure services and technologies continue to change, new opportunities and challenges will keep on emerging." [e-IRG-RMP, 2010]

6.3.2.1 Stakeholder requirements

Definition:

With stakeholder requirements we refer to the needs expressed by the e-infrastructure users concerning improved functionality.

Considerations:

We have already stated that the uptake of an e-infrastructure and its related services is a requirement for the sustainability of that e-infrastructure. Taking into account the needs of the user - and in general all stakeholders - to improve the functionality is a step towards a successful uptake. An e-Infrastructure needs to listen to its users and be pro-active in responding to their needs and wishes.

DCI, HPC, Networks:

NRENs should consult with all key stakeholders when taking very important strategic decisions [EARNEST-GOV, 2007]

Involve the user communities in the definition and exploitation of e-Infrastructure services. [e-IRG-WP, 2011]

DCI:

"There is no uniform approach to external communication in e-Infrastructures, although it is of great importance to project sustainability and success. Some projects have sophisticated user engagement plans even in their development phase (e.g. Clarin, EGEE, OSG), when others pay much less attention to these issues [17]. Moreover, there are challenges in intra- and inter-disciplinary collaboration between developers and users, between actors in different research areas, or even between developers in different domains." [e-IRG-D4.3, 2011]

"Related to external communication is the process of user recruitment. Although users determine the sustainability of e-Infrastructures, the eResearch2020 project finds that user relationships are not always prioritised. Reasons cited include: focusing on pure technology development and delaying user engagement, perceiving the e-Infrastructure mission as one that excludes take-up, as well as estimating a great probability of project discontinuation." [e-IRG-D4.3, 2011]

6.3.2.2 Technological Capabilities

Definition:

Under technological capabilities we understand the technical features or conditions that may be improved or developed.

Considerations:

In the ICT world, technological changes happen at a rapid pace. e-Infrastructures should follow these changes and implement them where appropriate in an acceptable timeframe because users will want to explore the boundaries of existing e-infrastructures in order to overcome boundaries of their research applicable to networks.

Networks:

"….highlight that state-of-the-art network infrastructures are needed that are capable of adapting flexibly to the needs of the applications and researchers relying on them." [e-IRG-DMTF, 2009]

MNT:

The critical evolution parameter for MNT RIs is the availability of new or improved technological capabilities. [IMEC, 2011], [LETI, 2011]

6.3.2.3 New/adapted services

Definition

New or adapted services mean in this context new or adapted ways of utilising an existing system.

Considerations:

In addition to raw infrastructure, each e-infrastructure provides a number of primary and additional services that are preferentially tailored to user demands. However, these demands can change over time—be it to new requirements induced at the research level, requirements by new user communities or changes at the technological level. Inability to flexibly upgrade or modify existing services and introduce new services might lead to user desertion as has already been mentioned above.

DCI & HPC:

"To accelerate and expand the adoption of e-Infrastructures attention must be paid to their ease of use. Investing in improving the usability (e.g. by hiding complexity and increasing interoperability) will broaden their user base, adding significant value to the science community and increasing European competitiveness." [e-IRG-SeI, 2006]

DCI:

"The new opportunities presented by distributed infrastructures require increased training and an improved skills base for the research community, which also needs to form part of any national or European strategy for e-Infrastructure." [e-IRG-SeI, 2006]

6.3.3 Time horizon

Figure 21: The time horizon branch of the sustainability part of the mind map

Definition:

Time horizon is the period of time for which the functionality of the e-infrastructure is defined

Explanation:

Keeping an e-Infrastructure at or beyond the state-of-the art means to project its evolution in the short (1-3 years) and long term (5-10 years) based on evolving requirements and technological changes. Projections on the short term can be useful for a flexible adaption to changing user requirements. The incorporation of major technological changes or the implementation of new concepts will need long term projections.

Considerations:

Evolution plans have to be made for the short and long term. Change policy relevant to the short term (could be on a yearly basis) gives a guarantee to stakeholders that the e-Infrastructure is not at a stand-still and that the required functionality will be available. Planning for the long term in a rapidly evolving technical world is not always obvious. However, it is necessary to plan on how to cope with these technological changes in combination with the growing demands that can be expected from the users. The participation of e-Infrastructure providers in R&D activities could help the take-up of new technologies and at the same time make investments in R&D more effective. One drawback to efficient planning on a long term basis is the fact that funding is almost never guaranteed for a long term, very often funding is only available on a short term basis.

Networks:

"Many NRENs do not have budget planning in place for more than one year ahead, which potentially could lead to problems when planning medium- and long-term programmes for network service development and upgrade. This situation is not ideal, because the development and running of networking infrastructures needs to be planned and budgeted over a period of several years. Some NRENs and their funding bodies need to consider how longer-term planning might be improved. "[EARNEST-chal, 2008]

DCI:

If you have an investment in e.g. an X-Ray instrument or a telescope which has an active life time of 10-15 years, the computing infrastructure that supports it needs to have an equivalent lifecycle. […] The concerns raised by the user community were that they could not commit to using this capability for the long term if they only see a two year funding horizon and there was no clear picture of what would be in place over the timescale of a decade [EGI, 2011]

MNT:

Key MNT equipment can become obsolete in three years' time. [IMEC, 2011], [LETI, 2011]

6.3.3.1 Short term

Definition:

Short term is defined as a projection on 1 to 3 years.

Considerations:

Most e-infrastructure stakeholders have funding on at least a yearly basis; thus it might be useful in terms of sustainability to do some planning on a yearly basis. It could be envisaged to plan for upgrades and adaptations to user requirements even over such a short term. When projects are conceptualised, the planning could take 2 to 3 years.

6.3.3.2 Long term

Definition:

Long term is defined as a projection over 5 to 10 years.

Considerations:

Experience within the existing e-infrastructures has shown that funding on a long term basis is an extremely difficult issue and this is independent of the source of funding. However, the implementation of new technologies or new concepts might not fit into the short term planning mentioned above. Planning for the long term in a rapidly evolving technical world is also not always simple. However it is necessary to plan on how to cope with these technological changes in combination with the growing demands that can be expected from users.

MNT:

The renewal cycle of typical MNT cleanrooms is in the 7 to 10 years' range. The evolution plans of MNT should be adapted to these cycles. However, the funding cycles of national program based funding typically do not extend beyond a four to five year period. Cleanroom renewal is therefore typically a one-time investment of a national funding agency that can only be prepared by multi-year lobbying efforts but that cannot be properly planned because these one-time investments can only be obtained if a funding opportunity occurs.

6.3.4 R&D

Figure 22: The R & D branch of the sustainability part of the mind map

Definition:

R&D stands here for research and development in ICT, both hardware and software.

Considerations:

The participation of e-infrastructure providers in R&D activities could help the take up of new technologies and simultaneously make investments in R&D more effective. The importance of R&D activities is crucially dependent on the specific RI considered. Collaboration in the Open Source philosophy might be a way to realize this collaboration, but it might also be important to make new technological developments.

6.3.4.1 Open Source

Definition:

In production and development, open source is a philosophy, or pragmatic methodology, that promotes free redistribution and access to an end product's design and implementation details. As an example Open-source software (OSS) is computer software that is available in source code form: the source code and certain other rights normally reserved for copyright holders are provided under a free software license that permits users to study, change, improve and at times also to distribute the software.

Considerations:

Most of the e-infrastructures do not do R&D themselves but depend on third parties for these aspects. As has already been explained, an e-infrastructure should stay at the state-of-the-art and be able to provide advanced use to researchers. Hence, the uptake of R&D in the field of that e-Infrastructure is not negotiable. For this reason, e-Infrastructures should stay in close contact with "R&D providers". The use of open source philosophy might make the collaboration task easier

6.3.4.2 Technological Innovation

Definition:

Innovation is the creation of better or more effective products, processes, services, technologies, or ideas that are accepted by markets, governments, and society[19]. Technological innovation in this context means innovation in the technical field in which the RI is active.

Considerations:

For most ICT Research Infrastructures (RIs), technological innovation comes from implementing new products that become available from its vendors. For MNT RIs, the technological innovation is typically the result of effort carried out inside the RI by scientific personnel of the RI and in close collaboration with vendors.

Technological innovation is not only important to maintain the research infrastructure at the state-of-the-art for the specific research field but it could also reduce the costs of the infrastructure (e.g. reduced power consumption).

MNT:

The technological innovation in MNT RIs comes in part from new equipment that is acquired by the RI. However, the innovative use of the available equipment or the innovative combination of processes available on different pieces of equipment contributes in large part to the technological innovation of the MNT RI [CSEM, 2012]

DCI, HPC and networks:

"Infrastructures need to remain state of the art; therefore new technologies should be evaluated and introduced continuously. In order to make investments in R&D more efficient, the take up of new technology in production infrastructures should be improved by appointing e-Infrastructure providers as stakeholders in relevant R&D efforts." [e-IRG-SeI, 2006]

DCI:

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19 http://en.wikipedia.org/wiki/Technological_innovation

"The EGI ecosystem encompasses technology providers as important stakeholders [R15]. Technology providers offer technology ready for deployment into the production infrastructure that satisfies the needs of its user communities – the end-users and operations staff. The availability of technology able to meet these needs from diverse sources – either from the mainstream open-source community, the open-source development community within EGI or commercial providers – is vital for the long-term sustainability of EGI." [EGI-D2.7, 2011].

"If National Research and Education Networking organisations are to maintain support from their user communities and funding bodies, they must continue to innovate and provide cost-effective and reliable services that are required by the research and education communities that they serve." [EARNEST-GOV, 2007]

6.4 Miscellaneous

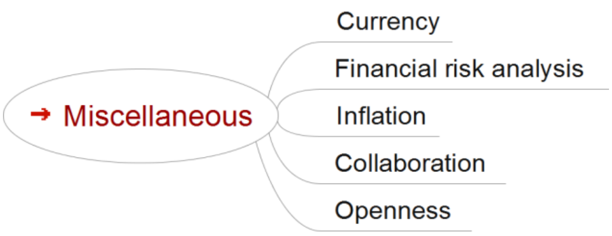

Figure 23: The miscellaneous branch of the sustainability part of the mind map

Definition:

Miscellaneous is consisting of diverse things or members.

Explanation:

Factors other than those already described might have an influence on sustainability. Fluctuating currency rates and inflation can have financial implications. In general a sound financial risk analysis will reduce financial problems. Collaboration, transparency and openness are three factors that should not be forgotten when defining a trans-national e-infrastructure.

Considerations:

A financial risk analysis can inform the e-infrastructure management about the probabilities and consequences of perturbations to the established funding scheme. Such an analysis should take into consideration all elements that influence the financial situation, such as defaulting membership fees, ending projects, inflation, fluctuating currencies, rising energy prices, etc. A European e-Infrastructure will need collaboration from national entities to secure funding and bring awareness to potential users Collaboration with other e-infrastructures is necessary to build a European e-infrastructure ecosystem. Openness is an important factor; an e-Infrastructure that is dedicated to one user community might not get enough support to remain sustainable.

6.4.1 Currency

Definition:

According to the Webster's Dictionary currency is the current medium of exchange; coin or bank notes.

Considerations:

In a European e-infrastructure, currency and especially the fluctuation of the currency might be less of a problem as costs will most probably be expressed in Euro. However, not all funding contributors might belong to countries in the Eurozone and, hence, the amount of their contributions might become much higher if their local money loses value compared to the euro. Such a change in due contribution might result in a defaulting payment from the member concerned.

All ICT RIs:

"A dependence on annual cash contributions will make a project more sensitive to currency exchange rate fluctuations. As in other areas, there is no recognised universal method for dealing with this difficult matter, but it should be examined during the discussions between potential collaborating Partners. Normally, cash contributions are re-computed annually (and accounts are kept) in the currency of the host country (unless the infrastructure is located in a given country simply because of scientific/physical requirements such as physical altitude, air quality, etc.). If desired, a limit can be placed on the maximum annual change in any contribution due to a change (positive and/or negative) in exchange rates." [OECD-GSF, 2010]

MNT:

The currency used in MNT equipment purchases is often the US$. This presents a serious currency risk, as the equipment purchase price is often very high. [IMEC, 2011], [LETI, 2011]

6.4.2 Financial risk analysis

Definition:

Financial risk analysis in the context of this document refers to an analysis of the funding scheme used to finance the Research Infrastructure.

Considerations:

A financial risk analysis can inform the e-infrastructure management on the probabilities and consequences of perturbations to the established funding scheme. When the funding scheme includes a membership fee, there is the possibility that one or more members will ultimately not be able to pay or will be late with their contribution. The more important the part of the membership fee is in comparison to the total budget, the more defaulting payments can perturb the functioning of the whole e-infrastructure. When part of the funding is realised by in-kind commitments, then extra funding will be needed when, for one or another reason, this commitment cannot be fulfilled. When part of the funding is based on projects, there is a need to analyse what will happen at the end of the projects: it is probable that new projects will take over the financial burden or that the activities carried out by the project will be stopped or that the financing of those activities will have to be taken over by other funds available in the e-infrastructure. Also, what happens when energy prices rise dramatically, when inflation is high or when fluctuating currencies give problems to some partners? A financial risk analysis will show where the limits of the chosen funding scheme are and will also give an idea about how much money is needed for contingency planning.

DCI, HPC, Networks:

"To conduct a financial risk analysis that will inform them about the probabilities and consequences of potential perturbations to the nominal work plan and financial arrangements." [OECD-GSF, 2010]

"A cash-intensive project is, sooner or later, likely to encounter problems, chiefly in the form of cost overruns and delays. In that event, it could become a target of criticism at national levels, especially in Partner countries that, in their own projects, practice financial rigour and have a very low tolerance for not meeting budgetary and schedule targets (although such countries will be more likely to allocate contingency funds to the overall budget). Countries differ in how they deal with overruns and the ease with which additional funds may be forthcoming, so it may be difficult to achieve a consensus on this sensitive matter.

When a Partner encounters difficulties in fulfilling in-kind commitments, it may turn to the Collaboration (i.e., to the other Partners) with a request for additional funds. This would typically occur when technical problems made it unlikely that performance or schedule obligations could be met for an item that the requesting Partner had agreed to deliver in-kind or via the process of "internal bidding" described above. It may be prudent for the Partners to agree beforehand on the rules and procedures (if any) that would govern the granting of such assistance. Conversely, it is possible to envisage that a Partner would return any savings or unused monies to the Common Fund. "[OECD-GSF, 2010]

"Potential Partners may wish to consider the possibility that, at some future time, one of them may not be able to fulfil their operating cost obligations (for example, due to unanticipated severe national budgetary restrictions, a collapse of domestic political support for the project, extreme currency fluctuations, etc.). It could be that the defaulting Partner already made a significant contribution to construction and operations, so various provisions can be designed (such as a grace period, or a graduated series of penalties: removal from decision-making, suspension from publications, etc.) to deal with the undesirable contingency, especially if the difficulties are seen as temporary." [OECD-GSF, 2010]

6.4.3 Inflation

Definition:

In the Webster's Dictionary inflation is described as the over-issue of currency or the state resulting there-from or also an increase in price levels arising from mounting effective demand without corresponding increase in commodity supply.

Considerations:

An e-infrastructure has no control over the inflation that can occur at national or at international level. But a budget of an e-infrastructure will need to take into account a certain level of inflation because the cost of salaries, hardware, housing, energy could be linked to inflation. This issue in a European e-infrastructure can be rather complicated to forecast as the Inflation rate can be different from one country to another.

6.4.4 Collaboration

Definition:

Collaboration is the cooperation with another, especially in literary or scientific pursuit.

Considerations:

The setup of a sustained European e-infrastructure will need cooperation between all the involved partners and stakeholders. Cooperation will be needed to define a governance model, a funding scheme, to agree on operational aspects and many others. This cooperation can be facilitated by working towards a strong common goal.

A key element will also involve the coordination of the technological developments in a collaborative way. A common strategy might drastically improve the sustainability because it will reduce the cost of development (one common development instead of multiple developments in parallel). It will also coordinate the adoption or adaptation of existing developments and will increase the uptake by users (who need only learn a certain technology, interface or platform once). Relying on some sort of standardization (formal or de facto) will also improve the collaborations amongst partners and stakeholders and will improve the Return on Investment.

From experience gained at the level of existing e-infrastructures it is also clear that these e-infrastructures should collaborate amongst themselves, on one hand to provide a uniform, easy and transparent service to the user and, on the other, to profit from economies of scale created by this collaboration.

DCI, HPC, Networks:

"Sustainability can only be achieved through strong national e-Infrastructure initiatives willing to merge efforts to form coordinated pan-European structures and be open to all user communities." [e-IRG-SeI, 2006]

"The e-IRG recommends that major e-Infrastructures initiatives such as EGI and PRACE cooperate closely in order to define a complementary and interoperable environment for the benefit of European researchers. This environment should ensure that access to resources in Europe is granted through an open and transparent process, based on international standards and interoperable middleware." [e-IRG-WP, 2009]

6.4.5 Openness

Definition:

Openness can be defined as without barriers, restrictions.

Considerations:

It might not be possible or wise to open up an e-infrastructure to any individual who wishes to make use of it. However, an e-infrastructure must make sure that it is not designed to accommodate only one or a very small number of user communities. Such a situation might be a hindrance to its growth and to the general uptake by a large number of user communities.

Openness might also apply to chosen hardware or software. Using very specific hardware or software can cause vendor lock-in and user lock-out. Standardisation of software and services that conform to the available international standards and/or interoperability with other systems might considerably contribute to the openness of the RI.

DCI, HPC, Networks:

"E-Infrastructures must be application-neutral and open to all user communities and resource providers. National funding agencies should be encouraged to fund multi-disciplinary and inclusive infrastructures rather than disciplinary-specific alternatives independent of any individual user community or resource provider" [e-IRG-SeI, 2006]

MNT:

Contrary to other ICT RIs, openness is not normally pursued for MNT RIs, because their main customers are from industry. The development projects carried out by MNT RIs are often strategic mid-term developments with which the industrial partner wants to gain a competitive advantage. Strict confidentiality is therefore the best policy in the field of MNT. [CSEM, 2012]

6.5 Governance

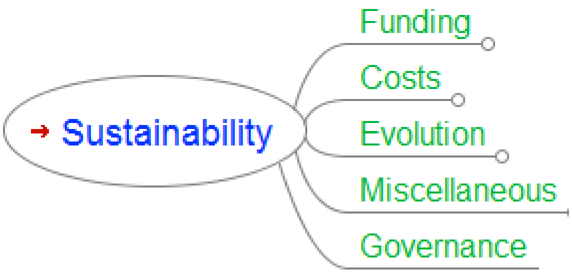

Figure 24: The governance branch of the sustainability part of the mind map

Explanation:

Governance was defined and further explained in Chapter 5 of this document.

Considerations:

The choice of an effective governance model is of the utmost importance in guaranteeing the sustainability of an e-infrastructure. At the level of financing the e-infrastructure, the chosen governance model can be linked to the scale of contributions and/or to the voting system. The definition of the membership and its representation in the management body can be very important. If for instance, user communities think that they are not well represented by the governance structure, they might refrain from taking up the access to that e-infrastructure and hence indirectly endanger its sustainability.

DCI, HPC and networks:

"Effective governance is an indispensable component of sustainability and success. The specificities of e-Infrastructure governance require novel and innovative approaches." [e-IRG-D4.3, 2011]

"Large-scale scientific research projects are no longer being conducted within a single research group, single institutions or even in a single country, but in VRCs (i.e. large organised research collaborations) that span national borders encompassing many different organisations with a need to share ICT resources. These VRCs have their own internal structures and coordination activities that EGI seeks to leverage to scale out its interactions with user communities. It is noted that different VRCs will have different structures, and the EGI model is able to adapt to deal with this." [EGI-D2.7, 2011].

"Through this support, the EC is not only financially supporting the EGI ecosystem through EGI-InSPIRE project, it is also strongly influencing the strategic and policy priorities set up by the EGI community. Therefore, the EGI community must be aware of the strategic initiatives coming from the EC in order to fully exploit emerging opportunities for financial support that the EC can offer to the EGI ecosystem. One organisational aspect that needs to be considered in this context is the additional funding opportunities that may be associated with the ERIC legal framework" [EGI-D2.7, 2011].

"Overall, if the EGI's strategic policy responses do not mirror EC expectations and their priorities, then it is possible that future European funding streams may be significantly reduced. In the next decade, it appears that the challenges identified in the Europe 2020 Strategy [R14] will drive the funding priorities in FP8 providing the greatest funding opportunities for the EGI ecosystem. Therefore, it is essential that EGI.eu continue to actively engage in the EU policy setting process and seek recognition from the EU for the central role it plays, which will have a direct impact on sustainability." [EGI-D2.7, 2011].

“Many National Grid Initiatives are supported primarily by their national research councils to deliver a service to their national research communities as part of a strategy to deliver innovative technology and economic growth. The financial crisis that is being experienced in Europe is having an impact on national funding objectives varying from significant reductions in science budgets, reduction in staff salaries in the public sector, freezing of international subscriptions, or withdrawal from international projects.” [EGI-D2.7, 2011].

“The future of EGI relies heavily on the sustainability of the NGIs and EIROs.” [EGI-D2.7, 2011].

“The study has concluded that there are many different governance models in place for the different NRENs, and that the funding and charging mechanisms and the methods of making decisions are also diverse.” [EARNEST-GOV, 2007]

7 Access Policy

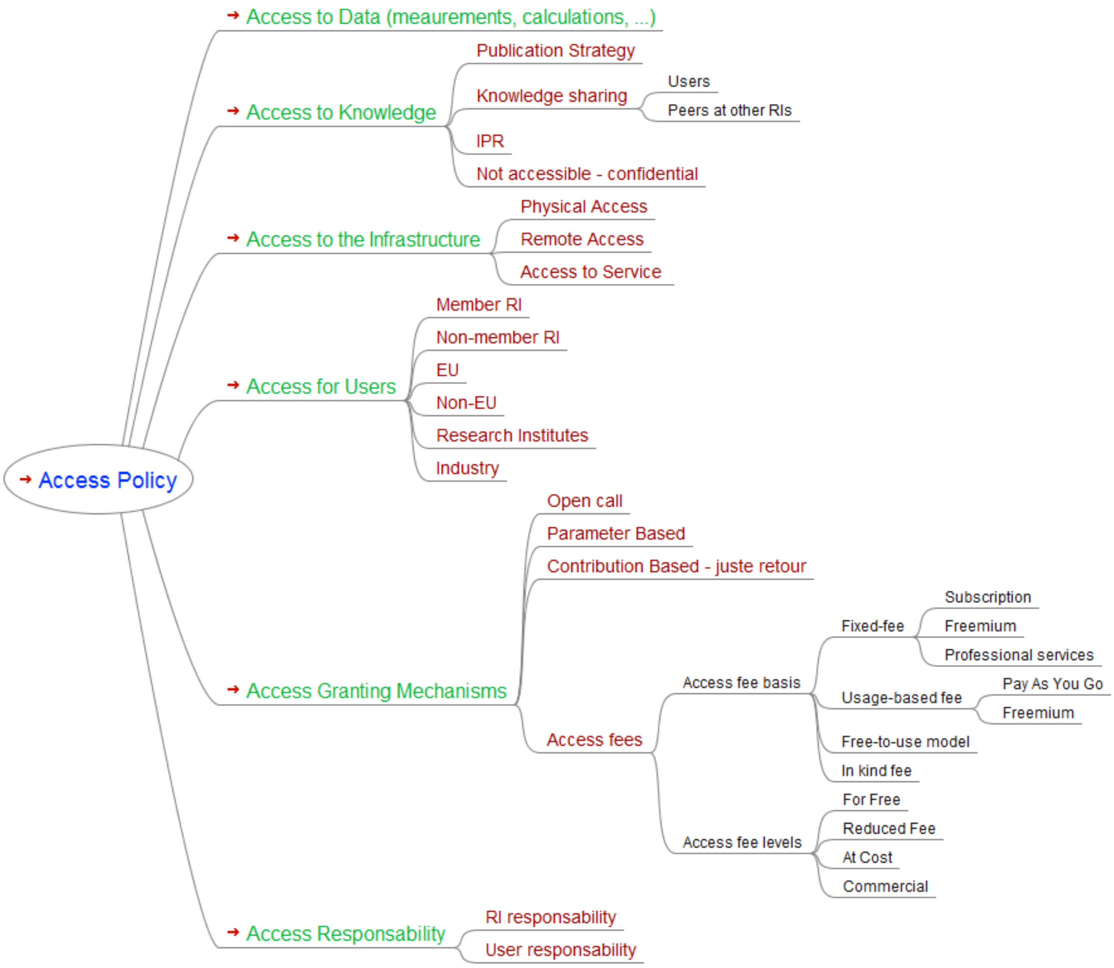

Figure 25: Mind map of the access policy

Definition:

The most appropriate choice in Webster's dictionary[20], defines access as: permission, liberty, or ability to enter, approach, or pass to and from a place or to approach or communicate with a person or thing. In the same dictionary, the most appropriate definition of policy is: a high-level overall plan embracing the general goals and acceptable procedures especially of a governmental body. In the case of a European ICT Research Infrastructure (RI), the access policy can be defined as a high-level overall plan to enter or to communicate with the RI.

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20 See: http://www.merriam-webster.com/dictionary/access

Considerations:

The different facets of the access policy can be listed as follows:

- *Access to data*
- *Access to knowledge*
- *Access to the infrastructure*
- *Access for users*
- *Access fees*
- *Access consequences*

7.1 Access to data

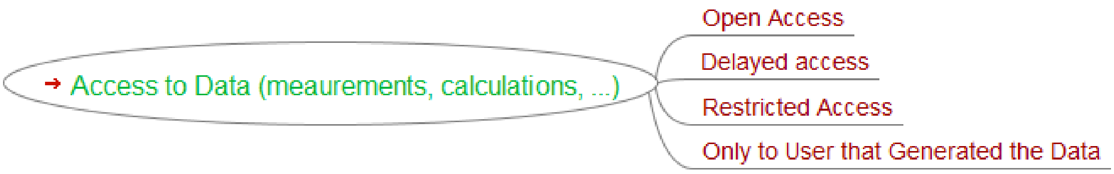

Figure 26: The access to data branch of the access policy part of the mind map

Definition:

Data is factual information[21]. In this context, it means the result of measurements, observations, or calculations.

Explanations:

Access to data is very important, for example digital repositories store enormous amounts of data that may have been gathered over long periods of time. Scientific Instruments often obtain or generate large amounts of data each day.

The access to data can be defined in three different ways:

[21] http://www.merriam-webster.com/dictionary/data

1. Open access: unlimited access to the data to anyone interested.
2. Restricted access: only access to users who have rights.
3. Access only for the user who generated the data

Considerations:

The cost of documenting the data and maintaining access to the data should be taken into account in the operational cost of the RI. In particular, the documentation of the data (description of the experiment in full detail (including minor glitches in instrument performance), of the formatting of the results, etc.) presents a major effort. The e-IRG Data Management Task Force recommends that it is IMPERATIVE for all resource and service providers to create and provide quality metadata descriptions [e-IRG-DMTF, 2009].

Data repositories:

The [e-IRG-DMTF, 2009] reference contains many specific recommendations for data repositories and describes many projects involved in definition of data repositories.

7.1.1 Open access

Open access can be defined in this context as[22]: access to data via the Internet in such a way that the data is free for all to read and to use (or reuse) to various extents.

Considerations:

[22] Modified from: http://en.wikipedia.org/wiki/Open_access_%28disambiguation%29

There is currently a movement in academia that demands that the results of research that is publicly funded should be available as open access. Moreover, in order to diminish scientific fraud, it is frequently proposed that the raw data on which scientific publications are based will become open access as well. In much the same way, the EIROforum states that RIs are created and operated with the main purpose of conducting and enabling cutting-edge scientific and technological research, and generating new knowledge. There is a growing recognition that there is a moral, if not a legal, obligation to disseminate the information and knowledge generated as a result of publicly funded research [EIROForum, 2010]. However, this open access concept can be in contradiction to the decision of very large RIs to reserve access to the data only to partners involved in the construction of the relevant RI. In this case other interested partners can get access by paying for the data or contributing to the project in a well-defined way.

7.1.2 Delayed access

In some cases access to data will be given for a certain period of time only to the user who generated the data (e.g. 12 months), after which access to the data will become openly available.

7.1.3 Restricted access

Restricted access can be defined as the access that is only allowed to users who meet certain criteria. In general, access is granted only to users who have paid the access fees.

7.1.4 Access only to the user who generated the data

Access only to the user who generated the data.

Considerations:

There is a trend to attract more industry to use RI facilities (especially in the case of computing infrastructures). In that case it might be a prerequisite that the data is only accessible to the user (the industry).

7.2 Access to knowledge

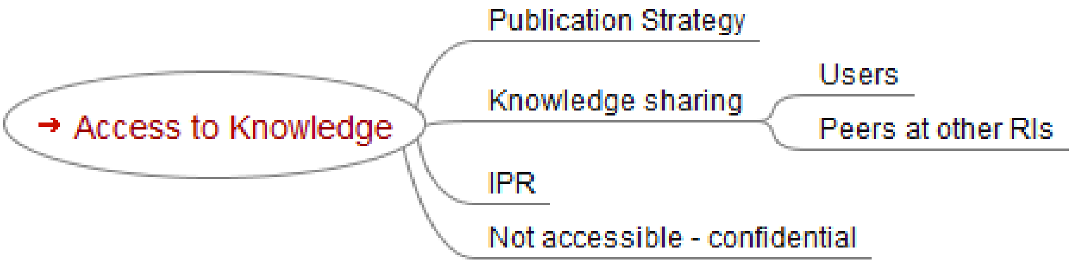

Figure 27: The access to knowledge branch of the access policy part of the mind map

Definition:

Knowledge is a familiarity with someone or something that can include facts, descriptions, information and/or skills acquired through experience or education[23].

Explanation:

The knowledge to which the RI gives access is the knowledge that resides both with the people working in the RI and that is documented by the RI. It is acquired through the experiences gained by working in the RI. Here we do not consider the knowledge that is generated by the users of the RI.

Knowledge can be treated in four different ways:

1. It can be published;
2. It can be shared with users or peers at other RIs;
3. It can be made proprietary through Intellectual Property Rights (IPR) protection (patents, copyrights, etc.). In this case, it is published, but others cannot use the knowledge for their own benefits without the agreement of the RI;
4. It can be kept confidential.

[23] See: http://en.wikipedia.org/wiki/Knowledge:

Considerations:

The EIROforum states that Knowledge sharing should receive consideration during the creation of an RI because it can have a major impact on the long-term health of the organisation. For example, a general policy to provide all results on technical developments and design without compensation to the member states may impose a difficult burden on the organisation. In the worst case scenario, the RI may be held responsible for faults caused when other organisations use and alter the designs. [EIROForum, 2010].

7.2.1 Publication strategy

Definition:

The publication strategy of an institute is its plan of action on how and when to publish the results of its research.

Considerations:

The reasons for publishing can be multiple. To enunciate but a few: it might be spreading knowledge to the scientific community, gaining respect and visibility, blocking IPR protection for others, or frustrating competition by demonstrating its own advanced position.

7.2.2 Knowledge sharing

Definition:

Knowledge sharing is an activity by means of which knowledge (i.e. information, skills, or expertise) is exchanged amongst people, friends, or members of a family, a community (e.g. Wikipedia) or an organisation[24].

Considerations:

The sharing of knowledge can take place with a group of persons who are the users of the RI or that are peers at another RI. The goal in the two cases is different.

[24] http://en.wikipedia.org/wiki/Knowledge_sharing

In the first case the knowledge must be shared with the users enabling them to make proper use of the facilities of the infrastructure. Virtual Research Communities (VRCs) of EGI are an example of knowledge sharing. In the VRCs people with similar computing requirements can exchange information on how best to use the facilities of EGI.

In the second case, the knowledge shared with peers typically has a mutual benefit. This can be simply that each peer increases their knowledge through learning from another. It may also be necessary to initiate a standardisation effort or closer cooperation between RIs.

MNT:

Knowledge sharing that often appears in the field of MNT is the offering of design kits to users of a semiconductor foundry. The design kits contain knowledge on how to design electronic circuits that can be fabricated by the semiconductor foundry. This knowledge must be communicated to allow the users to use the foundry, but is typically only available after the signature of a non-disclosure agreement. The non-disclosure agreement prevents the information on the particularities of a fabrication technology of the foundry from being passed on to another foundry.

7.2.3 IPR

IPR in this context stands for Intellectual Property Rights. Intellectual property (IP) is a term referring to a number of distinct types of creations of the mind for which a set of exclusive rights are recognized—and the corresponding fields of law. Under intellectual property law, owners are granted certain exclusive rights to a variety of intangible assets, such as musical, literary, and artistic works; discoveries and inventions; and words, phrases, symbols, and designs. Common types of intellectual property rights include copyrights, trademarks, patents, industrial design rights and trade secrets in some jurisdictions[25].

Explanation:

Patents are very often used to valorise ideas, knowledge, and know-how. The inventor precisely describes an idea and deposits it as a patent submission. If the idea is new and original (that is: it should not be evident to a person knowledgeable in the field). If the patent is awarded, nobody can use the claims of the patent in the countries in which the

[25] http://en.wikipedia.org/wiki/Intellectual_Property_Rights

patent has been awarded without the agreement of the patent owner. The patent owner can permit somebody to use the claims of the patent, typically against the payment of a license fee (one-time or annual fixed amount) or royalties (an amount per product that uses the claim in a product that is sold).

In the ICT domain, patents are sometimes hard to obtain as an original idea is implemented in software code. In this case the code is protected by copyright, which prevents people other than the depositor of the copyright to use the identical or similar code.

Considerations:

In most European ICT RIs, the RI serves as a facility to the users and does in general not perform much research itself. The creation of IPR in such a RI is therefore unlikely and is not foreseen as a source of income for the RI. Although software might be developed within such RIs, in many cases the software will become Open Source. In the field of MNT, the situation is almost the opposite: the RI creates much IPR (especially patents) and can consider it as a long term source of income.

In the Cross-sectoral Analysis of the Impact of International Industrial Policy on Key Enabling Technologies [KET, 2011], it is noted that the success of industrial uptake of IPR developed in academia is very limited. It is also noted that the role of Research Institutes (RTOs in this paper) is crucial for the transfer of technology to industry.

In some cases limitations to the exploitation of IPR are put forward by funding agencies (national or European). One might restrict the collaborations with external parties due to IPR (e.g. IPR should be used preferably within the country or within Europe). This is a very important consideration that might have a profound impact on the sustainability of the RI.

DCI:

"Resource sharing should include the use of and access to repositories of educational and training materials. Intellectual Property Rights (IPR) issues arise in this context. Resolving such IPR issues is required in order to spur greater uptake of e-Science. Currently, no specific IPR model has been widely accepted across the European Research Area (ERA).The 2001 EU Copyright Directive is an attempt at harmonising copyright law among Member States, keeping in mind certain modern requirements of the information society. But the challenges arising from the sharing involved in use of e-Infrastructures are still in the process of being unravelled and addressed. There are repository examples that can be held up as models, showing the way forward, and these include the ICEAGE Digital Library and EGEE Repository, both of which provide educational materials and tackle the issue of IPR using deposit agreements and Creative Commons licences." [e-IRG-WP, 2009]

"It is important to notice that some of the identified issues such as open access and IPR policy must be dealt with within EGI community regardless of whether the ERIC will be considered or not. Thus, these issues will have to be addressed in any case not only if the EGI Council decides to accept the ERIC model. However, it is clear that an infrastructure cannot join ERIC legal instrument if these issues are not addressed." [EGI-MS212, 2011]

HPC:

The PRACE report on the options for a legal entity [PRACE-D2.1.1, 2008] also takes IPR issues into consideration in its choice.

MNT:

For LETI, the licensing fees are considered as the most important source of revenues. Their principal key performance indicator is the number of patents awarded per year [LETI, 2011]. At IMEC, IP is shared with the customers in the framework of development projects [IMEC, 2011]. At CSEM, patents are often submitted prior to talking to potential customers. The valorisation takes place through a development project that includes a license fee for the patent. [CSEM, 2012]

The KET initiative foresees a policy that Key Enabling Technologies that are developed in Europe should be developed in Europe first. IMEC, with its global customer base, is an avid opponent of such policy. [IMEC, 2011]. It appears that LETI, with its more French customer base is not particularly worried about this issue, but is more generally worried that the number of rules related to KETs will be so high that there will always be one rule that prevents a project from being created. [LETI, 2011]

7.2.4 Confidential

Definition:

The word confidential means in this context private or secret[26].

Explanation:

Knowledge generated by the RI can be kept confidential if all employees of the RI have signed a confidentiality agreement with their employer. All employees are then bound by this agreement to keep the knowledge confidential. Of course technical security measures should also be in place to keep this knowledge confidential.

[26] http://www.merriam-webster.com/dictionary/confidential

Considerations:

Most European ICT RIs have a very open access to knowledge which they have generated and do not have much confidential knowledge. Confidential knowledge is very important in the case of MNT RIs.

MNT:

Some knowledge cannot be protected by IPR instruments. A typical example is a "how to" knowledge that increases the yield or facilitates the fabrication of some device. Such knowledge is kept confidential and is only communicated after the signing of a technology transfer project.

7.3 Access to the infrastructure

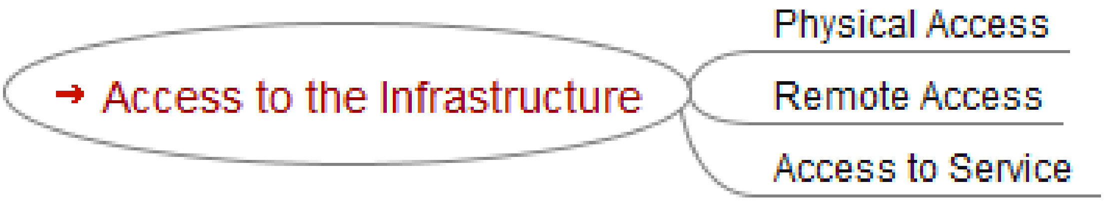

Figure 28: The access to the infrastructure branch of the access policy part of the mind map

Access to the infrastructure means that the user can use the facilities of the infrastructure.

Explanation:

There are three ways that a user can have access to the infrastructure:

1. Physical access.
2. Remote access.
3. Access to service.

7.3.1 Physical access

Definition:

Physical access means that the user can physically enter the premises of the RI and use the facilities on which he/she is allowed to work

Considerations:

When physical access needs to be given to (parts of) an ICT, RI special care needs to be taken at the security level: only authenticated and knowledgeable persons should be granted access. Most ICT RIs do not need to grant physical access to users.

In the case of physical access, the visa requirements of the host country are an important consideration [OECD-GSF, 2010]

MNT:

Most MNT RIs do not give physical access to their RI, even though this kind of access is necessary to follow the fabrication. Most MNT RIs prefer the "access to service"model described later.

7.3.2 Remote access

Definition:

Remote access means that the user can communicate between his/her computer and the computers at the RI.

Considerations:

Depending on the type of ICT RI, remote access is the normal way to access the facilities, since there is a negligible difference between the possibilities to access on-site and remotely.

7.3.3 Access to service

Definition:

In the case of access to service, the user never goes beyond the meeting rooms of the RI. The personnel at the RI perform the requested experiment (e.g. fabricate the device) and deliver the result to the customer.

Considerations:

This is a fairly common practice in Micro- and NanoTechnology (MNT) where there is a requirement for a high level of training in order to operate the facilities. In the field of HPC there are support teams available that help with making programs run in parallel, but the service does not go as far as running the simulations for the user.

7.4 Access for users

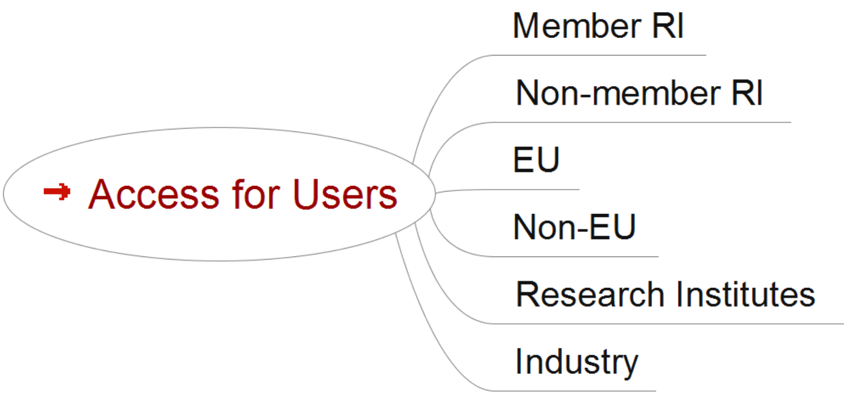

Figure 29: The access for user branch of the access policy part of the mind map

Definition:

The users are the people / institutes that have access to the facilities of the European ICT RI.

Explanations:

These users can be classified in many orthogonal ways:

- EU, Associated States, or non-EU: based on the location of the user
- Member or non-member of the RI: based on the shareholders or partners of the RI.
- Research, academia, or industry: based on the institute of the user.
- Other criteria

Considerations:

The access granting mechanisms of the European ICT RI can typically vary with the types of users. For example, the members of the RI may have free access to the RI, whereas non-members are charged an access fee. Similarly, RIs that are funded by the EC may have different access policies for EU and non-EU members.

In most of the ICT RIs an Access Use Policy (AUP) regulates the access of the users to the infrastructure. For instance, for the GÉANT (and also the National Research Networks) the AUP stipulates that the network is only to be used for research and commercial activity is excluded. Industry can only get access to the research network for its research activities.

In EGI, the access to the infrastructure is regulated at the Virtual Organisation (VO) level. A user needs not only to be authenticated but also needs to obtain permission to become a member of a Virtual Organisation. That VO will then ultimately grant access to the computing resources. Each VO has its own AUP.

7.5 Access granting mechanisms

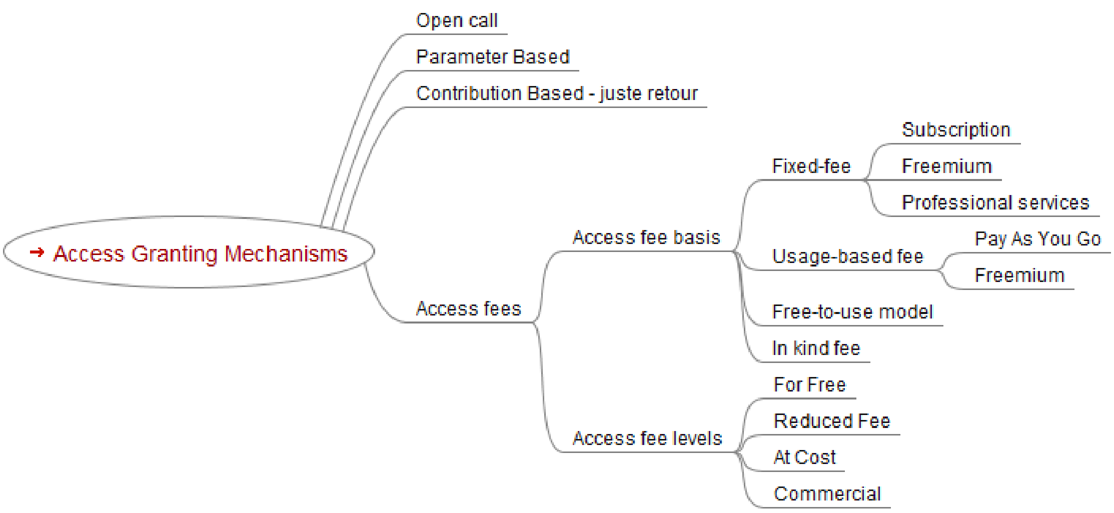

Figure 30: The access granting mechanisms branch of the access policy part of the mind map

Definition:

Access granting mechanisms are the set of rules by which the access to the facility of the RI is defined. There are many different access granting mechanisms possible for European ICT RIs that can be further differentiated for different kinds of users.

Explanations:

The most common access granting mechanisms are:

- Open call
- Parameter based
- Contribution based / juste retour
- Access fees

Considerations:

Access granting mechanisms can be strongly related to the legal form of the RI. For example if a RI wants to have an ERIC as its legal form, it needs to have an open access policy in place [EGI-MS212, 2011].

The access granting mechanisms are also strongly related to the funding model of the RI. If a part of the funding of the RI should come from access fees, this affects its sustainability. When an RI charges access fees, its service to fee ratio should remain attractive in order to maintain its user base. Maintaining or increasing its user base is necessary to guarantee its access fee income.

7.5.1 Open call

Definition:

In the case of an open call the European ICT RI launches a call for proposals to which anyone can submit. The proposals are accepted on their scientific or technical merits as evaluated by the RI.

Considerations:

The EIROforum considers an open call, based on scientific excellence, the best access mechanism. It also recognises the importance of the juste retour and concedes that sometimes a balance between those two access mechanisms needs to be found [EIROForum, 2010].

EGI:

EGI.EU arranges access to the GRID through Virtual Organisations (VOs) that are defined as an organisational grouping that represents a community of users with common interests. EGI.EU has a Memorandum of Understanding with each VO.

PRACE:

PRACE has an open call mechanism in place with scientific publications being the major criteria. [PRACE-Interview, 2011].

7.5.2 Parameter based

Definition:

In the case of a parameter-based access, the available resources of the European ICT RI would be distributed based on some parameter, such as the GNP of the accessing country.

Considerations:

The definition of the parameter and the way to update it must be carefully specified.

In the field of ICT RIs, parameter-based contributions do not appear to be frequently used.

7.5.3 Contribution based / juste retour

Definition:

In the case of a contribution based access, the available resources of the European ICT RI are distributed based on the contributions of the different partners. The idea of "juste retour" is that each contributor receives approximately as much from the RI (in this case, access) as it has contributed.

Considerations:

In a number of cases it could be directly related to the funding approach: "Historically, large international research projects have been funded using a wide variety of schemes, among them:

- *equal shares;*
- *shares that are computed according to some algebraic formula, using one or more input variables. A common variable is Gross Domestic Product (GDP) or its equivalent;*
- *shares that are identical within any of several fixed "bins" that are defined according to some variable such as GDP." [OECD-GSF, 2010]*

7.5.4 Access fees

Definition:

In the case that access fees are applied, some type of fee has to be paid for the use of the facilities of the European ICT RI.

Explanations:

In all other access granting mechanisms, one must meet certain criteria to get access to the Research Infrastructure. In the case of access fees, the only qualification is the payment of the fees.

There are two important parameters for the determination of the access fee:

- The access fee basis
- The access fee level.

Considerations:

When a European ICT RI charges access fees to its users, it must be kept in mind that these users are generally funded by public money.

Networks:

"Many different charging mechanisms are used by those NRENs that make a significant charge to the institutions connected to the network. (In this context, a significant charge was defined as 20% or more of the total annual funding of the NREN).

The most popular model is to charge based on the bandwidth of the interface used to connect the institution; a quarter of the responding NRENs use this mechanism. Other NRENs use the bandwidth consumed or usage (15%), or a combination of several different parameters including the size and type of institution as well as the bandwidth of the interface used to connect the institution. Other charging models are based on linear cost sharing or on the bandwidth of the commercial Internet subscription that the institution takes.

The proportion of user funding varies considerably from NREN to NREN, so the impact of the type of charging model on the charges to institutions will also vary considerably. The details of the proportion of user funding for each NREN can be obtained from the TERENA Compendium." And, "In general, models for charging user institutions are based on policies of individual governments or NRENs. Those models and policies are not co-ordinated at European or global level. However, it is important that charging models are such that they do not discourage international - and especially European – collaborative research and education." [EARNEST-GOV, 2007]

"NRENs are funded in various ways: some receive all of their funding directly from the national government; others are funded entirely by their users (who may, in turn, be government-funded to some extent)." [TERENA-C, 2010]

7.5.4.1 Access fee basis

Definition:

The access fee basis determines on what basis the access fees are calculated.

Explanations:

There are four types of access fee bases that can be distinguished:

- Fixed fee
- Usage-based fee
- Free-to-use model
- In kind.

The fixed fees and usage-based fees are paid in money or monetary equivalent.

7.5.4.1.1 Fixed fee

Definition:

A fixed fee is an access fee that is not based on the usage.

Explanations:

There are three types of fixed fee schemes that can be distinguished:

- Subscription: the access fee is charged periodically and gives access for a certain period of time.
- Freemium: a basic access is for free, but a higher performance access needs to be paid for periodically.
- Professional services: the access is for free, but any kind of help with the access (helpdesk, programming, etc.) must be paid for periodically.

These fixed fees are paid in money or monetary equivalents for all three types of schemes.

Considerations:

Most European ICT RIs have a kind of annual subscription fee.

DCI:

"A subscription is when a customer must pay a monthly or yearly fee to have access to the product/service. This has been common in the publication sector (i.e. magazines, newspapers), but is now used by many businesses and websites such as Netflix, web hosting companies, etc. Usage of the services covered, as part of the subscription, is generally un-metered.

The fees currently paid to EGI.eu by its participants are effectively a "subscription" for all of the services provided by EGI.eu and its partners regardless of use. The participants pay an annual participation fee in order to support the required coordination efforts provided by EGI.eu and its partners that is based on a scheme that links a participant's Gross Domestic Product (GDP) to their fees and votes. An evolution of this model may include modification of the GDP based key or identifying services that can be transitioned to other business models described in this section.

Under this model, greater transparency leads to improved sustainability by accurately allocating costs to particular services and allow specific communities to pay according to what they need and use." [EGI-D2.7, 2011]

7.5.4.1.2 Usage-based fee

Definition:

A usage-based model depends on assigning a cost to the use of a resource or service made available by the infrastructure to particular groups, whether real or virtual.

Explanation:

A usage-based fee can come in two forms:

- Pay-as-you-go: there is a direct correlation between using a service or a resource and paying for that resource or service.
- Freemium: a metered Freemium model offers a basic volume of a resource free of charge (e.g. storage) or offers a basic service free of charge whilst charging a

premium for greater usage volumes or charges a fee for advanced services. The charge will depend on the quantum of resources used or the type and amount of service required.

These usage-based fees are paid in money or monetary equivalents for both forms.

Considerations:

Usage-based fees have the associated risk of reducing the use of the RI as users try to minimise their fees. This might imperil innovation as users spend effort trying to find alternatives that are cheaper than using the RI and thus arrive at sub-optimal solutions.

The usage-based fees require special software to monitor and bill the usage of the RI.

MNT:

The usage based fees in MNT are typically based on the surface used for the device to be fabricated. In micro-electronics, there are often Multi-Project Wafer (MPW) services offered in some standard fabrication technologies. The designs from different sources are all fabricated on the same wafers, and the price for each design is based on the number of square millimetres it takes on the wafer.

DCI, HPC, Networks:

In [EGI-D2.7, 2011] there is the section 4.2 Usage-based Revenue Models from which the following 3 quotes have been taken:

It is reported that: "By implementing detailed accounting and billing tools, EGI would have the ability to record usage and identify the consumer(s) and charge for the cost of the resources that they have used. Currently, such accounting is done for "jobs", but further metered quantities could include other resources and the services that deliver them (e.g. storage, processing, bandwidth, active user accounts, etc.). Resource usage could be accounted for, monitored, controlled, and reported providing transparency for both the provider and consumer of the utilised resource. Payments would then be associated with actual usage."

"A metered *Freemium model* ***offers a basic volume of a resource free of charge (e.g. storage), while charging a premium for greater usage volumes. For an example, Dropbox, an online storage facility, offers a free account with 2GB of space that users can use for as long they like, with payment models for extra space required - 50GB $9.99/month or 100GB $19.99/month. Others businesses provide a 100% premium model, perhaps offering a short free trial period and then requiring a monthly payment to continue using the service. Such a model would allow EGI to provide a free "entry-level" service for new consumers of a service (e.g. a new VO or Resource Infrastructure Provider), while allowing high-volume users of a service to be charged for the resources they use in a "pay as you go" model."***

"The recent emergence of *cloud computing* ***as a business model, has demonstrated how new technologies (i.e. virtualisation) can enable dynamic execution environments or on-demand elastic service deployment with new, clear cost measurements and charging schemes. The ability to provision resources on-demand has shown the use of virtualisation to deliver*** *Infrastructure as a Service* ***(IaaS), hosted environments to provide a*** *Platform as a Service* ***(PaaS) and hosted applications to access*** *Software as a Service* ***(SaaS). Billing according to usage is applicable to services that can be quantified numerically."***

A clear statement was also obtained in the EGI interview: "The only source of funds at present is through the NGIs which have a tiered membership fee depending upon GDP of the country involved. If the debate about who pays for this continues (and it will) then any other funding model becomes artificial or charge per use will be implemented and this will have a consequence on the experiments that are performed because at present usage is not monitored. This means that quite large experiments are performed because there is no project size related charge for performing the experiment like is done at amazon.com If there was a charge for this, then the size (and possibly value) of experiments would diminish." [EGI, 2011]

7.5.4.1.3 Free-to-use model

Definition:

In the free-to-use model, the user does not pay for access but in return gives certain privileges to the RI

Explanations:

In the commercial world, for example the model is used by Hotmail and Gmail. These services give free e-mail capabilities, but in exchange are allowed to advertise heavily

(Hotmail) or to parse the contents of the user's mailbox with some unknown software (Gmail).

Considerations:

This model is found more often in commercial services than public ones.

HPC:

The PRACE requirement that PRACE must be acknowledged in scientific publications based on results obtained with the help of PRACE computers can be considered a "free-to-use" model.

7.5.4.1.4 In kind fee

Definition:

In-kind fees are fees that are not paid in cash.

Explanations:

Typical examples of in-kind fees are software or equipment. The user gives software that he or she has developed to the RI and in return is granted access to the facilities of the RI and the results of the performance of the software. Similarly, an equipment manufacturer places equipment at one of the RI facilities and in return is granted access to the RI and the results of the performance of its equipment in the complex environment of the RI.

DCI, HPC:

These collaborative exchanges can work very well when each party is happy with the service being provided and the community as a whole is happy that the relationship between the parties is equal. It is very hard to balance these models when one party either consumes or has to provide more services than the others, or provides these services at a quality that the rest of the collaboration finds unsatisfactory, yet there is no opportunity to transfer the service to another provider as part of the collaborative activity.

MNT and Nano-electronics:

Equipment as in-kind fee is quite usual. [LETI, 2011], [IMEC, 2011], [CSEM, 2012]

7.5.4.2 Access fee level

Definition:

The access fee level is the level of access fees charged to the user compared with the cost of the access.

Explanation:

Four different levels of access fees can be imposed:

1. For free;
2. Reduced fee;
3. At cost;
4. Commercial.

7.5.4.2.1 Free access

Definition:

In the case of free access, the access fee is zero, but access to the resources is recorded.

7.5.4.2.2 Reduced fee

Definition:

In the case of reduced fees, the access fee is below the cost of the operation of the European ICT RI as a function of the usage proportion.

Considerations:

This could be done to make the researcher aware of the value of the resources they are using, although not aiming at recovering the cost. A typical example is the usage of computing resources where RIs want to avoid the use of non-optimized code which consumes large amounts of computer time.

7.5.4.2.3 At cost fee

Definition:

In the case of at-cost fees, the access fee is equal to the cost of the operation of the European ICT RI as a function of the usage proportion.

Considerations:

The at-cost fee level is used mainly when fees should cover the cost of the RI.

7.5.4.2.4 Commercial fees

Definition:

In the case of commercial fees, the access fee is above the at-cost fee.

Considerations:

This is especially important when certain services are offered that could also be available from industry. In this way the RI does not act in an anti-competitive manner by using public money to offer the same services as offered by industry but at below market prices.

7.6 Access responsibility

Figure 31: The access responsibility branch of the access policy part of the mind map

Definition:

The access responsibility is the set of responsibilities stemming from the fact that the RI has granted access to the user.

Explanations:

When the European ICT RI grants access to a user, the user and the RI enter into a relationship. Both partners in this relationship have responsibilities towards each other. On one side, the RI has a responsibility for the results or facilities it grants access to. On the other, the user has a responsibility for the proper use of the data or facilities he or she has gained access to.

Considerations:

Typically, a User Agreement stipulates the responsibility of the user as well as the responsibility of the RI towards the user.

7.6.1 RI Responsibility

Definition:

The RI access responsibility is the responsibility that the RI has towards the users having gained access to the RI.

Explanations:

The RI is responsible for the safety of personnel working on its premises, including users to whom physical access has been granted.

The RI is responsible for maintaining the security of the infrastructure which it operates.

The RI is responsible for the level of service it offers to its users, especially if the access offered is not free.

The RI is responsible for the training of users to access its resources.

Considerations:

The RI must have a policy to address these responsibilities. The rules stemming from this policy are typically laid down in general Conditions of Sale or similar documents, Rules of Conduct for the premises of the ICT RI, License conditions, Service Level Agreements, etc.

The training responsibility of the RI can represent a significant proportion of its operational budget, but can easily be overlooked in the budgeting of the OPEX.

EGI:

EGI used to have a "GRID security policy" and a "GRID site operations policy". The security policy explains the policy that EGI uses to augment the security policy of individual sites. The site operations policy explains the criteria that a site must fulfil in order to be connected to the EGI grid. EGI.EU is now re-organising as a grouping of Research Infrastructure Providers, with these RI providers often being National Grid Initiatives. The RI provider is a legal entity, allowing it to sign contracts. EGI.EU has a model Memorandum of Understanding with each RI provider, which in turn has a "Resource Centre Operational Level Agreement" with each Resource Centre that it is composed of. This Agreement demands a certain level of quality in the operations of the Resource Centre. Criteria for availability, reliability, etc. are defined in this OLA.

Data repositories:

EIROforum, which consists mainly of instruments, states that a policy for data acquisition, management, and access is also a necessity, and protocols and procedures need to be built into the operation of the RI from the outset. These considerations should extend to defining and implementing standards of data quality, data cleaning, data storage and preservation, and the creation of meta-data. [EIROForum, 2010].

7.6.2 User access responsibility

Definition:

The user access responsibility is the responsibility of the user after having been granted access to the RI.

Considerations:

The user of the RI has the responsibility to use the data or facilities of the RI in the way it was intended and to refrain from any inappropriate use of the access he or she has gained. This implies that the user must make sure that his / her access credentials (passwords, access codes, etc.) do not fall into the hands of a third party. It also implies that the user uses his / her access in the way in which it was intended and avoids any illegal, illicit, or inappropriate use of the RI.

Most ICT organisations have some kind of Acceptable Use Policy (AUP). Sometimes, the RI has AUPs with an intermediary organisation (NRENs in the case of networks and VOs in the case of EGI.EU). In this case, the intermediary organisation is responsible for taking the rules of the AUP and copying them to the AUP which it has with its users.

EGI:

EGI has a "GRID acceptable use policy". [EGI-AUP, 2010]

8 Operational Principles

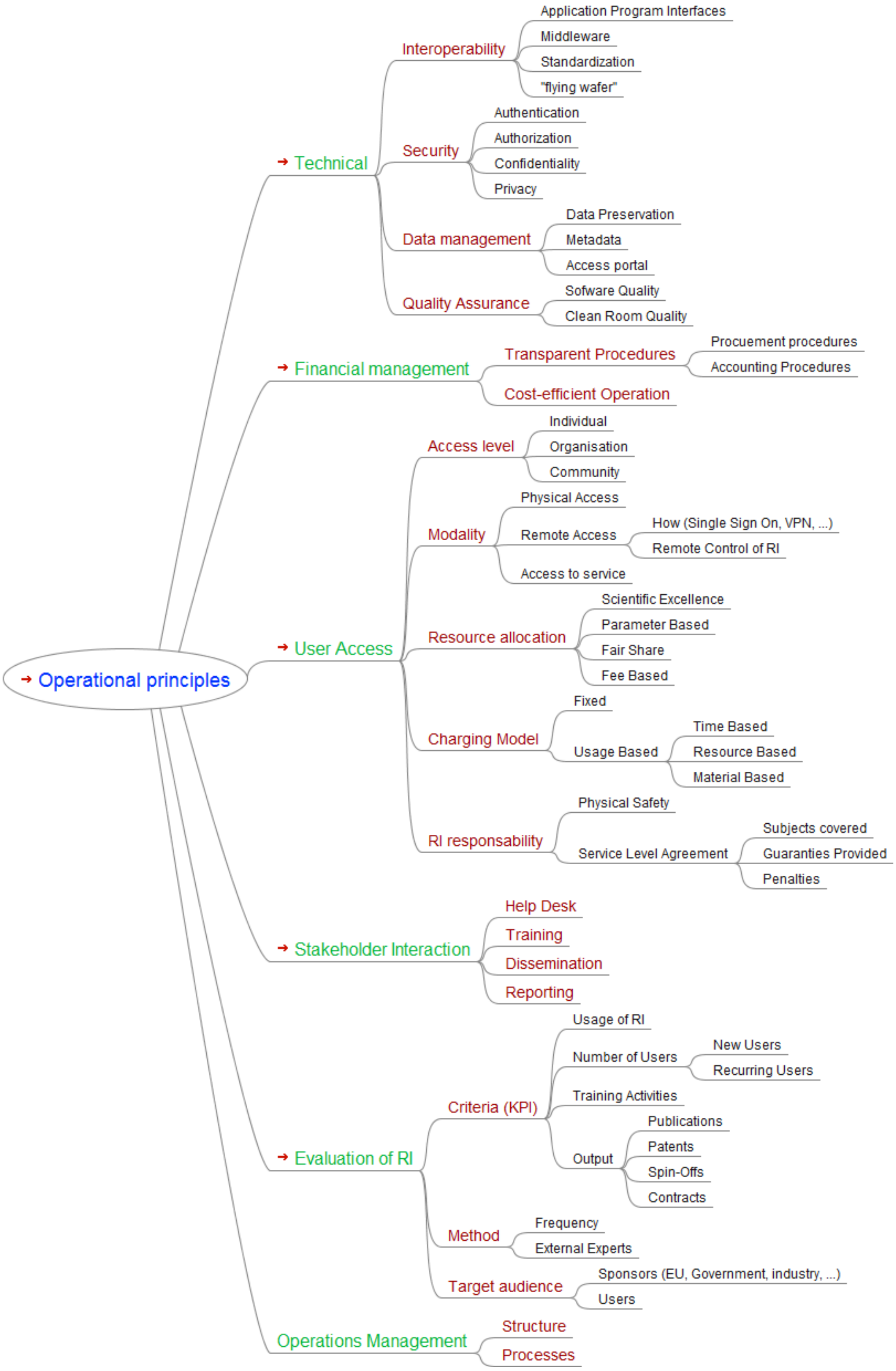

Figure 32: Mind map of the operational principles

Definition:

Service Operation is the phase in the *Information Technology Service Management* (ITSM) Lifecycle that is responsible for 'business-as-usual' activities.[27]

Explanations:

The meaning of "operations" in ICT can be understood by referring to the *Information Technology Infrastructure Library* (ITILT). This publication is written in the context of the ITIL Framework as a source of good practice in Service Management. ITIL is used by organisations worldwide to establish and improve capabilities in Service Management. ISO/IEC 20000 provides a formal and universal standard for organisations seeking to have their Service Management capabilities audited and certified. While ISO/IEC 20000 is a standard to be achieved and maintained, ITIL offers a body of knowledge useful for achieving the standard.

The ITIL core publications describe service management practices. Each provides the guidance necessary for an integrated approach as required by the ISO/IEC 20000 standard specification:

- Service Strategy;
- Service Design;
- Service Transition;
- Service Operation, and
- Continual Service Improvement.

Service Operation can be viewed as the 'factory' of IT. This implies a closer focus on the day-to-day activities and infrastructures that are used to deliver the services. However, this publication is based on the understanding that the overriding purpose of Service Operation is to deliver and support services. Management of the infrastructure and the operational activities must always support this purpose.

The following aspects of the operation have been selected for more detailed analysis:

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[27] ITILT Service Operation book [ITIL-SO, 2007]

- Technical (characterization), regarding interoperability strategies, security, data access, quality assurance;
- Financial (model), regarding the charging model of the RIs, financial procedures and cost-efficient operation;
- User access, regarding level (of the user community organisations), the modality of access, the amount of resources granted, and Service Level Agreements (SLAs);
- Cooperation of distributed RIs;
- Stakeholder interaction, with help desk, training, dissemination and reporting;
- Evaluation of RI, the criteria, methodology and responsibility of evaluation;
- Management structure and tasks for operations.

8.1 Technical

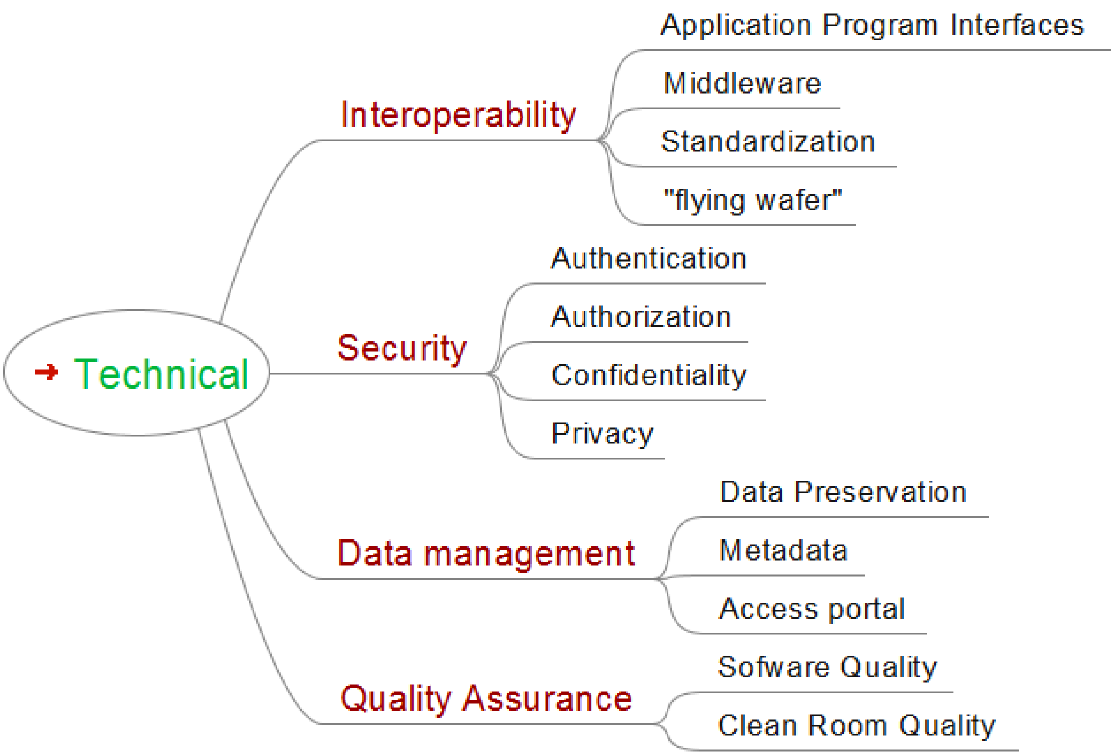

Figure 33: The technical branch of the operational principles part of the mind map

Explanation:

The technical branch of the operational principles describes how the European ICT RI has implemented its service at a technical (software) level. There are four different aspects to this technical implementation:

1. Interoperability;
2. Security;
3. Data access;
4. Quality assurance.

8.1.1 Interoperability

Definition:

The IEEE Glossary defines interoperability as: "the ability of two or more systems or components to exchange information and to use the information that has been exchanged".

And extracted from Wikipedia: "Interoperability is a property of a product or system, whose interfaces are completely understood, to work with other products or systems, present or future, without any restricted access or implementation"[28].

Explanation:

This generalized definition of interoperability can then be used on any system, not only an information technology system. It defines several criteria that can be used to discriminate between systems that are "really" inter-operable and systems that are sold as such but are not because they don't respect one of the aforementioned criteria, namely:

- non-disclosure of one or several **interfaces**
- implementation or **access restriction** built into the product/system/service.

28 http://en.wikipedia.org/wiki/Interoperability.

Considerations:

Interoperability is a primary requirement for research and industry collaborations. Software engineering has introduced the practice of Application Programming Interfaces (APIs) for making different software applications and libraries interoperate.

Interoperability at a (multi-)computing level requires, at a higher level than APIs, the deployment of appropriate middleware. Middleware is a critical layer for the functionality of a distributed computing infrastructure and the tool for the integration of high performance computing centres sited in different locations.

More generally, standardization is needed for industrial process integration from different providers.

In the field of MNT, interoperability is defined as the ability to exchange material (wafers, devices, etc.) between different fabrication sites.

Data repositories:

"How can we implement interoperability within disciplines and move to an overarching multidisciplinary way of understanding and using data?

How can we find unfamiliar but relevant data resources beyond simple keyword searches, but involving a deeper probing into the data? How can automated tools find the information needed to tackle unfamiliar data?" [HlEGSD, 2010]

"Interoperability requires that there be reciprocal agreements between governments – the digital equivalent of trade treaties. There must also be agreement that all countries contribute, according to their usage and needs, to the global effort; free riders can endanger the system. They urge the European Commission to identify a group of international representatives who could meet regularly to discuss the global governance of scientific e-infrastructure. It should also host the first such meeting." [HlEGSD, 2010]

DCI:

Interoperability is an "*intrinsic requirement* ***for*** **Distributed Computing Infrastructures** ***(DCIs)", and open standards are "****necessary***, but** *not sufficient****" [EGI-INT, 2010].***

Interoperability for DCIs is one of the main objectives of the Standards and Interoperability for e-Infrastructure Implementation Initiative (SIENA) This is a Support Action (CSA-SA) of the INFRA-2010-3.3: Coordination Actions, conferences and studies supporting policy development, including international cooperation for e-Infrastructures, that: "will contribute to defining a future e-Infrastructures roadmap focusing on interoperability and standards, in close collaboration with the European Commission, DCIs projects and Standard Development Organisations (SDOs) to gain an in-depth understanding of how distributed computing technology is being developed in this context. The roadmap will define scenarios, identify trends, investigate the innovation and impact sparked by cloud and grid computing, and deliver insight into how standards and the policy framework is defining and shaping current and future development and deployment in Europe and globally" [29].

In the context of grid computing, they are relevant the Open Grid Forum (OGF) efforts towards interoperability. The OGF mission is to: "accelerate grid adoption to enable business value and scientific discovery by providing an open forum for grid innovation and developing open standards for grid software interoperability. OGF provides an open forum that brings together key individuals and organisations from the grid community to align requirements; identify and remove barriers; workshop best practices that will expedite grid adoption. As an open standards organisation, OGF collaborates extensively with other standards development organisations to align with existing industry standards and develop new specifications to enable grid software interoperability." [30]

As reported in relation to **commodity computing*****:***

"The technical interoperability of different computing solutions also needs to be improved. Once interoperability has been achieved, standardisation will allow interoperability to be measured or codified, facilitating its use as criteria in public procurement processes, for example.

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[29] See: http://www.sienainitiative.eu/StaticPage/About.aspx.

[30] See: http://www.ogf.org/About/abt_ataglance.php.

Commoditisation that best serves users and achieves required levels of interoperability can be most effectively reached by approach from several angles, rather than by relying on an individual solution. As a minimum, these approaches should consist of simultaneous:

- ***monitoring of the development of de facto standards to ensure that the investment in formal standardisation efforts is justified by their impact;***
- ***pursuit of formal standardisation processes, with an emphasis on those standards organisations seen as relevant by stakeholders;***
- ***testing and development of third-party interoperability;***
- ***development of policy actions aimed at clearly distinguishing the roles of software, solution and service providers." [e-IRG-RM, 2010]***

We conclude with a recommendation on standards and interoperability:

"e-IRG recommends continuing interoperability benchmarking through global standardisation. In addition to making it easy to benchmark in terms of suitability, dependability and cost-effectiveness in different application domains, this will ensure long-term interoperability of different implementation technologies used for providing e-Infrastructure services and create a marketplace for commercial offerings. "[e-IRG-RM, 2010]

8.1.1.1 Application Program Interfaces (API)

Definition:

An Application Programming Interface (API) is a particular set of rules and specifications that software programs can follow to communicate with each other. It serves as an interface between different software programs and facilitates their interaction, similar to the way a user interface facilitates interaction between humans and computers. An API can be created for applications, libraries, operating systems, etc., as a way of defining their "vocabularies" and resources request conventions (e.g. function-calling conventions). It may include specifications for routines, data structures, object classes, and protocols used to communicate between the consumer program and the implementer program of the API[31].

8.1.1.2 Middleware

[31] See: http://www.wikipedia.org

Definition:

"Within e-Infrastructures there are many types and kinds of middleware. Even the term 'middleware' is not standardised, with its meaning changing depending on the environment in which it is developed or deployed. In a distributed computing system, for example, middleware is defined as the software layer lying between the operating system and the applications. In a broader sense, middleware is computer software that connects components or applications. Middleware is also used to refer to the 'glue' that enables virtualisation technology and services.

In addition, grid middleware is defined as the intermediate software between any local IT resource management system and the applications. It is built by layered interacting software packages that enable the shared usage of various ICT resources from multiple administrative domains for a common goal. The many different groups brought together in this collaborative effort, aiming, in general at solving a common problem, are identified as a Virtual Organisation (VO)."[32]

"Middleware services provide a more functional set of Application Programming Interfaces (API) to allow an application to:

- **locate transparently across the network, thus providing interaction with another service or application,**
- **filter data to make them friendly usable or public via anonymization process for privacy protection (for example),**
- **be independent from network services,**
- **be reliable and always available,**
- **add complementary attributes like semantics, when compared to the operating system and network services. […][33]"**

Considerations:

32 See: e-IRG Blue Paper, p.13 [e-IRG-BP, 2010]

33 See: http://en.wikipedia.org/wiki/Middleware.

"Middleware can help software developers avoid having to write an API for every control program, by serving as an independent programming interface for their applications. For Future Internet network operation through traffic monitoring in multi-domain scenarios, using mediator tools (middleware) is a powerful help since they allow operators, searchers and service providers to supervise Quality of service and analyse eventual failures in telecommunication services."[34]

Also from Wikipedia,35 "[…] various middleware projects have created generic infrastructure to allow diverse scientific and commercial projects to harness a particular associated grid or for the purpose of setting up new grids. […] Grid middleware is a specific software product, which enables the sharing of heterogeneous resources, and Virtual Organisations. It is installed and integrated into the existing infrastructure of the involved company or companies, and provides a special layer placed among the heterogeneous infrastructure and the specific user applications. Major grid middlewares are Globus Toolkit, gLite, and UNICORE."

DCI:

The middleware layer is a prerequisite in order to effectively operate grids and clouds. The European Middleware Initiative (EMI) project "aims to deliver a consolidated set of middleware products based on the four major middleware providers in Europe – ARC, dCache, gLite and UNICORE. The products, managed in the past by these separate providers, and now developed, built and tested in collaboration, are for deployment in EGI (as part of the Unified Middleware Distribution or UMD), and other distributed computing infrastructures, extend the interoperability and integration between grids and other computing infrastructures, strengthen the reliability and manageability of the services and establish a sustainable model to support, harmonise and evolve the middleware, ensuring it responds effectively to the requirements of the scientific communities relying on it."[36].

For a recent survey regarding the specific use of grid/cloud middleware in Research, see in particular [EMI-SV, 2011]. Familiarity with gLite was indicated by 80% of the respondents, followed by Globus (65%), dCache (33%), ARC (25%), UNICORE (19%), OpenNebula (for cloud, 15%).

8.1.1.3 Standardization

34 See: http://en.wikipedia.org/wiki/Middleware_%28distributed_applications%29

35 See: http://en.wikipedia.org/wiki/Grid_computing.

36 See: http://www.eu-emi.eu/middleware

Definition:

Standardization is the process of establishing a technical standard, which could be a standard specification, standard test method, standard definition, standard procedure (or practice), etc. In the context of business information exchanges, standardization refers to the process of developing data exchange standards for specific business processes using specific syntaxes. These standards are usually developed in voluntary consensus standards bodies such as the United Nations Center for Trade Facilitation and Electronic Business (UN/CEFACT), the World Wide Web Consortium W3C, and the Organisation for the Advancement of Structured Information Standards (OASIS)[37].

8.1.1.4 "Flying wafer"

Definition:

The "flying wafer" concept is the idea to efficiently exchange wafers between different RIs in the field of micro- and nano electronics or Micro- and Nano-Technology (MNT). Certain processes will be executed at one RI and then the wafers will be shipped to a second RI for further processing. Multiple shipments to multiple RIs are possible.

Considerations:

There is an on-going feasibility study for a 'Flying Wafer' Concept to Implement a European Virtual 300 mm R&D-Line. The strategic objective addressed in this project is a feasibility study concerning realising a "Flying Wafer"-concept by specifying and evaluating all the necessary logistical requirements and infrastructural pre-conditions for a European virtual 300 mm R&D-line. The most important issues to be covered are:

- *wafer/carrier handling, transport and logistics*
- *wafer/carrier tracking and monitoring*
- *standardisation of data interfaces and secure data access*
- *I/O-procedures and optimised contamination control*
- *virtual process flow planning including alternative scenarios for redundancy set-up.*

[37] See: http://en.wikipedia.org/wiki/Standardization

Thus, this project should achieve a demonstration of feasibility for cost-effectively interlinking industrial and institutional European R&D-nodes by the proposed "Flying Wafer"-concept.[38]

Even though this concept is very attractive in terms of optimisation of resources there are two main bottlenecks:

- *the virtual process flow planning requires the transparency of process flows between RIs. The details of a process flow sometimes contain proprietary know-how of a RI, which will therefore need to be protected from other RIs;*
- *the contamination control requires a high level of confidence between the participating RIs. Wafer contamination is extremely difficult to detect, is difficult to remove, and can have extremely serious consequence A contamination event can cost up to several tens of millions of Euros.*

The second bottleneck in particular limits the "flying wafer" concept to a subset of processes that are less critical to contamination problems.

8.1.2 Security

Definition:

In the European standard [ISO27001, 2005] information security is defined as:

"preservation of confidentiality, integrity and availability of information; in addition, other properties such as authenticity, accountability, non-repudiation and reliability can also be involved"

Other definitions from [ISO27001, 2005] can be useful to obtain a clear understanding of the information security framework:

Confidentiality: the property that information is not made available or disclosed to unauthorized individuals, entities, or processes;

Information security event: an identified occurrence of a system, service or network state indicating a possible breach of information security policy or failure of safeguards, or a previously unknown situation that may be security relevant;

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[38] See: www.flying-wafer.info.

Information security incident: a single or a series of unwanted or unexpected information security events that have a significant probability of compromising business operations and threatening information security;

Information security management system (ISMS): that part of the overall management system, based on a business risk approach, to establish, implement, operate, monitor, review, maintain and improve information security. Note: the management system includes organisational structure, policies, planning activities, responsibilities, practices, procedures, processes and resources;

Integrity: the property of safeguarding the accuracy and completeness of assets.

In [e-IRG-RMPC, 2010], 3.3: Authentication, Authorisation and Accounting, a definition of authentication is given:

Authentication allows entities (usually users) to establish their identity within a specific e-Infrastructure. In a highly distributed and collaborative environment that crosses multiple administrative domains and national boundaries it is of great value if the authentication is valid, not only in the researchers' home institution, but also in a large part of their collaborative environment. Authorization establishes the rights of individual users to perform certain operations within that specific infrastructure, where those rights are decided according to defined resource access policies. These policies are defined by the resource owner, or delegated to a trusted third party (e.g. a virtual organisation).

Considerations:

Security is a primary concern for research and industry collaborations. The physical security option is not always available for distributed infrastructures, so that logical security should be pursued. The triple-A, for Authentication, Authorization and Accounting is a common pattern in computer security. The first, Authentication, refers to the digital identity of the user; the second, Authorization, refers to the restrictions on activities, the third Accounting refers to the tracking of the resource consumptions. Confidentiality is the provider's counterpart of the user's authorization.

Finally, privacy is an increasingly important requirement related to the information that the provider accumulates regarding users' resource access profiles.

HPC, DCI, Networks, data:

There is a specific paragraph in [e-IRG-WP, 2011], regarding "Authentication, Authorisation and Accounting" that describes the objectives of the AAA process. According to [e-IRG-WP, 2011], the overall objective is "to establish and maintain the level of mutual trust amongst users and service providers, necessary for an open ecosystem to function. As an e-Infrastructure matures and its user community grows, requirements for aligning authentication and authorisations also grow." Also, "The development and deployment of Authentication and Authorisation Infrastructure (AAI) has taken place in different research and education environments, as well as in the private and public sector. In grids, for example, access control is based on standard X.509 certificates and a set of well-established global procedures and policies, supported by widely deployed software base as part of grid middleware."

Cons: "[…] there are two factors that hinder a widespread adoption of X.509 certificates. Firstly, it has turned out that X.509 procedures are difficult for the user to handle properly and securely. Secondly, the current organisational setup is not suited to issue certificates to a very large user base."

Regarding AAI for e-Infrastructures, in [e-IRG-RMPC, 2010] the following recommendations are made:

- ***continue to improve national infrastructures and their alignment with agreed standard procedures for identity management, accounting and assurance, with the objective of technical interoperability between all national AAIs;***

- ***accelerate the continued integration of different identity technologies, through supporting active collaboration between the IGTF, GÉANT and relevant European and international working groups;***
- ***require that, wherever possible, future pan-European e-Infrastructure and ESFRI RI projects define their access control policies and mechanisms from the beginning, in accordance with the standards and best practices adopted by the community;***
- ***draw up a roadmap to book progress for all stakeholders in the unified integrated approaches to replace existing authentication and authorization infrastructures based on national AAIs.***

In [EEF, 2010] it is reported in the conclusions that:

"Since many of the ESFRI projects have stated that they have a clear need to make use of several of the existing European e-infrastructures, improving the inter-operability between these structures will have a definite added-value for all the user communities. So as part of the analysis work, EEF members have identified areas where the infrastructures can work in tandem:

- ***access to resources (i.e. harmonising policies for Authentication, Authorization, Accounting and Auditing);***
- ***user support (i.e. problem handling procedures) and training;***
- ***security incident handling (i.e. cooperating security incident response group);***
- ***data management (i.e. seamless authorised access to data across the infrastructures for users);***
- ***dealing with perceived performance issues."***

And suggests:

"All the ESFRI projects consulted identified consistent identity management and single sign-on as a fundamental requirement. A unified single sign-on service has to ensure an individual's identity can be used across Network, HPC and grid services. All the e-infrastructures in EEF have existing Authentication and Authorization Infrastructures (AAI) which are similar but not identical and are separately managed. Harmonising policies for Authentication, Authorization and potentially Accounting and Auditing will simplify access and usage to the e-infrastructures. The issue for EEF to offer what is requested by the ESFRI projects is to make these existing AAI systems interoperate so that a user's identity can be established once and accepted by all the e-infrastructures."

Security is one of the great challenges cited in [HlEGSD, 2010] for scientific e-Infrastructures: "How can we guarantee data integrity? How can we avoid data poisoning by individuals or groups intending to bias them in their interest? How can we react in the case of security breaches to limit their impact?"

Also, in [e-IRG-WP, 2009]:

- ***security is hard to describe and measure: there exists no commonly accepted language and metric for all aspects of security and it is often judged on subjective grounds only;***
- ***security has different meanings depending on the domains and the scope;***
- ***security is costly: those willing to accept a lower level of security are generally not willing to pay more simply because others require a higher level;***
- ***security can be cumbersome: a higher level of security often makes it harder to use a piece of e-Infrastructure;***
- ***security is a moving target: what is secure enough today, might not stay secure enough tomorrow. Sometimes, such change occurs almost instantly: new discoveries might instantly render important security elements useless;***
- ***security has many stakeholders: an attacker needs to find only one particular method to successfully attack a service. The defender, on the other hand, needs to protect against all possible attacks to the service, covering the entire supply chain and involved parties.***

8.1.2.1 Authentication

Definition:

Authentication allows entities (usually users) to establish their identity within a specific e-Infrastructure. In a highly distributed and collaborative environment that crosses multiple administrative domains and national boundaries it is of great value if the authentication is valid, not only in the researchers' home institution, but also in a large part of their collaborative environment[39].

Considerations:

Ideally, the authentication should take place only once, after which the user receives the authorisation to use all resources he/she is entitled to, spanning different e-Infrastructures. Remarkable efforts are being made in the national and international authentication federations where participating research organisations and universities act as identity providers and registered e-infrastructures can act as service providers. The researcher has to follow only the authentication procedure in his/her institute to get access to all services to which he/she is entitled in the bouquet offered by the service providers. The authentication procedures should present a good balance between security and ease-of-use.

8.1.2.2 Authorization

Definition:

Authorization establishes the rights of individual users to perform certain operations within that specific infrastructure, where those rights are decided according to defined resource access policies. These policies are defined by the resource owner, or delegated to a trusted third party (e.g. a virtual organisation)[40].

8.1.2.3 Confidentiality

Definition:

Confidentiality is defined as: the property that information is not made available or disclosed to unauthorized individuals, entities, or processes[41].

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39 [e-IRG-WP, 2011]

40 [e-IRG-WP, 2011]

41 [ISO27001, 2005]

Explanation:

The confidentiality requirement binds information to authorised users and prevents unauthorised users from accessing this information.

8.1.2.4 Privacy

Definition:

Data privacy refers to the evolving relationship between technology and the legal right to, or public expectation of, privacy in the collection and sharing of data about one's self. Privacy concerns exist wherever uniquely identifiable data relating to a person or persons are collected and stored, in digital form or otherwise. In some cases these concerns refer to how data is collected, stored, and associated. In other cases the issue is who is given access to information. Other issues include whether an individual has any ownership rights to data about themselves, and/or the right to view, verify, and challenge that information[42].

8.1.3 Data Access

Definition:

Data access typically refers to software and activities related to storing, retrieving, or acting on data housed in a database or other repository[43].

Explanation:

ICT is the result of a smart combination of three structural dimensions: computing, network and data. The focus of ICT was traditionally on computing; then, the network took on the lead position – internet and web – and, now it is perhaps the turn of data (traditionally called memory, and later storage). It has currently registered an explosive growth in the quantity of digital data worldwide. This is estimated by IDC44 at 1.8 Zetabyte for 2011. Managing and giving access to this mass of data is becoming a problem. The large experimental facilities that are now in the European roadmap for science are capable of

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[42] http://en.wikipedia.org/wiki/Information_privacy

[43] http://en.wikipedia.org/wiki/Data_access

[44] Gantz, J., Reinsel, D.: Extracting value from Chaos. Technical report, IDC (2011).

continuously generating wide sets of data that need to be validated, preserved, qualified with metadata, managed, distributed and analysed.

Considerations:

Data is the target for a new class of ICT research infrastructures. Managing data access appropriately requires a careful management of the process of data generation, validation, qualification with metadata, preservation, and distribution. Then, data should be available to scientists for the required analysis. As the quantity of data grows, portals (gateways) are needed to allow user communities to orient in this increasing large world of (scientific) data in the search for the required information.

DCI, HPC, Data repositories:

“Our vision is a scientific e-infrastructure that supports seamless* access*,* use*,* re-use*, and* trust *of data. In a sense, the physical and technical infrastructure becomes invisible and* the data themselves become the infrastructure – *a valuable asset, on which science, technology, the economy and society can advance.” And, “The emerging infrastructure for scientific data must be flexible but reliable, secure yet open, local and global, affordable yet high-performance.” [HlEGSD, 2010]

8.1.3.1 Data Preservation

Definition:

From IT Law Wiki : “The term preservation has several different meanings. In general terms, preservation refers to a series of activities (managerial, financial, and technical) undertaken to prevent deterioration of a document or artefact and to ensure that it will continue to be usable. It may also refer to activities taken to ensure the integrity and long-term availability of information contained in rare or fragile documents or artefacts through the creation of surrogates for access purposes.”

Considerations:

“One of the great challenges for scientific e-Infrastructures is (data) preservation and sustainability. How can we be sure that the important information we collect will be usable and understandable in the future; in particular how can we fund our information resources in the long term? How can we share the costs and efforts required for sustainability? How can we decide what to preserve?” [HlEGSD, 2010]

8.1.3.2 Metadata

Definition:

From IT Law Wiki: “Metadata (also spelled meta data) refers to structured data that contain or define other data, making it more discoverable in online environments. Metadata also provides context to data and can make data easier to reuse and combine with other data. Metadata can also include information about the quality of the data.”

8.1.3.3 Portal

Definition:

From IT law Wiki: “A portal is a website that provides at least three essential functions: a search engine, e-mail, and personalized news. A portal is intended to be the site a user first connects to, whenever they log onto the Internet. It attracts users by providing personalized and customized services (e-mail and news) and providing search services which are frequently used to find and access other sites.”

8.1.4 Quality Assurance

Definition:

From [ISO9000, 2005] §3.2.11: “Part of quality management focused on providing confidence that quality requirements will be fulfilled”, where quality management is defined as: “Coordinated activities to direct and control an organisation with regard to quality”, and quality as: “Degree to which a set of inherent characteristics fulfils requirements”.

Explanation:

Quality assurance is the quality of the *process*. The processes can be related to *systems* or to *software*. System *Engineering* applies to “systems that are man-made and may be configured with one or more of the following: hardware, software, data, humans, processes, procedures, facilities, materials and naturally occurring entities.” (see: ISO/IEC 15288 for System Life Cycle processes). *Software Engineering* applies to software products and services (see: ISO/IEC 12207 for Software Life Cycle processes). There is then the quality of the *product*. In the ICT context, apart from the quality of services, quality assurance is relevant to the *quality of the software* and, for MNT, the quality of the equipment, which is mainly represented by the *clean room quality* (class) is also relevant.

8.1.4.1 Software Quality

Considerations:

Software Quality is heavily analysed in the ISO series of norms, the 25000 Software Engineering – Software Product Quality Requirements and Evaluation (SQuaRE) series.

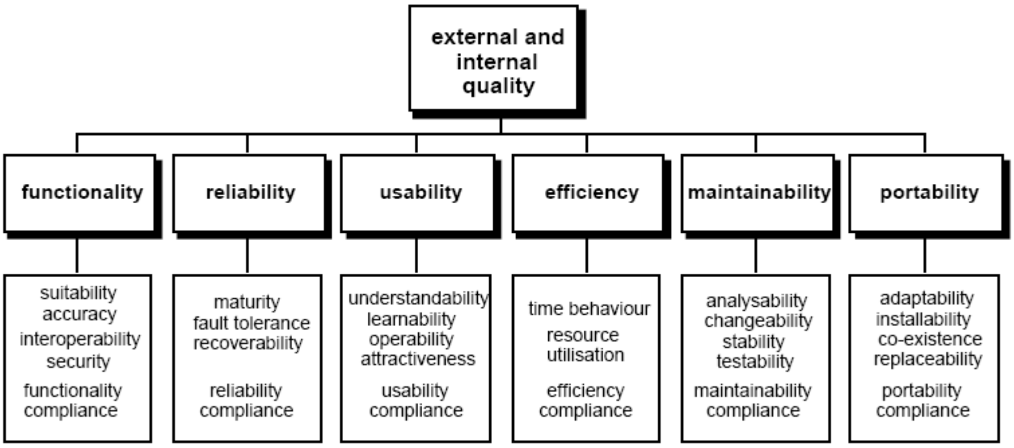

Figure 34: Software Quality ISO 25000 Characteristics

Also, the Software Engineering Body of Knowledge (SWEBOK) can be of help in understanding software quality. In [SWEBOK, 2004] Software Quality processes are analysed:

- ***Quality assurance** process – ensure that planned processes are appropriate and later implemented according to plan, and that relevant measurement processes are provided to the appropriate organisation*
- ***Verification** process – ensure that the product is built correctly, in the sense that the output products of an activity meet the specifications imposed on them in previous activities*
- ***Validation** process – ensure that the right product is built, that is, that the product fulfils its specific intended purpose*
- ***Review** process - management review This monitors progress, determines the status of plans and schedules, confirms requirements and their system allocation, or evaluates the effectiveness of management approaches used to achieve fitness for purpose", and technical review, which evaluates a software product to determine its suitability for its intended use*

- ***Audit*** *process – provides an independent evaluation of the conformance of software products and processes to applicable regulations, standards, guidelines, plans, and procedures.*

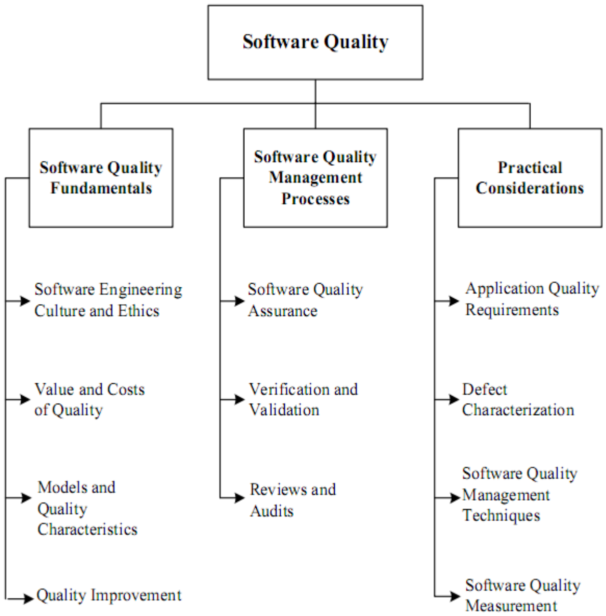

Figure 35: SWEBOK Software Quality processes

8.1.4.2 Clean Room Quality

Definition:

From Wikipedia: "A cleanroom is an environment, typically used in manufacturing or scientific research, that has a low level of environmental pollutants such as dust, airborne microbes, aerosol particles and chemical vapours. More accurately, a cleanroom has a controlled level of contamination that is specified by the number of particles per cubic meter at a specified particle size. To give perspective, the ambient air outside in a typical urban environment contains 35,000,000 particles per cubic meter in the size range 0.5 µm and larger in diameter, corresponding to an ISO 9 cleanroom, while an ISO 1 cleanroom allows no particles in that size range and only 12 particles per cubic meter of 0.3 µm and smaller.".

Regarding the quality standards, the same Wikipedia source says that "[…] Cleanrooms are classified according to the number and size of particles permitted per volume of air."

“Large numbers like "class 100" or "class 1000" refer to FED-STD-209E, and denote the number of particles of size 0.5 µm or larger permitted per cubic foot of air. The standard also allows interpolation, so it is possible to describe e.g. "class 2000". A discrete-particle-counting, light-scattering instrument is used to determine the concentration of airborne particles, equal to and larger than the specified sizes, at designated sampling locations.

Small numbers refer to ISO 14644-1 standards, which specify the decimal logarithm of the number of particles 0.1 µm or larger permitted per cubic metre of air. So, for example, an ISO class 5 cleanroom has at most 10^5 = 100,000 particles per m^3.

Both FS 209E and ISO 14644-1 assume log-log relationships between particle size and particle concentration. For that reason, there is no such thing as zero particle concentration. The table locations without entries are non-applicable combinations of particle sizes and cleanliness classes, and should not be read as zero. Because 1 m^3 is approximately 35 ft^3, the two standards are mostly equivalent when measuring 0.5 µm particles, although the testing standards differ. Ordinary room air is approximately class 1,000,000 or ISO 9.”

Considerations:

The quality of the air in a cleanroom is achieved by passing it regularly through High-Efficiency Particulate Air (HEPA) filters. The more often the air is passed through the filters the lower the particle count that can be achieved. The air speed resulting from this repeated passing through filters can achieve the m/s level for ISO 1-2cleanrooms. The energy required to pump the air at such a speed is quite high and is one of the principal contributions to the electricity consumption of a cleanroom.

8.2 Financial management

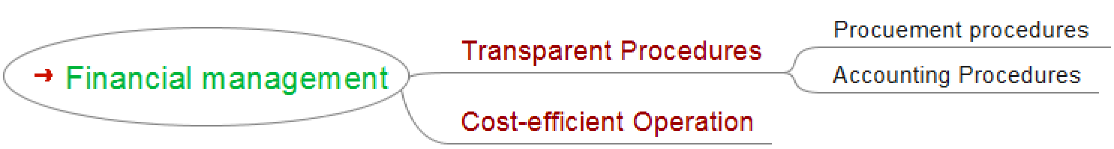

Figure 36: The financial management branch of the financial part of the mind map

Definition:

Financial Management is one of the more important functions of management in dealing with the resource and monetary aspect of business for funding and operating a business with adequate return[45].

Explanation:

The financial management handles all the income and expenses of a European ICT RI. The financial management has two key parameters which it needs to achieve in order to guarantee an efficient operation:

1. It needs to have robust and efficient procedures;
2. It needs to continuously strive to have a cost-efficient operation.

[45] http://en.wikipedia.org/wiki/Financial_management

Considerations:

As noted in [ITIL-SS, 2007], operational visibility, insight and superior decision making are the core capabilities brought to the enterprise through the rigorous application of Financial Management. Just as business units accrue benefits through the analysis of product mix and margin data, as well as customer profiles and product behaviour, a similar utility of financial data continues to increase the importance of Financial Management for IT.

Financial Management as a strategic tool is equally applicable to all three service provider types. Internal service providers are increasingly asked to operate with the same levels of financial visibility and accountability as their business unit and external counterparts. Moreover, technology and innovation have become the core revenue-generating capabilities of many companies.

Financial Management provides the business and IT with the quantification, in financial terms, of the value of IT Services, the value of the assets underlying the provisioning of those services, and the qualification of operational forecasting. Talking about IT in terms of services is the crux of changing the perception of IT and its value to the business. Therefore, a significant portion of Financial Management needs to work in tandem with IT and the business to help identify, document and agree on the value of the services being received, and the enablement of service demand modelling and management. [ITIL-SS, 2007]

Service and strategy design both benefit greatly from the operational decision-making data that Financial Management aggregates, refines and distributes as part of the Financial Management process.

Rigorously applied, Financial Management generates meaningful critical performance data used to answer important questions for an organisation:

- *Is our differentiation strategy resulting in higher profits or revenues, lower costs, or greater service adoption?*
- *Which services cost us the most, and why?*
- *What are our volumes and types of consumed services, and what is the correlating budget requirement?*
- *How efficient are our service provisioning models in relation to alternatives?*
- *Does our strategic approach to service design result in services that can be offered at a competitive 'market price', substantially reduce risk or offer superior value?*
- *Where are our greatest service inefficiencies?*

- *Which functional areas represent the highest priority opportunities for us to focus on as we generate a Continual Service Improvement strategy?*

8.2.1 Transparent Procedures

Definition:

From [ISO9000, 2005], §3.4.5, *procedure*: specified way to carry out an activity or a process (3.4.1). Procedures can be documented or not. When a procedure is documented, the term "written procedure" or "documented procedure" is frequently used. The document (3.7.2) that contains a procedure can be called a "procedure document".

Explanation:

In order for the procedures of financial management to be transparent, they need to be documented and verifiable. This means that the procedures that are described in documents can be verified by inspection and that the procedures are carried out according to the documents.

Considerations:

European ICT RIs, which often get funded by public money, will be regularly audited by the funding agencies. For example, the EU has put in place audits for almost all research projects that it funds. RIs should therefore have financial procedures in accordance with such audit mechanisms.

8.2.1.1 Procurement procedures

Definition:

Procurement is the acquisition of goods or services. It is beneficial that the goods/services are appropriate and that they are procured at the best possible cost to meet the needs of the purchaser in terms of quality and quantity, time, and location. Corporations and public bodies often define processes intended to promote fair and open competition for their business while minimizing exposure to fraud and collusion[46].

Considerations:

We can refer to the [ISO9001, 2008], §7.4.1 Purchasing process:

"The organisation shall ensure that purchased product conforms to specified purchase requirements. The type and extent of control applied to the supplier and the purchased product shall be dependent upon the effect of the purchased product on subsequent product realization or the final product. The organisation shall evaluate and select suppliers based on their ability to supply product in accordance with the organisation's requirements. Criteria for selection, evaluation and re-evaluation shall be established. Records of the results of evaluations and any necessary actions arising from the evaluation shall be maintained."

And, to the [ISO20000, 2005], §7.3 Supplier management:

Objective: To manage suppliers to ensure the provision of seamless, quality services.

The service provider shall have documented supplier management processes and shall name a contract manager responsible for each supplier.

[46] http://en.wikipedia.org/wiki/Procurement

- *The requirements, scope, level of service and communication processes to be provided by the supplier(s) shall be documented in SLAs or other documents and agreed by all parties.*
- *SLAs with the suppliers shall be aligned with the SLA(s) of the business.*
- *The interfaces between processes used by each party shall be documented and agreed. All roles and relationships between lead and subcontracted suppliers shall be clearly documented.*
- *Lead suppliers shall be able to demonstrate processes to ensure that subcontracted suppliers meet contractual requirements.*
- *A process shall be in place for a major review of the contract or formal agreement at least annually to ensure that business needs and contractual obligations are still being met.*
- *Changes to the contract(s), if present, and SLA(s) shall follow from these reviews as appropriate or at other times as required. Any changes shall be subject to the change management process.*
- *A process shall exist to deal with contractual disputes. A process shall be in place to deal with the expected end of service, early end of the service or transfer of service to another party.*
- *Performance against service level targets shall be monitored and reviewed. Actions for improvement identified during this process shall be recorded and input into a plan for improving the service.*

8.2.1.2 Accounting Procedures

Definition:

Accountancy **is the process of communicating financial information about a business entity to users such as shareholders and managers. The communication is generally in the form of financial statements that show in money terms the economic resources under the control of management; the art lies in selecting the information that is relevant to the user and is reliable. The principles of accountancy are applied to business entities in three divisions of practical art, named accounting, bookkeeping, and auditing[47].**

[47] http://en.wikipedia.org/wiki/Accountancy

Explanations:

The body of rules that governs financial accounting in a given jurisdiction is called Generally Accepted Accounting Principles, or GAAP. Other rules include International Financial Reporting Standards, or IFRS[48].

[48] http://www.ifrs.com/

Considerations:

In [ISO2000, 2005], §6.4 Budgeting and accounting for IT services are defined.

Objective: To budget and account for the cost of service provision.

Note: in practice, many service providers will be involved in charging for such services. However, since charging is an optional activity, it is not covered by the standard. It is recommended to Service providers that where charging is in use, the mechanism for doing so is fully defined and understood by all parties. All accounting practices in use should be aligned to the wider accountancy practices of the service provider's organisation.

There shall be clear policies and processes for:

a) budgeting, and accounting for all components including IT assets, shared resources, overheads, externally supplied service, people, insurance and licences;

b) apportioning indirect costs and allocating direct costs to services;

c) effective financial control and authorization.

Costs shall be budgeted in sufficient detail to enable effective financial control and decision making. The service provider shall monitor and report costs against the budget, review the financial forecasts and manage costs accordingly. Changes to services shall be costed and approved through the change management process.

8.2.2 Cost-efficient Operation

Definition:

A cost-efficient operation in the context of a European ICT RI means that the maximum amount of revenue of the RI is spent towards achieving its scientific and technical goals.

Considerations:

Cost-efficient operations mean the minimisation of the Operational Expenses (OPEX) not spent on the scientific and technical goals of the RI. The OPEX of a RI is described in more detail in Section 6.2.2.

8.3 User Access

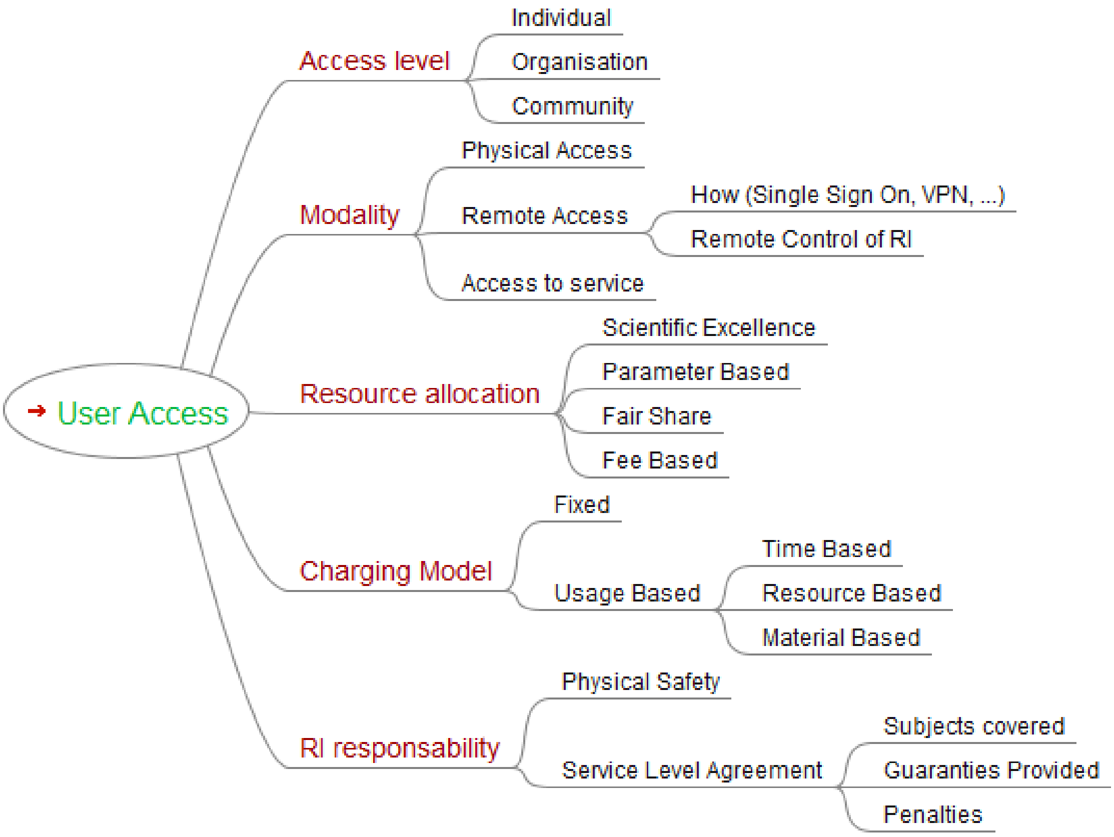

Figure 37: The user access branch of the operational principles part of the mind map

Definition:

The user access management in a European ICT RI is the implementation of the user access policy of the RI.

Explanation:

In the ICT Research Infrastructures user access requires that the following parameters be set:

- *The level of the organisation*: researchers as individuals, inside research institutions, across a community network;
- *The modality of access* to the RI (*how)*: physical access, remote access, or access to service;
- *The amount* of *resources* to be provided: with a fair share, fee-based or parameter based (such as scientific excellence) agreement;

- *The charging model used:* fixed or usage-based;
- The definition of the responsibility of the RI.

Considerations:

"A well-defined policy for user access is fundamental and should be clearly defined. In principle, RIs should offer open access to their facilities with peer review, ensuring priority is given to scientific excellence. However, where physical access is required to conduct experiments/observations members may elect to protect their "investment" in the RI and impose quotas and/or limit access for participants from non-member states. A fair balance between the promotion of science and juste retour to members needs to be found and agreed on and the legal requirements for data protection need to be taken into account. A policy for data acquisition, management, and access is also a necessity, and protocols and procedures need to be built into the operation of the RI from the outset. These considerations should extend to defining and implementing standards of data quality, data cleaning, data storage and preservation, and the creation of meta-data." [EIROForum, 2010], 4.9: User Access and Data Management.

8.3.1 Access Level

Explanation:

The access level management means in the context of the European ICT RI whether the user of the RI is:

- An individual;
- An organisation, or;
- A user community.

8.3.1.1 Individual (researchers)

Considerations:

Individual-level access is a common pattern for instance in HPC, where scientific excellence is the criteria adopted to assign the computing time resources. It is less common in distributed RIs (where communities and institutions are preferred).

8.3.1.2 Organisation (Research Institutions / Industries)

Considerations:

Organisation-level access is used by almost all the RIs.

Networks:

(Public) Institutions commonly participate in network or distributed RIs via National reference points (NRENs or NGIs).

MNT:

Private Industry typically signs contracts with MNT RIs to access their resources/facilities

8.3.1.3 Community

Definition:

"A virtual community is a group of scattered individuals and/or organisations that share common interests and resources. Popular examples of such communities are YouTube, eBay and Wikipedia. By analogy, Virtual Research Communities (VRCs) are widely dispersed groups of researchers and associated research resources working together in virtual research environments. The virtual (electronic) integration of distributed people and things through the underlying e-Infrastructure is a key enabler for supporting distributed research teams, facilitating inter- and multidisciplinary research, and driving innovative exploitation of the combined research potential of Europe. As such, VRCs are fundamental to the vision of the ERA. In practice, support of VRCs requires integration of e-Infrastructure and more general RI services into standard practices and tools used by researchers."[49]

Considerations:

"In addition to direct support for research endeavours, VRCs support can extend access to research and research outputs, increase openness, improve (virtual) mobility and cost sharing, as well as reducing duplication. VRCs not only enable integration of distributed research capacities/resources, but also allow:

- *virtual mobility of physically distant researchers,*
- *accessibility of intermediate as well as final research results,*
- *combination of distributed multidisciplinary knowledge,*
- *discovery of novel R&D directions,*

[49] [E-IRG-BP, 2010]

- *enhancement of innovation capabilities,*
- *integration of research and education,*
- *improvement of regional and global collaboration,*
- *development of high-performance, sustainable multilateral partnerships, and*
- *improvement of organisational as well as financial practices.*

VRCs developments will change attitudes and approaches within (virtual) research communities, directly supporting the wider integrating agenda of the ERA. VRC developments should proceed gradually, starting with domain-specific shared access to distributed resources, eventually expanding to integrate different research activities, and ultimately including wider support infrastructure integrating separate organisations / finances / management. Throughout, due emphasis on monitoring and motivating of researchers' attitudes and behaviour will be essential." [E-IRG-BP, 2010]

8.3.2 Modality

Definition:

Modality in the context of user access management of European ICT RIs means the way in which the user can have access to the facility.

Explanation:

Access to RIs can be:

- Physical access: the scientist goes to the facilities in order to make use of the infrastructure capabilities;
- Remote access: the right communication connections enable the scientist to make effective use of the RI resources while remaining in their own place /country;
- Access to service: the scientist communicates his / her needs to the RI and receives the results. The work of producing the results is carried out by scientists at the RI.

8.3.2.1 Physical Access

Definition:

“Physical access is a term in computer security that refers to the ability of people to physically gain access to a computer system.”[50]

Explanation:

Physical access needs to be limited to only allow authorised people to enter the premises. Physical access control is typically implemented using gates, barriers, access cards or badges, security guards, etc. The allowing of physical access to the RI directly implies the responsibility of the RI for the physical safety of the person accessing the premises.

[50] http://en.wikipedia.org/wiki/Physical_access

Considerations:

Physical access is required for microelectronics & nanotechnology RIs. HPC RIs also require that the researchers be present in order to adapt their code to the specific computing architecture and to monitor the runs.

8.3.2.2 Access to service

Definition:

In the access to service model, the RI executes the scientific work. The user specifies his / her needs and then the scientists at the RI translate these needs into a solution that can be implemented at the RI. The solution is then executed at the RI and the result is given to the user.

Considerations:

This access to service model is quite common in the field of MNT, where the training required to use the RI effectively is too long for many practical purposes. The implementation of this access model requires the RI to put a physical access control system in place that only allows employees of the RI to enter the premises or the laboratories.

8.3.2.3 Remote Access

Definition:

Remote access is defined in the context of ICT RIs as: pertaining to communication with a data processing facility from a remote location or facility through a data link. One of the more common methods of providing this type of remote access is using a VPN.[51]

Considerations:

[51] http://en.wikipedia.org/wiki/Remote_access

Remote Access is a common access pattern for DCI infrastructures like grid and cloud computing RIs, as well as for network RIs. Data infrastructures are being built with remote access as a prerequisite. The right combination of scientific instruments with network RIs, distributed computing RIs and data RIs should allow for an effective remote access of such instruments.

"Remote, authenticated and authorised access to laboratory equipment is an essential enabler for the ERA. Access to unique and expensive equipment is often a precondition for successful research; however, this kind of equipment is increasingly unavailable locally. Shared access, regardless of researcher and resource location and instead based primarily on (peer-reviewed) research quality, is an essential component of the trust that must be built if we are to deliver the ERA vision of common, shared, research infrastructure." [e-IRG-BP, 2010], §3.5: "Remote Access and Remote Instrumentation".

8.3.2.3.1 How (Single Sign On, VPN, ...)

Definition:

Single Sign-On (SSO) is a property of access control of multiple related, but independent software systems. With this property a user logs in once and gains access to all systems without being prompted to log in again at each of them. Single sign-off is the reverse property whereby a single action of signing out terminates access to multiple software systems. As different applications and resources support different authentication mechanisms, single sign-on has to internally translate to and store different credentials compared to what is used for initial authentication.[52]

A virtual private network (VPN) is a network that primarily uses public telecommunication infrastructure, such as the Internet, to provide remote offices or traveling users access to a central organisational network. VPNs typically require remote users of the network to be authenticated, and often secure data with encryption technologies to prevent disclosure of private information to unauthorized parties. VPNs may serve any network functionality that is found on any network, such as sharing of data and access to network resources, printers, databases, websites, etc. A VPN user typically experiences the central network in a manner that is identical to being connected directly to the central network. VPN technology via the public Internet has replaced the need to requisition and maintain expensive dedicated leased-line telecommunication circuits once typical in wide-area network installations.[53]

[52] http://en.wikipedia.org/wiki/Single_sign-on

[53] http://en.wikipedia.org/wiki/Virtual_private_network

8.3.2.3.2 Remote Control of RI

Considerations:

“The remote use of scientific equipment enables cost-effective sharing by substantially reducing the human and financial costs of research. Much research instrumentation is widely distributed or located in remote areas by necessity. In these cases, the ability to remotely access instruments improves efficient use of researchers’ time and increases return on investment for large installations (such as many of those in the ESFRI roadmap). Remote instrumentation is an important component of ESFRI RI projects across all thematic areas.

There is significant international activity to standardise interfaces to and integration of modern sensor networks. This standardisation should be encouraged and better integrated with existing activities in networking and data processing. Sensor networks, often leveraging ubiquitous radio frequency identification (RFID) technology, are increasingly network-aware and can be remotely configured, managed and controlled. This in itself creates new challenges for security and large-scale distributed data processing.

The development and spread of remote instrumentation techniques and technologies is opening new opportunities for scientific communities. However, to fully exploit these opportunities we need more effective integration of data acquisition infrastructures with data processing infrastructures via appropriate standard interfaces to sensor networks and remote instrumentation, the so-called ‘Internet of Things’. Standards will thus be of key importance in supporting increased exploitation of scientific equipment by diverse user groups as well as interoperability with cooperating infrastructures.” [e-IRG-BP, 2010], §3.5: “Remote Access and Remote Instrumentation”.

8.3.3 Resource allocation

Definition:

Resource allocation defines how the limited resources of the RI are attributed to the different users.

8.3.3.1 Scientific excellence

Explanation:

Scientific excellence is the most used criterion for open call access procedures (open calls are defined in Section 7.5.1).

Considerations:

PRACE has defined scientific excellence criteria for assigning HPC resources.[54] *These criteria can mutatis mutandis also be used for other open call evaluations.*

"The PRACE Peer review includes two types of assessment: ***technical*** *and* ***scientific****. The two assessments are carried out separately by different groups of experts with the applicant having the right to reply to the evaluation outcome of both the technical and the scientific reviewers (if necessary). The technical review precedes the scientific review and seeks to assure that the proposal is technically feasible for the intended platform requested. At the end of the peer review process, all applicants, whether their proposal is successful or not, will receive documentation of both the technical and scientific evaluation of their proposal.*

Technical assessment

All proposals will undergo a technical assessment. The technical assessment can result in three outcomes: 1) strongly recommended, 2) recommended, 3) proposed for rejection.

Criteria for technical assessment. A proposal must convincingly address the following criteria:

- *The need to use a PRACE resource;*
- *Software availability on the requested resource;*
- *Feasibility of the requested resource. The requested system must be suitable for the proposed project.*

The technical assessment may redirect projects to a more appropriate system.

Scientific assessment

Scientific review of the proposal is performed by internationally recognized experts in the field of research. During the scientific assessment an increase or decrease in the requested resources can be recommended for consideration in resource allocation.

Criteria for scientific assessment. The proposals must address the following scientific criteria:

- *Scientific excellence. The proposed research must demonstrate scientific excellence and a potential for high European and international impact;*

[54] See: http://www.prace-ri.eu/Peer-Review?lang=en.

- *Novelty and transformative qualities. Proposals should be novel, develop an important scientific topic of major relevance to European research, describe possible transformative aspects, and expected advances.*
- *Relevance to the call. Proposal needs to address how the proposed project is addressing the scope of the call if a specific scope is stated in the call.*
- *Methodology. The methodology used should be described and appropriate to achieve the goals of the project.*
- *Dissemination. The planned channels and resources for dissemination and knowledge exchange should be described. The applicant and the collaborators must include a list of recent publications relevant to the proposed project.*
- *Management. There must be a solid management structure which will ensure that the project will be successfully completed."*

8.3.3.2 Parameter based

Considerations:

When parameter-based access is given to the users, the RI needs to re-calculate its attribution level regularly, typically on an annual basis.

8.3.3.3 Fair Share

Definition:

Fair share in RIs means to give to all participants a *fair* quota of the resources they pay for. "Fair" is to be clearly understood in terms of agreements.

Considerations:

Fair share of ICT resources is technically managed in the distributed Research Infrastructures. For instance, in grid computing fair share between sites and VOs is managed according to specific techniques.[55]

[55] See: "Enabling a priority-based fair share in the EGEE infrastructure", by D Cesini, V Ciaschini, D Dongiovanni, A Ferraro, A Forti, A Ghiselli, A Italiano, D Salomoni INFN-CNAF, Bologna, Italy, 2008 J. Phys.: Conf. Ser. 119 062023, CHEP 2007.

8.3.3.4 Fee Based

Considerations:

When the RI collects fees for the use of its infrastructure, it needs to have procedures in place to handle late payments of the fees.

8.3.4 Charging model

Definition:

The charging model in the context of European ICT RIs is the way that the fees are leveraged.

Explanation:

The fees can be leveraged as fixed fees or usage-based fees.

8.3.4.1 Fixed fees

Considerations:

Fixed fees are the easiest to implement for a RI as they only require a regular billing.

8.3.4.2 Usage based fees

Considerations:

When fees are usage-based, a clear mechanism should be in place to calculate the fees on a regular basis (typical monthly) and bill the user. For distributed RIs the calculation of usage-based fees can become extremely complex

8.3.4.2.1 Time based

Definition:

Time-based fees charge the time of use of a particular resource of the RI.

Explanation:

A typical example of time-based fees in the context of ICT RIs is to use the CPU time of a particular computer of the RI to define the cost of doing a job.

Considerations:

In a Distributed Computing Infrastructure with different types of computers with different performances and different types of problems, it becomes very difficult to define a cost for each type of computer used.

8.3.4.2.2 Resource based

Definition:

Resource-based fees charge for the use of a particular resource of the RI.

Explanation:

A typical example of time-based fees in the context of ICT RIs is bandwidth or storage volume.

8.3.4.2.3 Material based

Considerations:

Material-based fees are typical in the micro and Nanoelectronics context, where a plethora of devices can be made using a standard fabrication technology, such as CMOS. RIs in this domain often offer Multi-Project Wafers (MPW) services. On these Multi-Project wafers, multiple designs of multiple devices and circuits are processed together. The price calculation for the devices in such MPW runs is based on the surface area consumed by the device (in mm^2) on the wafer. MPW runs are scheduled regularly and announced well in advance. There is a strict deadline for the submission of designs for such runs.

8.3.5 Research Infrastructure Responsibility

Definition:

When granting access to its facilities, the RI assumes a certain responsibility.

Explanation:

The responsibility of the RI is two-fold:

1. When granting physical access to the RI premises, the RI needs to assume the responsibility for the physical safety of the people to whom the access has been granted. This is the domain of occupational safety
2. When an access fee is charged, the RI has to give a certain level of service in return. This is typically covered by a Service Level Agreement

8.3.5.1 Occupational safety

Definition:

Occupational safety and health **is a cross-disciplinary area concerned with protecting the safety, health and welfare of people engaged in work or employment. The goal of all occupational safety and health programs is to foster a safe work environment. As a secondary effect, it may also protect co-workers, family members, employers, customers, suppliers, nearby communities, and other members of the public who are impacted by the workplace environment. It may involve interactions among many subject areas, including occupational medicine, occupational (or industrial) hygiene, public health, safety engineering / industrial engineering, chemistry, health physics."[56]**

Considerations:

OHSAS 18000 is an international occupational health and safety management system specification. It comprises two parts, 18001 and 18002 and embraces a number of other publications. OHSAS 18000 is the internationally recognized assessment specification for occupational health and safety management systems. It was developed by a group of leading trade bodies, and international standards and certification bodies to address a gap where no third-party certifiable international standard existed. This internationally recognized specification for occupational health and safety management system operates on the basis of policy, planning, implementation and operation, checking and corrective action, management review, and continual improvement.

8.3.5.2 Service Level Agreement

Definition:

A Service Level Agreement (SLA) is defined as: a written agreement between a service provider and a customer that documents services and agreed service levels.[57]

8.3.5.2.1 Subjects covered

Explanation:

[56] http://en.wikipedia.org/wiki/Occupational_safety_and_health

[57] [ISO20000, 2005]

A SLA can cover many subjects, such as:

- Uptime of RI;
- Performance and performance measurement:
- Problem management and remedy (response time following problem announcement, escalation procedure, ...);

Considerations:

If the RI is distributed, the SLA can become quite complex. In this case it is better to define, for example, the uptime as the time that a certain percentage of the total capacity is available.

8.3.5.2.2 Guarantees Provided

Explanation:

For each of the subjects in the previous section, values must be set in the SLA.

8.3.5.2.3 Penalties

Considerations:

If the guarantees provided, as described in the previous section, are not met penalties can be defined. These penalties can take different forms, such as:

- *Fine*
- *Pay-Back*
- *Reduced Fee*
- *Free Additional Access to RI*

There must also be a proportionality rule that defines the magnitude of the penalty with respect to the fraction of the guarantees missed.

8.4 Stakeholder Interaction

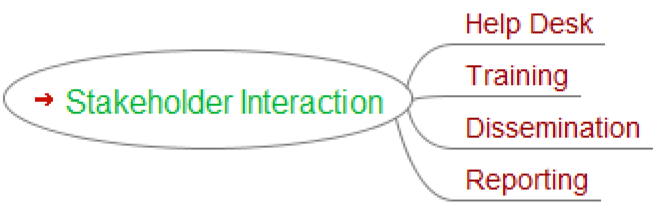

Figure 38: The stakeholder interaction branch of the operational principles part of the mind map

Definition:

Stakeholders are individuals or institutions that may, directly or indirectly, positively or negatively, affect or be affected by the ICT RIs. The stakeholder interaction is the way that the RI communicates with the stakeholders.

Explanation:

The interaction with stakeholders can occur in assistance processes, such as help (service) desk, training, dissemination or reporting.

8.4.1 Help Desk

Definition:

Service Desk (preferred term over the Help Desk nomenclature) is defined as: a Service Desk is a functional unit made up of a dedicated number of staff responsible for dealing with a variety of service events, often made via telephone calls, web interface, or automatically reported infrastructure events.[58]

Considerations:

The Service Desk is a vitally important part of an organisation's IT Department and should be the single point of contact for IT users on a day-by-day basis – it will handle all incidents and service requests, usually using specialist software tools to log and manage all such events.

The primary aim of the Service Desk is to restore the 'normal service' to users as quickly as possible. In this context 'restoration of service' is meant in the widest possible sense. While this could involve fixing a technical fault, it could equally involve fulfilling a service request or answering a query – anything that is needed to allow users to return to working satisfactorily.

8.4.2 Training

Considerations:

"Training provision should to be planned from the very beginning of an RI to ensure resource requirements are met at the right time. The inherent cost of training provision, trainer fees, staff time away from paid activity and the cost of equipment usage, facilities and services, need to be accounted for in the budget. Training is a public good and a private benefit.

With each RI providing training, the recruitment pool is enriched and ultimately all stakeholders benefit from the availability of a trained and skilled research and technical labour force. Mobility of staff – between countries and institutes and across industrial and academic sectors – is an important element of the European Research Area. At the level of each RI the intellectual capital is increased, and individuals gain the opportunity to develop their careers. Training provision for staff should include:

- *Career development as part of the recruitment programme and embedded within each employment contract;*

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[58] [ITIL-SO, 2007] 6.2

- *Specialist training to cover on-site safety and security, and to ensure that staff have the necessary skills and knowledge;*
- *General training to improve 'soft skills', in particular management and communication skills." [EIROForum, 2010], 4.10 Training.*

Education and training is also one of the great challenges cited in [HlEGSD, 2010] for scientific e-Infrastructures:

"How can the citizen make these benefits available for sensible investigations, and how can they be safeguarded from fakes? How can scientific e-infrastructure foster and increase popular interest and trust in science? How can we foster the training of more data scientists and data librarians, as important professions in their own right?"

And, [HlEGSD, 2010] concludes, there is a need to train a new generation of data scientists and broaden public understanding:

"Achieving all this requires a** *change of culture* **– a new way of thinking about when you share information, how you describe or annotate it for re-use, when you hide it or protect it, when you charge for it or give it away. It requires new knowledge about how researchers use and re-use information, in different disciplines and countries. [HlEGSD, 2010] urges that the European Commission promote, and the member-states adopt, new policies to foster the development of advanced-degree programmes at our major universities for this emerging field of data science. The member-states should include data management and governance considerations in the curricula of their secondary schools, as part of the IT familiarisation programmes that are becoming common in European education."

8.4.3 Dissemination

Considerations:

Print publications are a popular dissemination tool, mainly due to their versatility and potential reach. The project can decide on the length, quality and number of copies and distribution of a print product with relative ease. However, project managers need to craft the message and tone of the publication carefully to suit the audience.

There are numerous types of print products:

- *newsletters and magazines are released periodically and often distributed via a mailing list. They inform the target audience about the latest developments in the project;*
- *press releases are released to the media and other stakeholders to flag a forthcoming event or to draw attention to a newsworthy recent development. They are typically brief and written in a manner that makes them easy to re-use by busy journalists;*

- *projects are often involved in producing articles for the local, regional, national or even international press. The project's spokesperson or press officer will typically assist the journalist writing the piece. Alternatively, someone in the project, such as an expert, may write the article;*
- *brochures and leaflets with summaries promote the activities or outputs of the project, usually in a rather timeless fashion;*
- *other print products include compendiums and directories which contain information on groups of activities and the outputs of projects.*

Websites have started to overtake print products as a dissemination tool. As reported by the European Commission,[59] the internet has become the dissemination tool of choice for millions of organisations and individuals. Websites are powerful tools for reaching your target audience and promoting your project. Project managers primarily use their websites to provide information about the project and news of its activities and results. When building websites, there is a temptation to put form over content in a bid to 'wow' visitors. But users tend to prefer good content presented in a simple, clear and easy-to-navigate interface.

With billions of webpages floating around in cyberspace, one of the main challenges for websites is ensuring that they are visited by the target audience. This means that, although websites are dissemination tools, it is not enough to just simply put them on-line, but they also need to be actively promoted and publicised. Mutual linking with websites in complementary fields, and promoting the site in the blogosphere are two ways of getting noticed. Priming a website to make it more visible to search engines is also useful.

Symposia are a very intensive tool to reach a selected target audience. Thematic workshops (or thematic monitoring of projects) aim at creating an exchange forum for project (ICT RI) coordinators working on the same topic. Exchange of knowledge and experience amongst actors involved in European cooperation projects on a specific theme is important for effective transfer of innovation and for building synergies. National agencies, experts and stakeholders/potential users of results are often associated with this kind of thematic activity in order to have a more interactive exchange among the providers of results (the projects) and those who could potentially benefit and take up such results (the users/stakeholders).

[59] http://ec.europa.eu/dgs/education_culture/valorisation/process_en.htm

8.5 Evaluation of RI

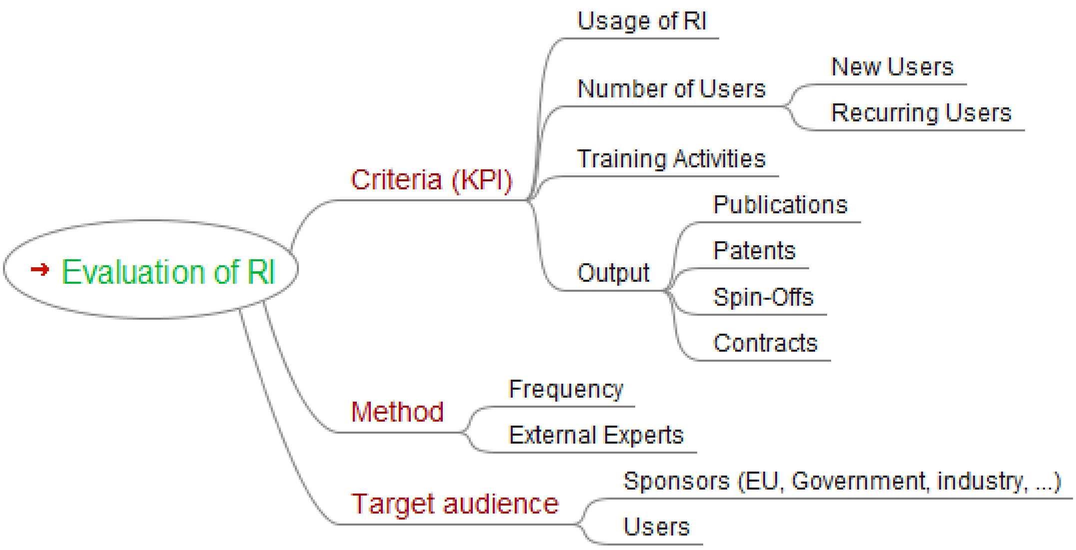

Figure 39: The evaluation of the RI branch of the operational principles part of the mind map

Definition:

Evaluation is the rigorous analysis of completed or on-going activities that determine or support management accountability, effectiveness, and efficiency.[60]

[60] http://www.businessdictionary.com/definition/evaluation.html

Considerations:

The European ICT RIs are typically expected to submit evaluation reports of their activities to their stakeholders in order to continue receiving their funding.

8.5.1 Criteria (KPI)

Definition:

A performance indicator or *key performance indicator* (KPI) is an industry jargon for a type of performance measurement. KPIs are commonly used by an organisation to evaluate its success or the success of a particular activity in which it is engaged. Sometimes success is defined in terms of making progress toward strategic goals, but often, success is simply the repeated achievement of some level of operational goal (for example, zero defects, 10/10 customer satisfaction, etc.). Accordingly, choosing the right KPIs is reliant upon having a good understanding of what is important to the organisation. 'What is important' often depends on the department measuring the performance - the KPIs useful to finance will be quite different from the KPIs assigned to sales, for example. Because of the need to develop a good understanding of what is important, performance indicator selection is often closely associated with the use of various techniques to assess the present state of the business, and its key activities. These assessments often lead to the identification of potential improvements and, as a consequence, performance indicators are routinely associated with 'performance improvement' initiatives. A very common method for choosing KPIs is to apply a management framework such as the balanced scorecard.[61]

Explanation:

In order to evaluate the activity of a RI, specific aspects have to be analysed; the activity as a whole is too vaguely defined to permit a rigorous analysis. These specific aspects are often called Key Performance indicators (KPIs). The minimum values that these KPIs have to meet are the criteria of the evaluation.

ICT RIs can be evaluated according to several metrics:

- usage (hits, accesses, resources …),
- users (new and recurring users),

[61] http://en.wikipedia.org/wiki/Key_performance_indicator

- training activities / courses,
- publications,
- patents generated,
- spin-off (enterprises),
- new contracts with industries.

DCI:

EGI defines the following metrics (KPIs) on its Web site [http://www.egi.eu/projects/egi-inspire/metrics]:

- ***Number of production resource centres,***
- ***Number of job slots available,***
- ***Monthly reliability [availability] of site middleware services,***
- ***MoUs with VRCs,***
- ***Number of papers from EGI Users,***
- ***Number of jobs done a day,***
- ***Number of production sites supporting MPI,***
- ***Number of users from HUC VOs,***
- ***Amount of integrated desktop resources,***
- ***Number of users from non-HUC VOs,***
- ***Public events organised by EGI.eu & NGI teams,***
- ***Number of MoUs or agreements signed with external (non-EGI) Resource Infrastructure Providers,***
- ***Number of MoUs or agreements signed with technology providers,***
- ***Number of production HPC clusters,***
- ***Amount of virtualised installed capacity accessible to EGI users.***

8.5.1.1 Usage of RI

Considerations:

The usage of an RI is always a Key Performance Parameter, since it defines the need for the services of the RI. An intensive usage is not easy to achieve and depends on the dissemination of the RI and the effectiveness of the training it gives.

"How can we move to a situation where non-specialists can overcome the high barriers to their being able to start sensible work on unfamiliar data, perhaps using intelligent automated tools for an initial investigation?" [HlEGSD, 2010]

8.5.1.2 Number of Users

Considerations:

The number of users is an important metric for most RIs as well. A high number of users is an indication of the uptime of the infrastructure. A high number of recurrent users is an indication of the usefulness of the RI. A high number of new users is an indication of the effectiveness of the dissemination and training activities.

DCI:

The EGI metrics (http://www.egi.eu/projects/egi-inspire/metrics) give a good example.

8.5.1.3 Training Activities

Considerations:

The number of new users is a good indication of the effectiveness of the training, but also more specialised metrics such as "new users divided by the number of people trained" can be very important.

8.5.1.4 Output

Explanation:

The outputs are the results of work performed in the RI. These outputs can be of different nature:

- Scientific publications;
- Patents;
- Spin-offs;
- Contracts.

Considerations:

The output of the RI is another important performance indicator. Whereas the usage and number of users measures how well the RI is used, the output is an indicator of the impact that the RI has. Different aspects of the output, as listed above, can have different weights, depending on the mission of the RI.

8.5.2 Method

Definition:

The evaluation method is the way in which the evaluation of the RI is carried out.

Considerations:

If all the criteria for the evaluation of the RI are specific and measurable, an entirely neutral evaluation is possible.

DCI:

The EGI metrics (http://www.egi.eu/projects/egi-inspire/metrics) treat the evaluation method as well.

8.5.2.1 Frequency

Considerations:

Typically, an evaluation is carried out once a year. If all KPIs are measurable and can be extracted automatically, a more frequent evaluation is often performed. If the evaluation is carried out by external experts, the frequency might be lower than once a year.

8.5.2.2 External Experts

Explanation:

The evaluation of a RI can be carried out by a group of external experts that will give a qualitative assessment of the performance of the RI.

Considerations:

For a large European ICT RI, it can be difficult to find external experts that are neutral with respect to the RI.

8.5.3 Target audience

Definition:

The target audience are the stakeholders to whom the results of the evaluation of the RI should be presented.

Explanation:

The target audience can be either the sponsors or the users.

8.5.3.1 Sponsors (EU, Government, industry, …)

Definition:

The sponsors are the persons or organisations that fund the RI.

Explanation:

Typical sponsors of a European ICT RI are:

- The EU;
- National governments or their funding organisms;
- Industry, etc.

8.5.3.2 Users

Considerations:

In general, the users are less interested in the outcome of the evaluation of the RI than are the sponsors. However, a bad evaluation could endanger the continuity of the RI and in this case the users would like to be informed.

8.6 Operations Management

Figure 40: The operations management branch of the operational principles part of the mind map

Definition:

Operations management is an area of management concerned with overseeing, designing, and redesigning business operations in the production of goods and/or services[62].

Explanation:

The operations management is concerned with managing the process that converts inputs (in the forms of materials, labour, and energy) into outputs (in the form of goods and/or services). One can consider the process of converting inputs into outputs as consisting of different interacting processes (purchasing, human resources management, operational processes, customer interaction, IT management, etc.). The ISO9001:2008 quality system describes these different processes and requires the description of the role of all the different persons in the organisation in these processes.

The operations management can be described by its organisational structure and the processes for which it is responsible.

[62] http://en.wikipedia.org/wiki/Operations_management

8.6.1 Structure

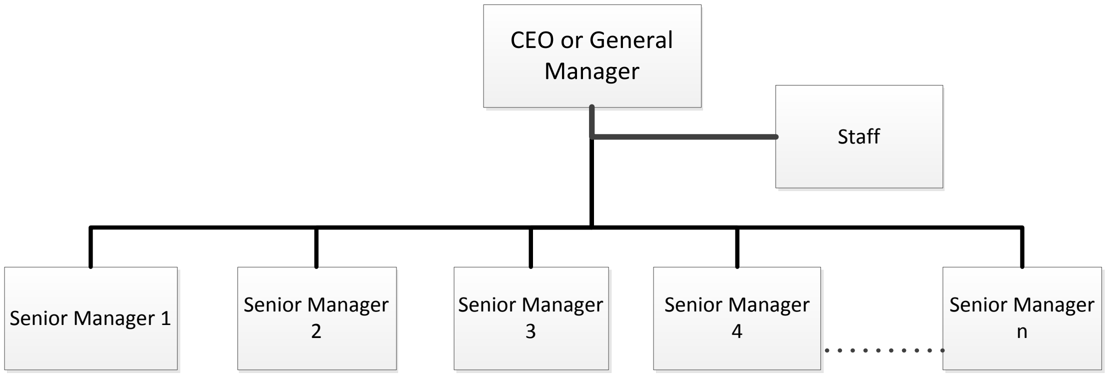

Figure 41: The typical structure of the operations management of a European ICT RI

Considerations:

The typical structure of the operations management of a European RI is depicted in Figure 41. It consists of a general manager overseeing a number of senior managers. The staff of the organisation are typically attached directly to the office of the general manager, but in general do not participate in the executive committee. The executive committee consists of the general manager and the senior managers (vice-presidents) and makes the strategic decisions of the organisation.

8.6.2 Processes

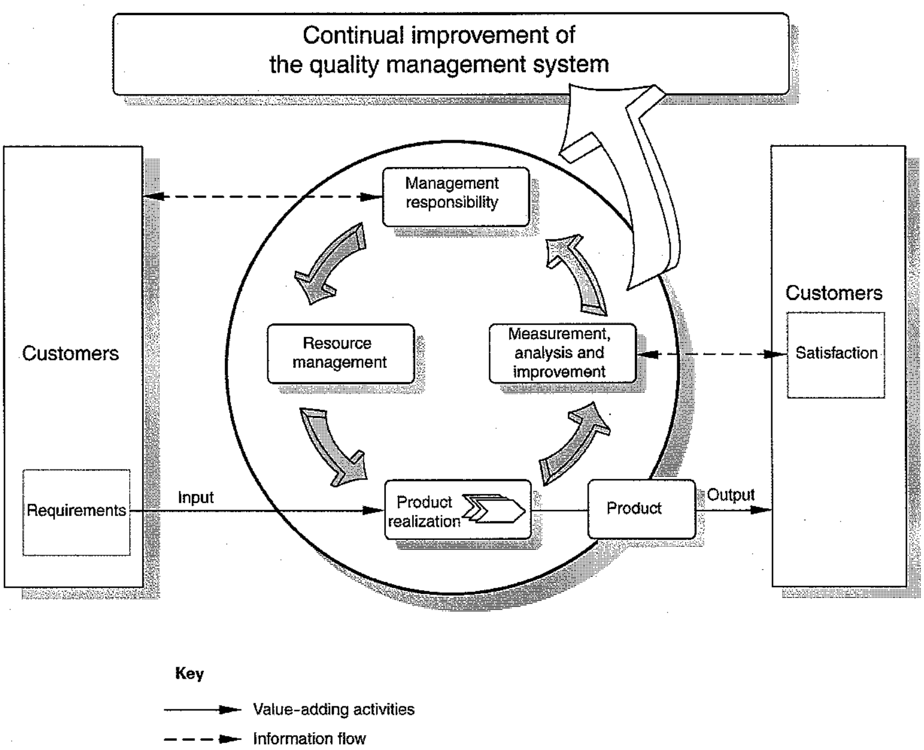

Figure 42: The ISO 9001-2008 model of a process-based quality system

Considerations:

The ISO9001:2008 norm has a model of a process-based quality system that is depicted in Figure 42. The model defines five main processes:

1. *Quality management system;*

2. *Management responsibility;*
3. *Resource management;*
4. *Product realization;*
5. *Measurement, analysis and improvement.*

The management responsibility foresees six major tasks:

1. *Management commitment;*
2. *Customer focus;*
3. *Planning;*
4. *Quality objectives;*
5. *Responsibility, authority, and communication;*
6. *Management review.*

Each of these tasks is further defined in the ISO 9001-2008 quality manual.

DCI:

"The EGI Operations Management Board (OMB) develops the strategy and defines the technical priorities of EGI's production infrastructure.

The OMB also oversees the status and progress of the global EGI and individual NGI operational services. Main tasks:

- ***Advise the EGI.eu Director on operational strategic and technical issues.***
- ***Identify current and future problem areas and propose corrective actions.***
- ***Compile usage information and collect technical operational requirements and bring this input to the Technical Coordination Board (TCB).***
- ***Examine requirements from Virtual Research Communities (VRCs), external software provider and other parties that will require changes to the operational procedures and tools, and to liaise with the User Community Board (UCB).***
- ***Define plans for the long-term development of EGI operations." [http://www.egi.eu/policy/groups/Operations_Management_Board_OMB.html]***

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