SEVENTH FRAMEWORK PROGRAMME

Report on key challenges based on previous studies

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Abstract:

This deliverable presents the major challenges concerning ICT Research Infrastructures that will be addressed in the OSIRIS project survey and further activities. They are collected from the results of previous initiatives and surveys.

Keyword list:
Research Infrastructures, ICT , Infrastructure challenges, survey

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

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Executive summary

This deliverable describes the ICT landscape within the broader concept of ERA and gathers information about main challenges related to the successful development, deployment, usage, sharing, finding and staffing of the ICT Research Infrastructures and e-Infrastructures in general.

The major challenges concerning ICT Research Infrastructures that will be discussed in the Survey of the OSIRIS project are collected based on the results of previous initiatives and surveys including the Reports from the National ICT Research Directors Working Group on Research Infrastructures, on Future Internet, the ESFRI's European Roadmap for Research Infrastructures updated in 2009 and other materials.

Identified challenges would have to be addressed by the OSIRIS project starting. The initial information will be gathered in the Survey and further on appropriate models and suggestions will be provided.

The following groups of challenges are discussed in the document:

- Policies: public policy, science policy, innovation policy, cooperation policy, technological policy
- Resources: financial resources, human resources, users
- Frameworks: legal framework, organizational forms of e-Infrastructures, intellectual property rights, infrastructure security and data privacy
- Scale: regional dimension and global dimension.

These challenges are discussed and will be further elaborated in to the Survey questions in Deliverable D2.2.

Content

1. Introduction

This document describes the ICT landscape within the broader concept of ERA and gathers information about main challenges related to the successful development, deployment, usage, sharing, funding and staffing of the ICT Research Infrastructures and e-Infrastructures in general.

The major challenges concerning ICT Research Infrastructures that will be discussed in the Survey of the OSIRIS project are collected based on the results of previous initiatives and surveys including the Reports from the National ICT Research Directors Working Group on Research Infrastructures, on Future Internet, the ESFRI's European Roadmap for Research Infrastructures as updated in 2009 and other materials. The input of the stakeholder group provides important advice regarding the focus of the Survey and specific issues that have to be covered by the Survey.

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These challenges are discussed and will be further elaborated in to the Survey questions in Deliverable D2.2.

In the context of the deliverable the ICT Research Infrastructures are the e-Infrastructures dealing with Research and Development in the ICT area and/or ICT facilities for Research and Development, including research centers for Micro and Nano technologies.

2. E-Infrastructures as an essential building block for the European Research Area (ERA).

In this section the leading ideas of the European Research Area (ERA) related to ICT are discussed and the main features of the e-Infrastructures as the most important building blocks of the ERA are reviewed.

2.1 ERA and its importance

In its Communication *"Towards a European Research Area"*, the Commission outlined a new strategy. The aim to better integrate and exploit the European scattered excellence in research and innovation, to create a genuine European 'internal market' for research to increase pan-European co-operation and co-ordination of national research activities, was thus clearly expressed. The European Council in March 2000 in Lisbon recognised ERA as an objective of the EU and paved the way for its implementation.

The main tasks for the ERA[1] were defined as:

Enable researchers to move and interact seamlessly, benefit from world-class infrastructures and work with excellent networks of research institutions.

Share, teach, value and use knowledge effectively for social, business and policy purposes.

Optimise and open European, national and regional research programmes in order to support the best research throughout Europe and coordinate these programmes to address major challenges together.

Develop strong links with partners around the world so that Europe benefits from the worldwide progress of knowledge, contributes to global development and takes a leading role in international initiatives to solve global issues.

ERA should inspire the best talents to enter research careers in Europe, incite industry to invest more in the European research.

The development of the ERA was broadly supported by national and EU resources during the last decade.

The creation of ERA has become a central pillar of the Lisbon Strategy for growth and jobs, progressively has been interlinked with the European broad-based innovation strategy and with the European Higher Education Area.

On 4 April 2007 the Green paper "*The European Research Area: New Perspectives*" was published[2]. It assessed the progress made and discussed future orientation of the ERA development.

This document has declared that the ERA developed for the needs of scientific community, business and citizens should have, among others, also the "***World-class research infrastructures****, integrated, networked and accessible to research teams from across Europe and the world, notably thanks to new generations of electronic communication infrastructures*".

Taking into account this statement, further activities were provided to enhance the overall governance of ERA results and the strategic document – "*2020 Vision for the European Research Area*" [3] – was adopted by the Council of the EU on 2 December 2008. It was declared that by 2020, all actors benefit fully from the "*Fifth Freedom*" across the ERA: free circulation of researchers, knowledge and technology.

Fifth Freedom: - free circulation of researchers, knowledge and technology.

The Vision 2020 also aims to achieve that the "Actors are able to access, manage and share knowledge (including via open access) across the ERA using interoperable high performance information systems" and that the rapid development of new distributed infrastructures is ensured.

The importance of Research Infrastructures was recalled by the Conclusion on Research Infrastructures and the Regional Dimension of the ERA adopted on 29 May 2009, by the Lund Declaration adopted at the "*New world – New solutions*" [4] conference held under SE PRES, by the conclusion of the ERA 2009 Conference – Working together to strengthen research in Europe held on 21-23 October 2009 or in the consultation on the EU 2020 Strategy.

Conclusion: *Research Infrastructures are a pillar in developing ERA. This holds true particularly in the field of ICT Infrastructures. Progress in ICT and its Infrastructures is a conditio sine qua non for most of the other installations.*

2.2 Research Infrastructures

It is not expected that an exact definition of the Research Infrastructures accepted by scientific communities in all member states will ever be developed, though several attempts have been made. For example, for the FP7 Capacities programme such a definition was proposed in the *Work Programme 2010 - Capacities Part 1. Research Infrastructures* [5]:

> ... the term 'research infrastructures' refers to facilities, resources and related services that are used by the scientific community to conduct top-level research in their respective fields. This definition covers: major scientific equipment or set of instruments; knowledge based-resources such as collections, archives or structured scientific information; enabling ICT-based e-Infrastructures such as Grid, computing, *software and communication networks; any other entity of a unique nature essential to achieve excellence in research. Such infrastructures may be 'single-sited' or 'distributed' (a network of resources).*

ESFRI in its *Roadmap 2008* [6] uses a rather similar definition:

> *They are facilities, resources or services of a unique nature that have been identified by pan-European research communities to conduct top-level activities in all fields.*

This definition underlines the unique character of the facilities to be recognized as a Research Infrastructure.

European Research Advisory Board (EURAB) in the *EURAB Recommendations on Research Infrastructures (RI)*[7] proposes a more detailed definition:

> *Research infrastructures are defined as 'facilities and resources that provide essential services to the research community in both academic and/or industrial domains. Research infrastructures may be 'single-sited' (single resource at a single location), 'distributed' (a network of distributed resources, including infrastructures based on Grid-type architectures), or 'virtual' (the service being provided electronically).*

It seems that the most important difference in the EURAB's definition is that this definition openly mentions also the research community of **industrial** domain as an eventual user of Research Infrastructures, which, of course, is necessary, if research is considered as the basis for innovation.

Both the above cited definitions divide Research Infrastructures into the following groups groups – a) single-sited, b) distributed or c) virtual RIs. This classification allows further analysis of the real situation especially from the ICT point of view.

For this goal rather helpful is the homepage of the European Commission where the above cited definition of Research Infrastructures from the materials of the FP7 Capacities is repeated and the particular examples of the RIs are also listed.[8] These

> "e*xamples 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."*

This list of the Research Infrastructure examples shows that many of the distributed RIs will exploit ICT and may be considered as e-Infrastructures. At the same time, it is clear that the single-sited Research Infrastructures are very important for the ICT sector, for example, for the development of Micro and Nanoelectronics, especially for the elaboration of new technological process depending on experimental investigations.

To characterize such single-sited RIs, the term "*Infrastructural Centre of Competence*" used in the above citation may be adopted.

Conclusion: For <u>*the purposes of the OSIRIS project and the Deliverable 2.1, Research Infrastructures can be e-Infrastructures or Infrastructural Centres of Competence.*</u>

E-Infrastructures

The understanding of the e-Infrastructures relates with the definition of e-Infrastructures provided by the FP7 Capacities programme: [9]

> e-Infrastructure - new research environment in which all researchers - whether working in the context of their home institutions or in national or multinational scientific initiatives - have shared access *to unique or distributed scientific facilities (including data, instruments, computing and communications), regardless of their type and location in the world.*

It follows that e-Infrastructures have such important features:

a. Shared access to scientific facilities, which implies cooperation among scientists offering and using these facilities, as well as good communication facilities.

b. e-Infrastructures may be classified by the prevailing type of scientific facilities:

- data
- instruments
- computing
- communications.

c. e-Infrastructures may be also unique or divided.

It should be acknowledged that these types of e-Infrastructures provide different kinds of challenges.

Communication infrastructures

The main communication infrastructure for research and education is the European Gigabit Network for Research and Education – GÉANT. There are 36 members (32 member countries and 4 associated countries) in the GÉANT3 network from all over Europe and beyond.

At the same time the gigantic GÉANT is not enough to provide communication facilities for researchers. The National Research and Education Networks (NRENs) provide information and communication services to the national research institutions, and the institutions are responsible for ICT services in their campuses.

GÉANT can be characterised as a double-scope Research Infrastructure, i.e. it a) provides networking services to researchers in Europe and in other parts of the world, b) organizes and provides networking research by its own projects, for example, the FP7-Capacities Federated E-infrastructure Dedicated to European Researchers Innovating in Computing network Architectures (FEDERICA) project.

E-Infrastructures for computing

The computing infrastructures are crucial for e-science, i.e. for discovering new scientific facts by computer simulation and similar approach. These infrastructures are developing in two directions:

a. The high performance technology represented by supercomputers. For example, DEISA and DEISA2 (Distributed European Infrastructure for Supercomputing Applications), is a consortium of leading national supercomputing centres that aims at fostering the pan-European world-leading computational science research. PRACE (Partnership for Advanced Computing in Europe) will create a persistent pan-European high performance computing service and infrastructure.

b. Multidisciplinary grid for scientific computation and data processing. The development of grid infrastructures was very intensive in FP6 and is continued in FP7. The leading projects are EGEE (Enabling Grids for E-sciencE) and EGEE II. It is planned that the resources currently coordinated by EGEE will be managed through the European Grid Infrastructure (EGI) from the end of April 2010. EGI, the National Grid Initiatives and EGI.eu will work together to operate and further develop a sustainable pan-European grid infrastructure, enabling optimal sharing of computing and data resources.

Instrumental e-Infrastructures

The Roadmap of ESFRI presents a group of infrastructures for instruments. These infrastructures cannot be considered as purely ICT based infrastructures, they are rather infrastructures for other scientific areas that have components with ICT technologies for access to these instruments and for transmitting the results. An example is the LHC (The Large Hadron Collider) that not only exploits ICT technologies but also has initiated serious progress in the grid technologies development.

From the ICT point of view the infrastructures for instruments can provide challenging problems for ICT sector, for example, in remote control of thousands of telescopes in the SKA (Square Kilometre Array) research infrastructure project or optical sensors in KM3NeT (Kilometre Cube Neutrino Telescope) project.

The infrastructures for instruments are important for ICT also because they can support research essential for the development of ICT research. As already mentioned above, the communication infrastructure GÉANT also provides research in communication technologies, and it becomes rather senseless to discuss if GÉANT is a communication infrastructure or an infrastructure for instruments also.

Another example of this type of infrastructures is PRINS (Pan-European Research Infrastructure for Nano-Structures) that will deal with research in Micro- and Nanoelectronics Technology and will help the development of technological issues for the fabrication of this type of devices. It should be noted that in this text the understanding of Micro- and Nanoelectronics Technology (MNT) is expanded to comprise also photonics, organic electronics and similar activities in the hardware development.

Data infrastructures

It is widely believed that the fourth paradigm to the scientific research – data intensive science – is emerging.[10] The ESFRI Roadmap shows that this is reality, because most of the infrastructures are created for gathering raw experimental or observation data. These data are collected and stored in huge data bases and provided to the scientific communities of Europe and beyond for further processing.

Fourth Paradigm: Data Intensive Scientific Discovery

These infrastructures belong to the scientific areas different from ICT, but their success is determined by the development of ICT technologies (new devices for massive data storage) and especially by the development of the processing methods for huge data volumes – advanced data search, data mining, knowledge representation, intelligent agents, etc.

2.3 Infrastructural Competence Centres

As the example of an important European Research Infrastructure in the advancement of knowledge and technology CERN is mentioned[11]. Approximately 6 500 researchers of 80 different nationalities conduct experiments at the Geneva-based complex. It is clear that CERN can be considered also as an Infrastructural Competence Centre. Its researchers and equipment ensure its competence, and its availability for the researchers of many countries ensures its character of a European infrastructure.

CERN has played an important role also in the development of ICT but it is clear that a considerable part of research activities is performed by scientists physically present at the Geneva-based complex. Necessity of the physical presence of researchers may be considered as an important characterization for the Infrastructural Competence Centre (ICC), though distributed ICCs also can be possible.

For the progress in the ICT sector it is important to have modern experimental facilities in Micro and Nano Technologies including those developing industrial technological processes. Creation of such Research Infrastructures was started already under the FP6.

The FP6 Research Infrastructure project ANNA (European Integrated Activity of Excellence and Networking for Nano and Micro-Electronics Analysis) [12] can be considered as example of a distributed Infrastructural Competence Centre that has established reference laboratories specialised in one or more analytical techniques.

Another example of this approach can be the FP6 Research Infrastructure project MNT-Europe (Staircase towards European MNT Infrastructure Integration) [13] that has led to the creation of a unique distributed platform for research and development in the field of Micro and Nano Technologies (MNT) based on the national facilities. In the frame of this project, it has been observed that a distributed MNT fabrication facility is not feasible due to possible cross-contamination of products (wafers) at various stages of the fabrication process. The MNT Europe project accepted the presence of large infrastructures where researchers could work on a particular technology. The cooperation between the infrastructures then consists of maximizing the complementarity of the research infrastructures so that all MNT technologies are covered by the infrastructures and only a small number of them compete in the same technologies.

It may be concluded that further successful development of Micro and Nano Technologies hardly can be expected using distributed facilities only, without physical presence of the researchers, though the ideas of networks of laboratories are viable.

Conclusion: *Creation of European Research Infrastructures or a network of them for the development of Micro and Nano Technologies is still a challenge. For the appropriate Infrastructural Competence Centres only achieving some degree of complementarity can be expected.*

3. ICT Research Infrastructures

In this section the general features of the ICT Research Infrastructures are defined and the most important of this kind of infrastructures are highlighted.

As already mentioned, e-Infrastructures being mainly distributed facilities are based on ICT technologies. The FP7 Capacities programme[14] stated "*ICT-based environments, commonly called e-Infrastructures, empower researchers by offering them access to facilities and resources regardless of their location*", i.e. this programme considers "*ICT-based environments*" and "*e-Infrastructures*" as synonymous.

Different e-Infrastructures are dependent on progress in ICT technologies in different ways. There are some infrastructures that are mainly envisaged for provision of research and development in various branches of information and communication technologies. This kind of e-Infrastructures can be called ICT e-Infrastructures, and they are the main object of the investigation in the OSIRIS project.

Another kind of ICT Research Infrastructures is the Infrastructural Competence Centres that can provide services for a wider research community based on an assembly of techniques and know-how. Such Centres may support researchers in Micro and Nano technology, photonics, organic electronics, etc. or in other activities in the hardware development.

ICT Research Infrastructures are the e-Infrastructures or Infrastructural Competence Centres **dealing with Research and Development in the ICT area and/or ICT facilities for Research and Development.**

3.1 GÉANT

The European Gigabit Network for Research and Education – GÉANT is the main communication infrastructure for research and education in Europe.

The almost unlimited possibilities of GÉANT are useful for research and collaboration, including virtual laboratories, tele- and video conferencing, access to grid computing and storage resources, streaming, multicasting, dedicated light paths connecting end users, enhanced data security and much more.

Actually GÉANT is the highest level of the academic networking infrastructure, uniting lower level networks of National Research and Education Networks (NRENs) and campus WANs. At the same time GÉANT organises and provides research using its own infrastructure for its own experimental and theoretical research in networking.

The *Report from the National ICT Research Directors Working Group on Research Infrastructures, July 2008 – November 2008* has concluded that GÉANT needs to reinforce its outstanding performance to meet the extra-scale dimension in a medium-to-long term time frame. The Report has found also that the top-of the range capabilities of GÉANT can be put at the service of Future Internet research and this can be done by supporting new paradigms for experimentation in new architectures, protocols and technologies along different abstraction layers, and addressing horizontal issues such as trust, security, privacy protection, user involvement and acceptance, regulatory and governance aspects, standardization, as well as the socio-economic dimension of the Future Internet. Initial steps to support this evolution of GÉANT have already been taken in FP7 (as for example in the FP7-Capacities project FEDERICA).

The Report predicts that GÉANT could further evolve from a purely academic-oriented infrastructure towards a more general research facility including virtualized research environments to support industrial needs in the form of test beds for large scale preproduction research and validation also involving end-users where possible. To achieve this, it is proposed to discuss a private-public cooperation model for the GÉANT public-public partnerships model.

3.2 PRACE

PRACE - *The Partnership for Advanced Computing in Europe* is an e-Infrastructure for computing and its goal is the creation of a persistent pan-European HPC service, consisting of several centres providing European researchers with access to high capability supercomputers and forming the top level of the European HPC ecosystem. PRACE is a project funded partly by EU's FP7.

Supercomputers are indispensable tools for solving the most challenging and complex scientific and technological problems through simulations. At this moment, however, the usage of supercomputers has not become routine in all Member States. PRACE is now in the implementation phase and has partners from 20 European countries. Participation of partners is graded as Principal partners (6), General partners (8) and Additional General partners (6).

3.3 PRINS

PRINS - *Pan-European Research Infrastructure for Nano-Structures* is a Research Infrastructure enabling European innovative research for the ultimate scaling of electronics component and circuits.

The focus of the project is on all needed preparatory actions to enable in the following phase the possible operational start up of a Research Infrastructure (RI) with the aim of enabling European innovative research for the ultimate scaling of electronic components and circuits. The platform should be truly interdisciplinary by allowing the convergence of "top-down" technology, which is today the main enabler of Moore's law (i.e. transistor scaling), with "bottom-up" methods derived from fundamental disciplines such as materials physics, chemistry, biotechnology and particle electronics. The open access of this infrastructure provided to the scientific community will enable the cross-disciplinary fertilization of academic and industrial competencies in the areas of nanoelectronics, nanosystems, nanobiology, nanophotonics, etc. In the first phase the focus will be on nanoelectronics, while the other mentioned areas such e.g.nanobilology, nanophotonics etc can be added at a later stage depending on their strategic importance and their direct link with nanoelectronics platform. The PRINS consortium consisted of three leading research centers (IMEC, CEA-LETI and FhG-VμE), four industrial partners (ASM-L, Infineon, NXP and STMicroelectronics) and the Public Authority/Funding Agency of the Region of Flanders (EWI). The preparatory phase of the project has been completed in fall 2010.

The Preparatory Phase of PRINS has clearly pointed out that a research infrastructure in nanoelectronics has some special features and requirements. Research in nanoelectronics is to a large extent application-oriented and is performed in close cooperation with industry in order to take into account potential manufacturing aspects. A technology-oriented Research Infrastructure needs access to very expensive state-of-the-art equipment and technologies, which has to be updated on a time scale of 3-5 years. Due to the high equipments costs and the high operating costs of the clean room facilities a nanoelectronics infrastructure is extremely expensive.

Building a new centralized RI facility would cost several billion Euros and would therefore require a strong and long time financial commitment of the funding agencies and/or Public

Authorities of the Member States and/or Associated States. Based on the interactions during the PRINS project it looks like an almost mission impossible for the Member States to agree on a new centralized RI for nanoelectronics. Therefore, the recommended PRINS RI will physically not be at one location, but has to be considered as a distributed research infrastructure with access nodes at sites. Depending on the research domains to which the scientific community is requesting access in the future, it might be needed to enlarge the tool set of the RI platform with specialized processing capabilities. In some cases this can be solved by buying additional tools. However, in other cases it may be preferred or required to expand the RI by increasing the number of access nodes.

The collaboration between PRINS and the academic teams intends to implement various access mechanisms for academic research community to the combined Research Infrastructure of the PRINS Research Organizations (RO's):

- hosting research teams in the RI and/or building up common R&D laboratories can enhance the long term collaboration between the academic research community and the hosting Research Organization;
- the mobility of researchers, which will be essential in order to leverage the impact of the research community and enhance the industry - research center - academic research community linkages;
- the cooperation between the academic research community and PRINS can also be achieved in a fast and cost-effective way by cooperating in scientific and technical projects between the RI and its associated laboratories;
- providing academic research teams with basic materials/data for their own research programs that are complementary and relevant to PRINS will leverage the whole investment of the RI.

These modes of operation can be performed using the PRINS platform. However, discussions with the different PRINS stakeholders indicated that in addition to PRINS there is also a need for access to a so-called flexible platform and a need for a more industrial demonstration of the concepts developed through PRINS. Such a platform is not using state-of-the-art industry-like equipment as PRINS, but allowing to execute more non standard and even exotic processing steps (with a higher risk for contamination) and/or using silicon wafers with a smaller wafer diameter or event parts of a wafer. It is therefore believed that both platforms would complement each other. After initial feasibility studies on a flexible platform the validation could be performed on the PRINS platform.

An important aspect within PRINS is the Intellectual Property (IP) and legal aspects. Depending on the access mode to be used during the operation of the RI, the IP ruling is different. An important issue is whether the scientific interactions are only based on the use of background information or whether new information is generated during the access period by the visiting and/or hosting organization or jointly by both. In the first case the IP remains within the hosting institution, while for the latter IP sharing models are more appropriate. The present ROs involved in PRINS have for the different operational modes generic documents for covering the IP ruling. These documents have to be fine tuned on a case by case basis in order to ensure an optimal protection of the IP of the different involved partners. As presently no separate PRINS legal entity for the operational phase of PRINS is envisaged, there is no need for preparing common IP ruling documents. The institution gaining access will negotiate directly with the hosting institution(s) or the institute(s) giving access on the governing IP ruling. Access/hosting at an international level beyond the EU has also been investigated. Although special regulations (e.g. export restrictions, IP protection, etc) may have to be applied, the 3 ROs within PRINS have already a lot of experience and a very long track record with scientific collaborations at an international level. The experience in access/hosting is both with academic research community and industrial partners.

The industry oriented business model and restricted contribution and interest of the Public Authorities and funding agencies, leads presently to the conclusion that forming a separation legal entity, e.g. based on the ERIC concept, would not be feasible and also not desirable. Looking at the envisaged activities and access/hosting operation modes there is no benefit for creating a separate entity, which would change the existing successful business models and revenues of the ROs and increase the administration and overhead. All the intended activities can easily be executed by a PRINS RI whereby the access nodes are keeping their independent legal status and collaboration agreements are signed between the ROs. This statement might change in the future depending on the strategy of the European Commission and of the Public Authorities of the different member States.

3.4 EGI

The *European Grid Initiative* (EGI) is a collaboration of *National Grid Initiatives* (NGIs) working together with a coordinating body (EGI.eu) to deliver a service to scientist communities and their collaborators. EGI.eu was founded on 8 February 2010.

EGI will provide a sustainable way to coordinate, evolve and operate the current grid infrastructure in order to guarantee its long-term availability for performing research and innovation work, delivering consistent, high quality service and support through its own operations infrastructure and through the NGIs that interface with this European infrastructure.

3.5 Infrastructure projects of ESFRI Roadmap

The ESFRI Roadmap updated 2008 comprises 44 projects for creating European Research infrastructures. These European level infrastructures widely use ICT technologies, though the importance of these technologies is different for various e-Infrastructures.

The projects can be analysed by usage of the 4 types of facilities described above. It is clear that the level of the usage can be estimated only approximately and, of course, any of the infrastructures has multiple characters and can be data, communications, computing, and instrument infrastructure at the same time.

Characteristics of Research Infrastructures are studied in the following table, where for each of 44 infrastructures it is estimated how related they are to the types of facilities from 0 (do not relate at all to this type) to 5 (the facilities of this type are essential for the infrastructure). The ranking is a proposal developed by IMCS UL scientists using publicly available information about the Research Infrastructures and estimating importance of each type of facility for each RI. The result is subjective but still provides overview of the general trends of the RIs.

			Projects of European research infrastructures	Year of start	Communications	Computing	Instrument	Data
1	Social Sciences and Humanities	1	CESSDA - Facility to provide and facilitate access of researchers to high quality data for social sciences	2013	3	0	0	4
2		2	CLARIN - Research infrastructure to make language resources and technology available and useful to scholars of all disciplines	2014	2	0	0	4
3		3	DARIAH - Digital infrastructure to study source materials in cultural heritage institutions	2013	3	0	0	4
4		4	European Social Survey - Upgrade of the European Social Survey, set up in 2001 to monitor long-term changes in social values	2008	2	0	0	4
5		5	SHARE - Data infrastructure for empiric economic and social science analysis of ongoing changes due to population ageing	2008	2	0	0	4
6	Environmental Sciences	1	AURORA BOREALIS - European polar research icebreaker	2014	2	1	5	5
7		2	COPAL (ex EUFAR)- Long range aircraft for tropospheric research	2012	2	0	5	5
8		3	EISCAT_3D - Upgrade - Upgrade of the EISCAT facility for ionospheric and space weather research	2015	2	3	5	5
9		4	EMSO - Multidisciplinary Seafloor Observatory	2013	2	2	5	5
10		5	EPOS - Infrastructure for the study of tectonics and Earth surface dynamics	2018	2	4	5	5
11		6	EURO-ARGO (GLOBAL) - Ocean observing buoy system	2011	2	2	5	5
12		7	IAGOS - Climate change observation from commercial aircraft	2012	2	4	5	5
13		8	ICOS - Integrated carbon observation system	2012	2	1	5	5
14		9	LIFEWATCH - Infrastructure for research on the protection, management and sustainable use of biodiversity	2019	2	0	0	5
15		10	SIAEOS - Upgrade of the Svalbard Integrated Arctic Earth Observing System	2012	2	0	2	5
16	Energy	1	ECCSEL - European Carbon Dioxide and Storage Laboratory infrastructure	2011	2	1	3	5
17		2	HiPER - High power long pulse laser for fast ignition fusion	2020+	3	2	5	5
18		3	IFMIF - (GLOBAL) International Fusion	2020	3	3	5	5

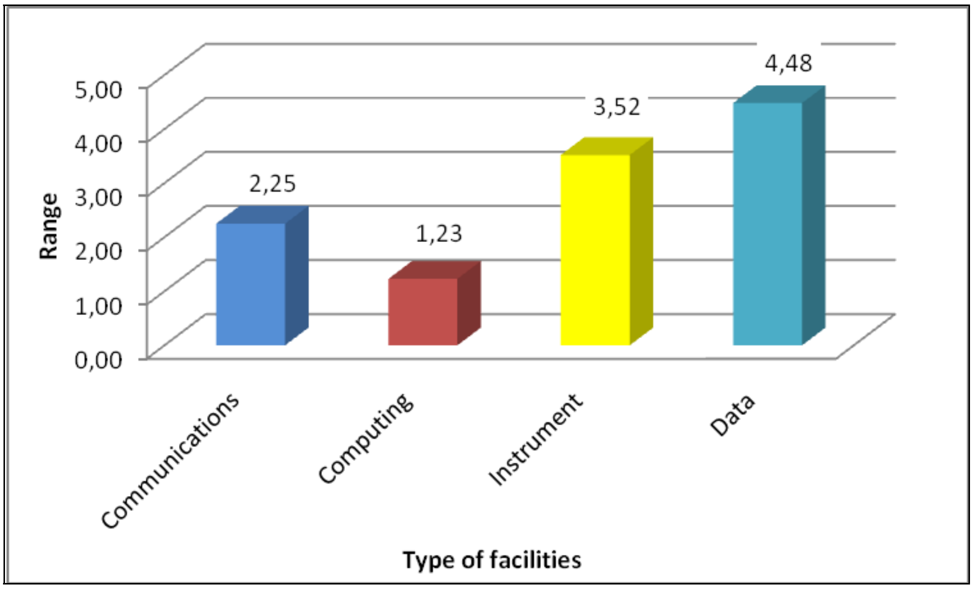
			Projects of European research infrastructures	Year of start	Communications	Computing	Instrument	Data
			Materials Irradiation Facility					
19		4	JHR - High flux reactor for fission reactors materials testing	2014	2	3	5	5
20	Biological and Medical Sciences	1	BBMRI - Bio-banking and bio molecular resources research infrastructure	2013	4	1	0	5
21		2	EATRIS - European advanced translational research infrastructure in medicine	2013	3	0	0	5
22		3	ECRIN - Pan-European infrastructure for clinical trials and biotherapy	2014	3	1	0	5
23		4	ELIXIR (GLOBAL) - Upgrade of the European Life-science infrastructure for biological information	2012	2	0	0	5
24		5	EMBRC- European marine biological resource centre	2018	1	0	0	5
25		6	EU-OPENSCREEN - European Infrastructure of Open Screening Platforms for chemical biology	2012	3	4	4	5
26		7	EuroBioImaging- Research infrastructure for imaging technologies in biological and biomedical sciences	2012	4	5	5	5
27		8	High Security BLS4 Laboratory - Upgrade of the High Security Laboratories for the study of level 4 pathogens	2018	1	0	5	2
28		9	Infrafrontier - European infrastructure for phenotyping and archiving of model mammalian genomes	2010	2	0	3	5
29		10	INSTRUCT - Integrated Structural Biology infrastructure	2012	2	1	3	5
30	Materials and Analytical Facilities	1	EMFL - European Magnetic Field Laboratory	2015	2	3	5	5
31		2	ESRF- Upgrade of the European Synchrotron Radiation Facility	2014	2	3	5	5
32		3	EuroFel (ex-IRUV-FEL)- Upgrade Complementary Free Electron Lasers in the Infrared to soft X-ray range	2020	2	1	5	4
33		4	European Spallation Source - European Spallation Source for neutron spectroscopy	2019	2	1	5	4
34		5	European XFEL - Hard X-ray Free Electron Laser in Hamburg	2014	2	0	5	4
35		6	ILL20/20 - Upgrade of the European Neutron Spectroscopy Facility	2017	2	0	5	4

			Projects of European research infrastructures	Year of start	Communications	Computing	Instrument	Data
36	Physical Sciences and Engineering	1	CTA - Cherenkov Telescope Array for Gamma-ray astronomy	2013	2	0	5	5
37		2	E-ELT - European Extremely Large Telescope for optical astronomy	2018	2	0	5	5
38		3	ELI - Extreme Light Intensity short pulse laser	2015	2	0	5	4
39		4	FAIR - Facility for Antiproton and Ion Research	2016	2	0	5	4
40		5	KM3NeT - Kilometre Cube Neutrino Telescope	2016	2	0	5	4
41		6	PRINS - Pan-European Research Infrastructure for Nano-structures	2015	1	3	5	3
42		7	SKA (GLOBAL) - Square Kilometre Array for radio-astronomy	2016	2	0	5	4
43		8	SPIRAL2 - Facility for the production and study of rare isotope radioactive beams	2014	2	0	5	4
44	e-Infrastructures		PRACE (ex EU-HPC) - Partnership for Advanced Computing in Europe	2010	5	5	5	1

The importance of different types of facilities can be evaluated by computing the average range values for all 4 types of facilities, which gives the characteristics for an average European Research Infrastructure. The values for the average ERI are presented in the following table:

Type of facilities	**Range**
Communications	2.25
Computing	1.23
Instrument	3.52
Data	4.48

And in the appropriate chart:



It may be noted once more that the methodology is rather subjective but the results allow to make the following conclusion:

Conclusion: *The processing of large amounts of data is the most important and challenging ICT problem compared, for example, with providing large computing facilities.*

Challenges of the e-Infrastructures

In this section the challenges created by and related to e-Infrastructures are summarised and studied. There are challenges common for most e-Infrastructures and there are also specific challenges for ICT Research Infrastructures only. 4 kinds of e-Infrastructures also present different kinds of challenges. Of course, specific challenges for Micro and Nano technology research centres must be recognized.

Public and science policy

No doubts the development of e-Infrastructures is well embedded in the EU policy. The problem, however, remains, to what extent Member States developed their conceptual and financial coordination on national level that is imminent for the smooth coordination of EU cooperation. In addition, the national tendencies towards developing complex e-Infrastructures should be examined. As a consequence, coherent strategy ensuring sustainability of proposed approach/models/policy should be ensured.

As already mentioned, shared access ("*open* access" or even "*free access*") to scientific facilities implies not only cooperation among scientists offering and using these facilities, but that the support and understanding of policy makers is an indispensable ingredient to it. Traditionally cooperation among scientists is very high, in any case higher than among many other social groups. It should be acknowledged, however, that the increasing cooperation among countries, political leaders, entrepreneurs, etc. will be reflected into better cooperation among scientists.

It can be concluded that the creation of the European Union is a prolific idea for stimulation of scientific cooperation, and it may be expected that the strengthening of the Union will stimulate the scientific cooperation and, *vice versa*, the strengthening of the scientific cooperation will foster strengthening of the Union.

The approach to scientific cooperation may be different in various member states, and could be seriously influenced by several aspects, the available financial resources for science being the most obvious. To ensure that cooperation becomes a cornerstone of the country's national policy in general and science in particular is a challenge for all but particularly for the new EU member states.

The wide introduction of e-Infrastructures usage demands favourable policy and politics surrounded with broad European scale cooperation as the base feature for scientific activities. Some organisational and management changes of scientific activities in Member States become necessary based on existing or future models.

The Member States while setting the national priority research themes should take into account the need of strategic approach to RI - especially by developing coherent national roadmaps taking into account the regional and EU context that would allow effectively pool resources and invite for consultation relevant stakeholders. It may happen that their self-dependency will be decreased and the decisions will be influenced by results of collective discussions. In contrast, the MS with its strategy led approach to policy making should take into account overall best practices, specific legal and financial aspects of RI and strengthen its effort to coordination, mutual discussion and to the consciousness of mutual interdependence, especially in the European Union.

The development of the ICT policy in the MS evidently will be challenged by the existing e-Infrastructures and by the need to maintain and develop them. Especially the needs of the data infrastructures should be taken into account according to the demands of the fourth paradigm.

Scientific activities in the ERA, wide usage of Research Infrastructures will challenge for more active cooperation of research organisation of different Member States, which should be organised and strengthened. Cooperative capacity will be needed for choosing sites for RIs, for agreement of financing and governance principles.

One of the most influential challenges in the science policy will be the setting of priorities concerning development of the Research Infrastructures, though it may be predicted that the ICT sector could hope for the highest priority.

Conclusion: The wide usage of the Research Infrastructures based on the principles of the Fifth freedom still is a challenge for the Member States and the development of Research Infrastructures will challenge the changes in the existing science policy of Member States and will challenge the ability to coordinate their national policies in the overall context.

Innovation policy

Innovative perspective of the investigations provided on the Research Infrastructures demands closer cooperation between scientists and business enterprises. As the investigations will be performed in close multinational cooperation, it follows that the eventual users of the infrastructures and/or of the results - business enterprises - also should be accustomed to or ready for multinational cooperation.

Another kind of the cooperation is also expected, i.e. the cooperation between stakeholders from public policy makers and business people, which can be a challenge especially if different legal and economic rules apply. At the same time it is possible for RI's to provide research services and capacities to private sector based on clear contracts and financial commitments. Of course, the legal form of these RIs should allow paid services and allocation of private investments, which again can sometimes be challenging.

Mrs. Máire Geoghegan Quinn, European Commissioner Designate Research Innovation and Science, in her *Opening remarks at the European Parliament January 13, 2010* [15] mentioned that one of the strategic aims of the European Research and Innovation reforms is to deliver the Single Market of Innovation. No doubts this is a real challenge.

Conclusion: *The organisation of cooperation between scientific institutions and business companies in the framework of Research Infrastructures is rather challenging because the interests of these two groups and their attitude to multinational cooperation may be different*.

Cooperation policy

The wide development of pan-European Research Infrastructures requires the need not only to cooperate in the elaboration of the priorities of scientific research but also in the management of scientific activities.

It is clear that the development of e-Infrastructures itself is impossible without close cooperation of stakeholders in both the scientific and industrial communities. Each e-Infrastructure is a huge project, which demands pulling together political will as well as scientific, human and financial resources. And, of course, it is necessary to manage these resources as efficiently as possible.

As far as ICT infrastructures are concerned, their development should be coordinated with various pan-European programmes and with the progress in networking. This process is going on in the European Commission, in its Directorates general, in the advisory groups like ISTAG (IST Advisory Group) in the numerous conferences of various formats like National IT Directors Forums and so on.

At the time of writing this deliverable several working groups are elaborating strategy for the Future Internet and in other ICT related domains in Europe. Their approach is broader than the development of e-Infrastructures only, and it is clear that the e-Infrastructures could not be deployed without close cooperation with such groups.

ESFRI

A strategic instrument to develop the scientific integration of Europe and to strengthen its international outreach is ESFRI (European Strategy Forum on Research Infrastructures)[16] formed in 2002. The mission of ESFRI is to support a coherent and strategy-led approach to policy-making on Research Infrastructures in Europe, and to facilitate multilateral initiatives leading to the better use and development of Research Infrastructures.

ESFRI's delegates are nominated by the Research Ministers of the Member and Associate Countries, and include a representative of the Commission, working together to develop a joint vision and a common strategy. One of the results of their work is *the European Roadmap for Research Infrastructures (2006)* and *its update (2009)* already discussed above that proposes priority Research Infrastructure projects.

e-IRG

Another important body of the European level is e-IRG (e-Infrastructure Reflection Group) that was created as an inter-governmental policy body, with government appointed delegates from 31 member state and representatives from the European Commission. Its mission is “to pave the way towards a general-purpose European e-Infrastructure.”

The e-IRG has elaborated a roadmap that provides a vision of the future and motivates continued efforts to create links between different stakeholders in a way that maximises the socioeconomic value of the common e-Infrastructure for research. The roadmap will also outline the role e-IRG wants to play in this development and how the organisation plans to execute its mission if the recommendations to the external stakeholders are heard and followed up at a higher policy level. In this roadmap important recommendations have been elaborated (see below).

DMTF

DMTF (Distributed Management Task Force) is an industry organization that develops, maintains and promotes standards for systems management in enterprise IT environments. The open industry standards developed by the organization enable systems management interoperability between IT products from different manufacturers or companies.

Taking into account the development of numerous e-Infrastructures, the standardisation of IT environment and interoperability will become a serious challenge for ICT researchers, so the activities of DMTF are important for e-Infrastructure projects.

EFII

EFII (European Future Internet Initiative)[17] is an initiative founded by 16 of the leading ICT companies in Europe and their main ambition is that a new approach is taken to addressing the challenges of the Future Internet in Europe. Their approach is to bring together the application domains and the ICT expertise to develop an Internet that fully supports the business processes of the different sectors while taking advantage of the common aspects of these diverse sectors.

In January 2010 they published the *White Paper on the Future Internet PPP Definition* that proposes the a new Future Internet pan-European coordinated partnership that will bring about clear benefits for Europe with the aim to reinforce and boost the competitiveness of enterprises and administrations, create new economic opportunities, while empowering innovators and citizens to benefit from the Future Internet.

EGI and EGI.eu

The European Grid Initiative (EGI) is a very important actor in the creating European cooperation for the development of a pan-European grid infrastructure. EGI is based on the partnership between National Grid Initiatives (NGIs) and a coordinating body, the EGI Organization (EGI.eu). Within the EGI partnership, NGIs and EGI.eu will work together to operate and further develop a sustainable pan-European grid infrastructure, enabling optimal sharing of computing and data resources. The full operation of the organisation is anticipated to begin in 2010 at the latest.

3.6 Technological policy

From the ICT point of view an e-Infrastructure is mainly a distributed information system, and it may seem that no new technical solutions are needed to set up and run these systems. In reality, however, the exploiting of the e-Infrastructures can turn out to be rather challenging and demanding process.

As the resources for creating and management of Research Infrastructures are (and always will be) limited, but the needs in RIs will grow steadily, it is highly desirable to develop common technological principles for the building of the Research Infrastructures and for their usage. In other words a science of Research Infrastructures is needed.

As far as Information and Communication Technologies are considered, the communication in the environment of RIs quite probably will not differ from the usual communication. The computational activities of RIs, though not much different from more traditional ones, already caused serious changes in the organisation of the computational process, for example, it was the need to process the results of the Large Hadron Collider that fostered development of the European Grid projects (EGEE, others).

Even more serious requirements for the ICT sector can be brought forward by the development of data intensive science. Processing of large amount data gathered by hundreds of investigators and finding regularities in them will never be possible for humans and is a challenging task for computers.

The processing methods, data mining tools, data formats and data library logics may be similar for many e-Infrastructures, and there is no need for each e-Infrastructure to developed its own software tools. That is another challenging direction for cooperation and synergy among e-Infrastructures.

Conclusion: *Creating of common technological policy for e-Infrastructures is a challenge for ICT researchers and for the ICT Research Infrastructures.*

Standardisation

The development of e-Infrastructures is very active, a lot of various structures are emerging and each of them is unique and deals with new and yet undiscovered matters. From the ICT point of view, however, common approaches to information processing and management can be searched and found. e-IRG, in the Roadmap 2009[18], recommends that the interoperability of e-Infrastructure components should be improved through **global** standardisation efforts. Consequently the standardisation of IT environment and interoperability is a serious challenge for ICT researchers.

Further, interdisciplinary science requires extensive standardisation of data formats and data library logics over very broad range of different e-Infrastructures, especially data e-Infrastructures. These integrating horizontal linkages are often essential. This is another challenge for ICT sector.

Conclusion: *Standardisation is necessary for the development of e-Infrastructures and its implementation is a serious challenge.*

Easy to use

Research e-Infrastructures frequently emerge as a by-product of long-term science programs where highly skilled specialists (like physicists or engineers) are first users of the technology. As a result, newborn ICT RIs face the challenge of becoming really usable outside its original technical community (say, biologists, medical researchers, or, even private user communities). In the absence of adequate effort towards simplicity and usability, ICT RIs are subject to the risk of being under-used.

The move to less-skilled communities requires a sort of industrialization transformation process of the ICT RIs that has to be accurately planned and projected.

Conclusion: *"Ease of use" principle should be a primary objective in the transition of ICT RIs from the skilled communities to wider, less skilled communities.*

3.7 Resources

Financial resources

It is evident that the development of e-Infrastructures can be accomplished by pulling together available resources of the Commission and all MS participating in creating a given RI. Common planning of investments and investment policies is a serious challenge for the funding bodies, because budgeting systems in the member states may be rather different. For many MS, also structural funds or EIB loans are accessible even for construction, operation, maintenance or development of ICT RI, however the national resources will prevail supplemented by EU budget if having added value for ERA scientific excellence.

Taking into account the real situation, it can happen that some MS will not allocate financial resources limiting themselves by in-kind contributions or by investment of intellectual resources only, though this kind of resources also may be essential to reach the "critical mass" of intellectual potential needed for high level research. The ownership and coverage of the running costs challenges, however, the open access concept. Free access to RIs may be granted to some research groups (or MS) and the need for regulatory rules for open access may cause a need for additional agreements between RI users or funders (including the Commission).

For the ICT sector the PPP (private public partnership) approach may be relatively more prospective on one hand, because even massive joint investments of multinational private companies in the ICT sector may be expected considering the ever growing importance of this sector (not only shared use, but also standardization is a driving issue in that context). On the other hand, as different rules apply in the public and private sector (legal, financial, etc.) this represents a further challenge and need for new approaches.

Human resources

New generations of researchers should be brought up for working in the environment of research infrastructures, new skills should be acquired for understanding, maintaining and supporting of ICT parts of e-Infrastructures. Undoubtedly, new employment opportunities arise as well as challenges for educational institutions. Moreover, the motivating and creative environment of RI brings not only researchers and students together but provides also common place of students and business and as such supports the intrasectoral mobility.

Human resources field offers among others the set of challenges like creating evidence-based conceptual framework, strong support of ethics and compliance functions and strategic workforce planning including awareness of specific impacts brought by ICT developments which need to be considered as a dynamic process. Such challenges must be not only embedded, but carefully treated throughout the whole life of the e-Infrastructures.

The idea of life-long education has been accepted by the ICT community from the very beginning as technology and software changes are very frequent. Nevertheless, the process of recruiting and training qualified stuff for the Infrastructure development and management will be a challenge.

3.8 Users and stakeholders

Not only scientists can profit from using the facilities of the RIs, but also business and other stakeholders. The identification of the possible user community of an infrastructure, as well as setting up the access policy are rather serious challenges because they depend on the financing model for infrastructure development, demand balance between free, open and restricted access, and presume well-defined solution of the usage of research results.

e-IRG, in the Roadmap 2009, recommends stimulating and supporting strongly the adoption of an Infrastructure as a Service (IaaS) model for attraction of stakeholders with the aim to increase the sustainability of e-Infrastructures and to identify and provide innovative solutions which could find a larger use in the society.

As for scientists, their access should be on fair, competitive, open and non-discriminating conditions. It is evident that some facilities have limited resources (while access to scientific data can be unlimited), therefore some regulation mechanisms should be considered. But, still there should be differences, or different usage modalities depending on the level of involvement in the infrastructure funding. Scientists, business partners, non-profit partners and other users should have the access granted by allocation schemes which may be very specific for different e-Infrastructures.

3.9 Legal framework

The creation of the legal framework for the construction and development of the Research Infrastructures, for their usage and for the implementation of the research results represents a very serious challenge. Another challenge is a balance between the basic legal frame common for all or most Research Infrastructures and the agreements, statuses, Terms of reference regulating activities of individual RIs.

The Fifth European freedom of free circulation of knowledge and technology is hardly imaginable without appropriate legal environment. For example, for the data infrastructures the ownership of the provided data should be clear and the terms of access and usage – paid or free, open or restricted should be determined in such a way that would stimulate data provision.

Problems arise from the encounter of different legal and financial environments in different MS. New solutions must be found for common funding and governance issues of distributed infrastructures with virtual ownerships. Public Private Partnership planned in some infrastructures and desirable in several others will be also challenging. For example, questions of IP ownership have to be solved respecting the legal frame and corresponding financial regulations for public funding. At the same time new concepts like "open innovations" must be developed in order to allow commercial use of results in publicly funded research. Problems related to different labour law that applies in countries where the units of the infrastructure are located must be solved.

Additional legal problems may arise in organising international cooperation with countries outside EU, and there the solution can be much more challenging.

Conclusion: *The work on the creating of the legal framework for Research Infrastructure activities has been started but still is a legal challenge.*

Organisational (legal) forms of e-Infrastructures

The existing Research Infrastructures have different organisational (legal) forms. For example, GÉANT3 will become a Company Limited by Guarantee (UK), other infrastructures go for different non-profit legal bodies, and some groups organize their work in form of virtual laboratories or institutes without any formal organisation, sometimes just on the bases of informal agreements.

An option is the new European legal body – European Research Infrastructure Consortium. This new legal form was introduced in the Council Regulation (EC) No 723/2009 of 25 June 2009 on the Community legal framework for a European Research Infrastructure Consortium (ERIC)[19]. As stated in this regulation, it establishes a legal framework laying down the requirements and procedures for and the effects of setting-up a European Research Infrastructure Consortium.

This Regulation is sufficient for setting-up an ERIC, but it seems to be still a challenging problem how the Research Infrastructures may operate, how the resources can be allocated and how the usage of eventual results will be organised. Of course, this can be set up differently by the individual RIs according to their needs. It should be remembered also that the members of an ERIC are Member States and the statuses of ERICs may need to be approved by MS parliaments and are themselves intergovernmental treaties.

Conclusion: The law for setting up of the European *Research Infrastructure Consortiums is adopted but the rules for functioning are still incomplete.*

Intellectual property rights

The activities of Research Infrastructures can produce tangible results, and the ownership of these would be regulated by civil laws, but, of course, the main results of the research are objects of the intellectual property rights.

For fruitful cooperation on the local or international scale all eventual intellectual property problems should be solved beforehand in statuses, agreements or other legal documents. It is obvious that the variety of IPR issues is ranking from protection of the results common to all scientific discoveries, till problems specific for the ICT domain. For example, the ownership of data in data infrastructures gathered by research institutions of several countries, or the ownership of the results acquired by processing of data in data infrastructures created by cooperative work of several researchers.

It is a challenge to decide if the principles of scientific publications are applicable to the data infrastructures, and if they are, then to what extent. In any case, the engagement of industrial or private partners in the activities of RIs may cause some changes in the understanding of rights to access the results.

Generally speaking, it seems that the IPR are more challenging for data infrastructures than for communication, computing or instrument infrastructures, but as has already been found, Research Infrastructures belonging to one type only are rare cases.

Conclusion: *The deployment of Research Infrastructures is challenging for the experts in the Intellectual Property Rights.*

Infrastructure security

Though ICT equipment is typically not damaged by its users it still may be challenging (e.g., transcontinental connections). Apart from this, the protection of Research Infrastructures from any kind of physical damage is necessary for its normal functioning.

More challenging is the security of infrastructure and data. The data infrastructures should be made available for large groups of researchers, and appropriate user access management and the maintaining of usage discipline becomes important.

Apart from standard threats for the data in the data infrastructures some new threats may arise. For instance, attackers may wish not to destroy but to change the other user data so that they corresponded better to the goals of attackers. As an example the data about global climate changes can be mentioned. Trust in data infrastructures may become a crucial point.

Conclusion: *Ensuring Research Infrastructure security (Solving security issues related to the RI) is rather challenging, and should be considered as an important part of any RI project.*

Data privacy

Several Research Infrastructures deal with personal data, and these data should be protected, so the privacy violation of any data would be made impossible. This may be particularly relevant for databases with medical information or political survey results. Collecting heterogeneous data in huge integrated databases, where the data provider may want to put some restrictions on the use or availability will require new and well elaborated data handling policies.

One of the ways to solve the problem would be to put only anonymized data in databases.

Conclusion: *Any projected Research Infrastructure should be audited regarding personal data protection issues.*

3.10 Regional dimension

Some Research Infrastructures, for example Infrastructural Competence Centres can be developed as regional (or meta regional) structures that could later be connected in the network of ICCs or coupled even stronger. Of course, such an approach can be fruitful for the ICT sector. It is easy to imagine regional centres for Micro and Nano technologies or for the development of IC technologies that share common standards and through synergies enhance the overall performance.

In the Report of the Expert Group on Research Infrastructures "*A vision for strengthening world-class research infrastructures in the ERA*" [20] the development of Regional Partner Facilities (RPF) is discussed. An important characteristics of the RPFs would be their association with large-scale research infrastructures (ICCs are unaffiliated). "The specific partnership role of RPFs would include participation in preparation of experiments (at lower costs), better exploitation of results through specialised smaller infrastructures, training young researchers and a broad promotion of research performed at the large facilities."

It can be easier to start a regional Research Infrastructure, but it should be ensured that their development corresponds to the needs and demands of the whole ERA and coordination at an early stage can provide further impetus. Also, the RPF provides a way to involve less research intensive countries in distributed facilities and to contribute to sustainable regional development.

Conclusion: *The development of regional level Research Infrastructures is an interesting and challenging task.*

3.11 Global dimension

The policy of ERA in general and the policy of Research Infrastructure in particular were always globally orientated with wide international cooperation and with full understanding that all humanity should profit from the scientific progress. For example, the e-IRG in the Roadmap 2009 [21] insists that "t*he European e-Infrastructure experts should be enabled to contribute to global e-Infrastructure developments, also in leadership roles requiring long-term commitments*".

The global dimension of real RIs may be challenging, however. Especially, if RIs that will demand continuous financial support for functioning are considered.

Conclusion: *Real work of some e-Infrastructures on the global scale will be challenging.*

4. Research Infrastructure strategy

4.1 European strategy for development of Research Infrastructures

The new European Commission was elected on 10 February 2010. In the mission letter from President J.M.Barroso[22] to Mrs M. Geoghegan-Quinn, European Commissioner designate Research, Innovation and Science it was stated that "*Your main priority should be to take a decisive step forward in building the European Research Area (ERA). Specific actions which will contribute to this include strengthening intra-EU co-operation, pooling human and financial resources across the EU, and promoting the fifth freedom - the free movement of knowledge, ideas and researchers*."

Mrs M. Geoghegan-Quinn in her opening remarks[23] made clear that "*Completing the European Research Area – this means developing the 5 ERA initiatives of Research Careers, Joint Programming, Infrastructure, Knowledge Transfer and International Cooperation*", so the developing of Research Infrastructures will be of high priority in the future and should be considered in close connection with main principles of the science development like cooperation, knowledge transfer, etc.

The development of Research Infrastructures is not mentioned in the mission letter to Mrs N. Kroes, European Commissioner designate Digital Agenda, and it is proposed to reconfigure DG Information Society that was responsible for this activity. In the opening remark Mrs N. Kroes mentioned the Infrastructures as the main building block of The European Digital Agenda in general without underlining their importance for research.

Conclusion: *The development of Research Infrastructures will continue, but some organisational changes may be expected.*

4.2 Scientific approach to the development of Research Infrastructures, need of OLWG

The experience already acquired in the building of e-Infrastructures clearly shows that the development of different infrastructures has some common features and elaborated common strategy needs steady educated support for its development and deployment.

The Open Living Working Group (OLWG) organized by the OSIRIS project will be able to perform this kind of activity including continuous analysis and recommendations on existing and future European ICT RIs regarding cross-border shared methodologies and best practices, elaborating sustainability models and recommendations for future coordinated investments within and across European ICT RIs, emphasizing on complementary or common planning of investments and investment policies, etc.

In future a possible working form of the Open Living Working Group could be a virtual laboratory or institute. Another form could be the creation of a meta-e-Infrastructure, i.e. a European Research Infrastructure supporting and intensifying ICT research for the needs of e-Infrastructures.

The experience of ICT may be useful also for other groups of RIs or even all Research Infrastructures as far as they are using ICT technologies.

5. Proposals for Survey questionnaire

According to the Work Programme of Osiris, the main scope of this Deliverable is the preparation of the future Survey that will serve as the basis for a mainly qualitative analysis of current challenges regarding Public Authorities and National Champions cooperation and ICT RIs. The Survey also should elaborate the potential routes for overcoming these challenges. The content and administration of the Survey will be elaborated in details in the Deliverable D2.2. This section outlines only the initial vision of the Survey.

The questionnaire for the Survey should consist of open questions and of a number of questions for statistical purposes (open and closed). To make the answering easier for the respondents and wherewith the response rate higher, it is planned to make as many as possible closed-end questions with proposed variants of answers to choose, though, of course, it will be impossible to avoid open-end questions.

The target group of the Survey consists of two types of respondents - Public Authorities and National Champions. A list of potential respondents from this target group and their contact data are to be compiled with the help of the consortium members and the stakeholder group. The group according to the Work plan consists of 1-2 representatives from Public Authorities and 2-3 representatives of National Champions from each Member State/Associated country), i.e. totally about 120-150 respondents.

The analysis of the possible challenges and the possible relevant questions allows supposing that the questions to Public Authorities may differ from the questions to National Champions; therefore the final questionnaire can contain contingency questions - questions that are proposed depending on the response to a question about the group.

It is decided to administer the Survey by means of the Webropol[24] – an online solution for conducting surveys, gathering data, managing feedback, and reporting data. The Webropol system will distribute unique webpage addresses to every respondent for connecting to the webpage with the questionnaire. The system will be used to store answers, send remainders, monitor the progress, etc.

All respondents will receive the survey questions in a plain-text document as well in case they would prefer filling it in on a paper or in a separate document file. Those surveys will be entered in the system by OSIRIS project participants to have full set of answers in one system.

In this Deliverable the groups of questions are highlighted and discussed. Proposal of exact survey questions will be elaborated in the Deliverable D2.2.

5.1 Public and science policy

The questions should clarify the attitude of the public bodies to the scientific cooperation as the tool for reaching scientific excellence of the specific country and Europe in general. The perspectives of the implementation of the Fifth Freedom in the country or at least in the country's ICT sector should be clarified.

How the public and science policy of the specific country is targeting development of the Research Infrastructures should be clarified in the next group of questions about the science policy. The questions may include but are not limited to the following problems:

- how the science policy is coordinated with different instruments of ERA (for example, Joint Programming initiative)
- are the priority research themes influenced by coordination with other MS
- are the priority research themes coordinated with the existing or planned RIs
- to which degree the development of the ICT is affected by the existing or planned RIs
- to which extent the development of European level horizontal infrastructures are considered important for the local science
- are the priorities for existing and planned ICT RIs well elaborated and agreeable
- has the development of Infrastructural Competence Centres started or is it planned
- and others.

5.2 Innovation policy

As the innovation policy is crucial for the success of scientific activities, the Survey should focus on its development plans and on possible ways of intensification.

The following issues should be discussed:

- the approaches of individual countries to Innovation policy
- legal, financial, and other obstacles in cooperation between scientists and businesses
- new concepts and ways of improving the intersectorial cooperation it
- are paid research services considered by the existing or planned RIs as a possible way to improve innovation development
- is the possibility to implement research of local scientists in the business enterprises of different countries considered relevant
- is the Single Market of Innovation developing in any way in the local business and scientific community

and so on.

5.3 Cooperation policy

Though the development of ICT in a country is dependent on the general scientific cooperation climate there, the cooperation in this sector may qualify for better scores compared in some other sectors. So the study of cooperation in the ICT may be confined to the elucidation of the impact of European coordination undertakings and organisations like ESFRI, e-IRG, DMTF, EFII, etc.

5.4 Technological policy

It is highly desirable to develop common technological principles for the building of Research Infrastructures and for their usage. The level to which the understanding of this need is common for all stakeholders may be investigated by the Survey.

The same is true also for the development of common software tools like processing methods, data mining tools, data formats, data library logics, etc. for data infrastructures. Easy to use of the RIs is another way how the common problems manifest themselves and dictates common ways to solve them.

The development of the research Micro and Nano Technologies also may be coordinated and have common strategy for different research centres. The attitude and approach of various countries are to be investigated.

Additionally to common research strategy for hardware and software, the development of standards in the field of RIs is also important and needs consensus. The readiness of ICT leaders to such approach can be studied in the Survey.

5.5 Financial resources

The ways in which financial resources will be pulled together for building and management of ICT RIs should be revealed in this Survey. Common planning of investments and investment policies for this goal is a problem that should be investigated. The expected proportion for financial and intellectual investments would be highly desirable to derive from the results of the Survey, which might not be so easy, however.

The perspectives for the PPP approach in the ICT sector may be estimated by the respondents bringing insight in this important issue.

5.6 Human resources

The plans and responsibilities for education of researchers capable of working in the emerging ICT Research Infrastructures, as well as of skilled stuff for maintenance and governance of these infrastructures can be studied in the Survey.

5.7 Users

What groups of investigators can be involved in the usage of commonly built ICT Research Infrastructures? This is a question with different possible answers. Other questions could be – how the balance between open and free access could be reached according to grant allocation schemes, how the model of an Infrastructure as a Service (IaaS) can be adopted, how the scientists with perspective ideas and preliminary results can have non-discriminating access to the RIs, etc.?

5.8 Legal framework

There are a lot of serious problems to solve for creating a working and consistent legal framework for activities of the Research Infrastructures. This Deliverable and Project can not propose any kind of final solution, but can only initiate discussion and discover some problems related to the ICT deployment. It seems that for the principal activities of the communication networks of the NRENs the existing legal environment currently is satisfactory, but the further development may require some improvements.

One of the problems from an ICT point of view could be the data ownership in the data infrastructures corresponding to the investments in the creating of a given infrastructure, the access to the data (paid, free, or open), etc. The work in the Infrastructural Competence Centres also needs legal regulation. The simplest way could be to elaborate a special agreement for each of the RIs and later to gather and to study the experience of them. These problems can be discussed in the Survey.

Another problem that can be touched in the Survey is if the existing legal framework is sufficient to guarantee normal functioning of the Fifth Freedom. The problems related to the introduction of PPP in ICT sector can be touched by the Survey as well.

5.9 Organisational (legal) forms of e-Infrastructures

The existing and more preferable legal forms of the e-Infrastructures may be highlighted by the Survey. These forms may be different for various types of Research Infrastructures and also for various types of the ICT Research Infrastructures. The governance and funding of data infrastructures or Micro and Nano research centres should not be the same.

The Survey can also touch the future perspectives of ERIC in the ICT sector.

5.10 Intellectual property rights

As main results of the research are objects of the intellectual property rights the development of the legal system in this direction is expected as the Research Infrastructures are deploying.

Do the respondents of the Survey expect any problems in IPR area and if they do what could these problems be? Are they expected in the data infrastructures or as the PPP will be developed for RIs? What kinds of IPR are not solved for fruitful research activities on the European or international scale? Are there any specific IPR problems for ICT community?

5.11 Infrastructure security and data privacy

The need and the importance of these items should not be argued, so the Survey is supposed to study only the ways how security and privacy will be ensured in the growing RIs environment. The same would be also true about the trust inside the users' community.

5.12 Regional dimension

The need and the relevance of regional Research Infrastructures should be studied by the Survey. Especially interesting could be the case of Infrastructural Competence Centres for the ICT sector and for investigation in Micro and Nano technologies. Analogous problems may be appropriate for Regional Partner Facilities, though their implementation for the ICT sector is not expected to be very intensive.

5.13 *Global dimension*

The Survey can study the plans for global activities of the Research Infrastructures. As far as ICT is concerned, the global dimension of the communication industry is well developed in contrast to the Micro and Nano technologies that could profit from the global research activities. The perspectives of the global research in this area can be investigated by the Survey.

6. Final Conclusion

- Research Infrastructures are a pillar in developing ERA. This holds true particularly in the field of ICT Infrastructures. Progress in ICT and its Infrastructures is a conditio sine qua non for most of the other installations.

For the purposes of the OSIRIS project and the Deliverable 2.1, Research Infrastructures can be e-Infrastructures or Infrastructural Centres of Competence.

- Creation of European Research Infrastructures or a network of them for the development of Micro and Nano Technologies is still a challenge. For the appropriate Infrastructural Competence Centres only achieving some degree of complementarity can be expected.

The processing of large amounts of data is the most important and challenging ICT problem compared, for example, with providing large computing facilities.

The wide usage of the Research Infrastructures based on the principles of the Fifth freedom still is a challenge for the Member States and the development of Research Infrastructures will challenge the changes in the existing science policy of Member States and will challenge the ability to coordinate their national policies in the overall context.

- The organisation of cooperation between scientific institutions and business companies in the framework of Research Infrastructures is rather challenging because the interests of these two groups and their attitude to multinational cooperation may be different.
- Creating of common technological policy for e-Infrastructures is a challenge for ICT researchers and for the ICT Research Infrastructures.

Standardisation is necessary for the development of e-Infrastructures and its implementation is a serious challenge.

- "Ease of use" principle should be a primary objective in the transition of ICT RIs from the skilled communities to wider, less skilled communities.
- The work on the creating of the legal framework for Research Infrastructure activities has been started but still is a legal challenge.
- The law for setting up of the European Research Infrastructure Consortiums is adopted but the rules for functioning are still incomplete.
- The deployment of Research Infrastructures is challenging for the experts in the Intellectual Property Rights.
- Ensuring of Research Infrastructure security (Solving of security issues related to the RI) is rather challenging, and should be considered as an important part of any RI project.
- Any projected Research Infrastructure should be audited regarding personal data protection issues.

- The development of regional level Research Infrastructures is an interesting and challenging task.

Real work of some e-Infrastructures on the global scale will be challenging.

- The development of Research Infrastructures will continue, but some organisational changes may be expected.

7. Abbreviations and acronyms

ANNA - European Integrated Activity of Excellence and Networking for Nano and Micro-Electronics Analysis

ASCR - Academy of Sciences of the Czech Republic

CERN - Conseil Européen pour la Recherche Nucléaire

CESNET - Czech academic network operator

CSEM - Centre Suisse d'Electronique et de Microtechnique

DEISA - Distributed European Infrastructure for Supercomputing Applications

DMTF - Distributed Management Task Force

EC - European Commission

EGEE - Enabling Grids for E-sciencE

EGI - European Grid Infrastructure

EFII - European Future Internet Initiative

EIB - European Investment Bank

e-IRG - e-Infrastructure Reflection Group

ERA - European Research Area

ERIC - European Research Infrastructure Consortium

ESFRI - European Strategy Forum on Research Infrastructures

EU - European Union

EURAB - European Research Advisory Board

IaaS - Infrastructure as a Service

IPR - Intellectual Property Rights

FEDERICA - Federated E-infrastructure Dedicated to European Researchers Innovating in Computing network Architectures

FP6 – Framework Programme 6

FP7 - Framework Programme 7

GÉANT – Gigabit European Academic Network

HPC – High Performance Computing

ICC - Infrastructural Competence Centre

ICT - Information and Communication Technology

IMCS - Institute of Mathematics and Computer Science, University of Latvia

INFN - Istituto Nazionale di Fisica Nucleare

ISTAG - IST Advisory Group

KM3NeT - Kilometre Cube Neutrino Telescope

LHC - Large Hadron Collider

MNT - Micro and Nano Technologies in this deliverable includes also photonics, organic electronics, etc. and similar activities in the hardware development

MNT-Europe – Staircase Towards European MNT Infrastructure Integration

MS – Member States

MSPRINS - Pan-European Research Infrastructure for Nano-Structures

NGI - National Grid Initiative

NREN – National Research and Education Network

OLWG - Open Living Working Group

OSIRIS - towards an Open and Sustainable ICT Research Infrastructure Strategy

PPP - Private Public Partnership

PRACE - Partnership for Advanced Computing in Europe

PRINS - Pan-European Research Infrastructure for Nano-Structures

RI - Research Infrastructure

RO – Research Organisation

RPF - Regional Partner Facilities

SKA - Square Kilometre Array

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