ERID-Watch

European Research Infrastructure Development Watch

Work Package 1

Deliverable D3

“Final Benchmarking Report”

1 Executive Summary

Deliverable WP1-D3 consists of two documents. The first is the present report, which contains the shortly summarised findings, main facts, conclusions and recommendations. Within this report the Executive Summary represents the summary within the summary - the most condensed version of facts and recommendations.

The Final Benchmarking Report is supplemented by a second document “D3 Annexes” containing the detailed findings and facts without drawing conclusions yet. The case study on industrial usage of synchrotrons forms an exception here, because it was formulated as a standalone report and inserted “as is” into the Annex. However, the conclusions and recommendations drawn from it have also been integrated into the appropriate parts of the present document.

1.1 The ERID-Watch project

ERID-Watch aims to mutually develop ideas and recommendations for decision makers for improving the policy mix of the Member States in order to increase the public investment efficiency for European Research Infrastructures and develop Public-Private Partnerships (PPP) in this context. It is funded under the 6th Framework Programme.

1.2 Participating Organisations

The ERID-Watch project was financed by the European Commission, as a Coordination Action. The project was initiated by CEA (France), DESY (Germany), STFC (UK), VR (Sweden), IEAP (Czech Republic) and Nenner Conseil (France). The interviews and analysis of Work Package 1 include 53 operating research infrastructures from 38 scientific institutions in 15 Member States. In the data analysis, sometimes a basis of only 51 or 52 RIs is mentioned. This is due to the fact that two previously non-interviewed RIs were added for the aforementioned case study on industrial synchrotron usage, and they did not answer all of the general questions. In addition to the RI interviews, feedback received from some companies has been considered on certain issues.

1.3 Main Facts

When collating the data, the lack of available and comparable key figures presented a recurring challenge in all areas investigated in this study. Thus, the analyses presented here have to be read with care - they are indicative rather than conclusive.

1.3.1 Main Facts on RI General Information and Organisation

During the interviews, four different RI organisational structures were found. More than half of the examined RIs belong to a Research Institution which hosts several Research Infrastructures.

This category is predominant in the scientific domains of Astronomy, Astrophysics, Nuclear & Particle Physics; Biomedical and Life Sciences; Environmental Sciences; and Material Sciences. The category of “Main RI hosting several pieces of equipment” can only be found in the domains of Material Sciences and Biomedical and Life Sciences. The majority (76%) of the institutions which host RIs are not integrated within any umbrella organisation.

The age of the interviewed RIs varies significantly; some date from as early as 1750. A high number of the interviewed RIs built in the 1980s (56%) were concentrated in the Environmental Sciences domain (e.g. research vessels), while in the 1990s, 44% of the newly built RIs belonged to the Biomedical and Life Sciences. Of the 10 interviewed Research Infrastructures that were built in the last 8 years; 50% were Material Sciences RIs and 20% Biomedical and Life Sciences RIs.

Nearly half of the institutes have the legal status of research institute, agency or university-attached department under public law.

Only about 60% (32 RIs) of the interviewed infrastructures could provide data on the distribution of industrial and scientific usage. Of these, six reported no industrial users at all. Among the RIs that could provide data, 14% of the total reported usage was allocated to industrial users. This might seem a high average, but it is distributed very unevenly, as only four infrastructures have a very high share of industrial usage, namely 90%, 60% and twice 30% (one each from Material Sciences, AANP, Environmental Sciences and Biomedical Sciences).

The number and the home countries of visiting scientists at RIs are seldom collected within the RI and seem to have minimal importance with regard to the connection between RIs and industry.

1.3.2 Main Facts on Know-How and Technology Transfer

Know-How and Technology Transfer (TT) were found to be organised at an institutional level at all interviewed RIs. None of the interviewed institutions handled the related issues at the level of individual RIs.

39 of 51 Research Infrastructures interviewed about TT issues reported that they had the option of using a TT-office/department, a separate TT company, or that there was at least a TT-responsible person that they could turn to. A further 12 infrastructures do not have this possibility.

The main funding source of TT offices is the general budget of the institution, as 23 of the 51 infrastructures (45%) state that TT receives no income from their activities with industrial partners. About 21 infrastructures (41%) are able to draw at least some income from their TT activities, but only seven infrastructures (14%) manage to obtain 50% or more of the money spent in this field from royalties or payments for contract research.

33 of the 51 interviewed infrastructures (65%) stated that, in principle, they offer services to industry, from mostly basic services like accommodation to full R&D service, as well as additional services such as special trainings. Engaging in patenting or licensing does not seem to be imperatively linked with the industrial usage of the infrastructures.

The annual number of the institutions' patent applications (based on responses from two-thirds of the interviewed RIs) is high in the domain of AANP and still above average in BLS and ES, while MS is somewhat below average. A large spread between many RIs is typical for all scientific domains, with many having none and some with high numbers of patent applications. The number of total patents held by the RIs turns out to vary significantly from the number of annual patent applications and indicates that some infrastructures do not keep up their applications for longer periods of time. RIs in Germany have the highest relative possession of intellectual property rights with an average of 7.56 patents held per 100 FTE, followed by the UK with 3.49 patents.

26 infrastructures gave information about licenses. On average, just over 20 licenses were given in the last three years in these infrastructures annually- that means only ca. 0.8 new licences for each infrastructure per year. The individual figures ranged from 0 to 12 licenses per year. The domains of BLS, AANP and ES are above average in giving licenses. All in all, just over one new license contract annually per 1,000 FTE indicates that giving licenses is currently not the core route for technology transfer from RIs. On average, 16,434 € license income is generated per 100 FTE, which calculates to 164 € per full time employee. The RIs in the domains of BLS and MS are more successful than others in generating higher royalties with their licenses.

Spin-offs could not be found in the small number of RIs in the domains of CDT, Energy and SSH. 16 out of 51 infrastructures gave no information about this topic, another 12 infrastructures have yet to produce any spin-offs and 23 RIs have had at least one. The number of spin-offs per institution with infrastructures normally is less than ten. The most spin-off companies per 100 FTE are found in the domain of AANP with 2.74 per 100 FTE, followed by Biomedical and Life Sciences with 1.75 per 100 FTE. All other domains are below the average of 0.95 per 100 FTE.

A problem often mentioned is the difficulty of comparing all research infrastructures based on simple key figures.[1] There are several fundamental reasons which lead to totally different

[1] A set of possible key figures is recommended in the box at chapter 6.2.1 on page 27.

situations in different RIs, including the character of research carried out, the scientific domain and the potentially addressed industry branches as well as the type, the legal environment and the TT policy of an RI. Furthermore, a central issue as regards TT policy is the unresolved duality between IP protection and the traditional open science approach of public research.

Only very few institutions invest enough time, money and personnel to be able to really go proactively into the markets for a transfer of know-how and patent applications to industrial licensees. Another overall problem is determined by the extreme discrepancies in the TT approach not only among different scientific fields but also within the same field. A set of commonly used standards could simplify the TT process.

Last but not least, a more successful TT, whose potential is indicated by patent applications and whose success is proven by license income and contracts and its licenses or co-operations with industry, still requires the commitment of the researchers.

1.3.3 Main Facts on Human Resources

The HR section of the questionnaires generated the most discussion during the interviews, as many problems for the RIs are directly related to HR – for example, finding appropriate staff for running the RIs. Problems frequently mentioned were low salaries compared to industry, the high number of fixed termed contracts vs. permanent contracts, and the related difficulties in recruiting staff. This seems to be predominantly an issue in public research organisations.

No notable programs for the exchange of staff between RIs and industrial partners/companies were found during the ERID-Watch Interviews. Once someone has left academia for industry, they usually do not return. The higher salaries in industry might be one of the reasons, but the different focuses of industrial vs. academic scientific work are also perceived as playing an important role. While in academic institutions, an ongoing update on the latest scientific developments via information exchanges with colleagues is part of the daily work, for most industrial scientists, their focus has changed and they are no longer part of this process. The careers of scientists are tightly linked to their publications; if they go to industry, their focus is no longer on publishing, which might be a problem if they want to return to academia. The majority of the interviewed RIs offer additional training for their staff, including soft skills training.

An institute which hosts one or more infrastructures has on average 733 staff members. The largest numbers of employees can be found in the scientific domains of Material Sciences; Environmental Sciences; and Astronomy, Astrophysics, Nuclear & Particle Physics. The highest number of employees per institute is found in Computation and Data Treatment; Astronomy, Astrophysics, Nuclear & Particle Physics; and Environmental Sciences.

65% of the staff of the interviewed institutions has permanent contracts. The two scientific domains of Material Sciences and Astronomy, Astrophysics, Nuclear & Particle Physics lie significantly above this with reported values of 89% and 72%, respectively.

1.3.4 Main Facts from the Case Study on Industrial Usage of Synchrotrons

All synchrotrons make a distinction between published research, where the research results are openly published for general scientific gain, and proprietary research, where the results are kept confidential and used privately for monetary gain. This distinction is applied to all users. Published research is generally free.

The prices for one hour of beamtime for proprietary research range from 100€ to 930€ and are not always based upon a detailed calculation of the real costs. The average sales price is 313€[2]. Three institutes charge additional or higher fees for Mail-In Service in the field of Protein Crystallography.

The average annual turnover from industrial use at these synchrotrons ranges from € 50.000 to € 2.5 million. The institute with the largest annual turnover earns as much as all the rest of the compared synchrotrons combined. This institute also has the highest number of users and staff. Average annual turnover of seven compared institutes lies around € 659,286.

Across the synchrotrons there is often a wide difference in the amount of industrial usage. Beamtime hours provided annually to industry ranged from 219 to 3700; this equals a percentage of 0.2% to 12%. The number of users ranges from 4 to 50 per year, and often these users visit more than once. All but one synchrotron reported that the majority of its customers come form the pharmaceutical area. At this one exception, most customers came from the field of “Chemistry and Energy”.

For the future, all but two institutes expect a near-term increase in industrial users, but hardly anybody expects an increase above 10% of the current total industrial usage. All agree that, seen globally, the industrial usage of synchrotrons will experience an increase. Life Sciences, closely followed by Chemistry and Energy, are seen as the fields with the most potential for the future. One synchrotron sees the greatest potential in the Electronics field.

All European synchrotrons offer rapid access for industrial customers. The U.S.-based NSLS is in the process of implementing this service, also. It is interesting that although everyone sees rapid access as an important demand of industrial customers, the NSLS already enjoys a

[2] Additional information on the calculation of the average: two institutes provided the lowest and highest prices for which their services are available; for these, we took the average of these numbers without knowledge of how many hours were in fact sold at each price level, because that information was not given. The others stated an average price themselves.

high usage rate by industrial customers (5.6%) without having rapid access implemented yet. Being able to offer service is generally regarded as most important, especially if one wants to draw in more local small to medium enterprises (SMEs). Indeed, drawing in more (local) SMEs was explicitly stated as a goal in several cases.

Services deemed necessary by synchrotrons for industrial users include general assistance by a beamline scientist, experimental setup, and analysis of the measurement results. Dedicated beamlines for industry are not very widespread and opinions on them vary. Most institutes do not have a beamline established exclusively for industrial use, though in some cases this is the de facto situation, as only industry uses a certain beamline. The study found one model where a beamline is financed by industry and a research institute. This model also exists at the NSLS in the form of the Participating Research Teams (PRTs).

We found that most institutes mix an indirect with a direct marketing approach: the indirect approach is evident in the institutes' emphasizing how important networking and going to scientific conferences is. The industrial users become aware of the synchrotrons via their scientific merits and can tap into the excellent research programmes that are offered. In general, high visibility and a good reputation are assumed to increase industrial usage. But many institutes also seem to have reached a point where they set out to try a more direct method of marketing synchrotron radiation by carrying out market surveys, making their product offer more transparent, developing strategies to communicate their product offer better, enlarging the service connected with the offer of synchrotron radiation, and in general trying to solve the problem of communicating the possibilities of synchrotron radiation and better understand the needs of industrial users.

For this, it is important to have specialized members of a service group, or at least someone who has the time and capability to "speak the language" of both the scientist and of the customer. Two thirds of the institutes have special service groups for industry that liaise between scientists and industry. In one case, an external company was founded to better service the larger, long-term customers.

In the selling of synchrotron radiation, it seems especially crucial to recognize analogies between fields to be able to offer the right solution. Thus, it is vital that experts from different fields work together: the scientists with the in depth knowledge of the methodological possibilities and the marketing and business people to mould it into a sellable product geared toward the needs of the market. This conclusion is in accordance with the general perception that the marketing of beamlines has to be a combined effort by people from the marketing/business sector and scientists, or through a combination of these skills by hiring people with skills from both fields in their profile who can act as liaisons between science and business.

1.4 Main recommendations

The recommendations below are further explained and annotated with examples in Section 7

1.4.1 Main recommendations on RI General Information and Organisation

R-RI-1: Develop and apply a simple, but comprehensive long-term scheme to register key data on all relevant areas, like Users, Technology Transfer and Human Resources.

R-RI-2: A scheme to register the users in all European RIs should cover the categories internal user, external scientific user and external industrial user and the origin from at least the member state, European Union and other countries.

R-RI-3: Create and expand European Networks of RIs and use them for the exchange of key figures and best practice in managing RIs.

R-RI-4: Develop and work with "Corporate Identity" of Research Infrastructures for internal and external purposes (Human Resources and Industrial Liaison).

1.4.2 Main recommendations on Know-How and Technology Transfer

R-TT-1: Develop and regularly revise a clear vision and strategy for K&TT.

R-TT-2: Develop and apply a simple, but comprehensive long-term scheme to register key data and best practice information for all relevant K&TT processes on the RI level. [3]

R-TT-3: Use a professional and sufficiently staffed TT office with clear processes, clear responsibilities and a dedicated focus on licensing.

R-TT-4: Organise your TT business with a separate budget in a profit-oriented way.

R-TT-5: Identify services that may be offered to industry in mutual compliance with the principles of responsible partnership and market these services in a pro-active manner.

R-TT-6: Use networks to exchange strategies, experiences and standards in K&TT among RIs.

R-TT-7: Transfer innovations and know-how to industrial partners by licensing to receive royalties at market conditions, while keeping the ownership of IPR.

[3] (Please, compare with section 6.2.1 for more details.)

R-TT-8: Support potential spin-off companies with consulting and financing early and use all professional means available.

1.4.3 Main recommendations on Human Resources

R-HR-1: Develop and apply a scheme to register key data on Human Resources in all European RIs. It should cover at least the categories: number of employees, national origin of staff, previous employer(s) = industrial or scientific, training.

R-HR-2: Offer exchange programs for industrial and public staff members.

R-HR-3: Support further efforts to modify existing payment systems towards performance oriented salaries, e.g. by offering incentives for scientists to counterbalance low salaries and fixed-term contracts.

R-HR-4: Create a modular and standardized social security system on national and European level to ease mobility between Research Infrastructures throughout Europe.

1.4.4 Main recommendations on Industrial Use of Synchrotrons

R-CS-1: Maintain a service group or at least a designated person for industrial liaison to secure a communication channel between industry and science

R-CS-2: Use uniform statistics for recording beamtime, type of use, users and customer fields to achieve more transparency.

R-CS-3: Offer fast and easy access for industrial customers.

R-CS-4: Carry out market analyses to be able to respond to the individual needs of different customers.

R-CS-5: Build a unique own profile by offering modular, fine-tuned service geared towards customer needs.

R-CS-6: Continue and expand networking at conferences to address potential industrial users.

R-CS-7: Combine an indirect marketing approach with a direct approach according to own profile.

R-CS-8: Further develop networking among synchrotrons to jointly achieve complete market coverage for the industrial use of synchrotrons.

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3 Glossary

- **EIROForum:** A partnership of Europe's seven largest intergovernmental research organisations, which are:
  - *CERN - European Organization for Nuclear Research*
  - *EFDA - European Fusion Development Agreement*
  - *EMBL - European Molecular Biology Laboratory*
  - *ESA - European Space Agency*

  - *ESO - European Organisation for Astronomical Research in the Southern Hemisphere*
  - *ESRF - European Synchrotron Radiation Facility*
  - *ILL - Institute Laue Langevin*
- **ERA:** European Research Area - In 2000, the EU decided to create the ERA. This means creating a unified area all across Europe, in which one should:
  - *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.*
  - *Inspire the best talents to enter research careers in Europe, incite industry to invest more in European research – contributing to the EU objective to devote 3% of GDP for research, and strongly contribute to the creation of sustainable growth and jobs.*
- **ERF:** European Association of National Research Facilities, of which the initiating associates are :
  - *Societe Civile Synchrotron Soleil (FR),*
  - *Gesellschaft für Schwerionenforschung GSI (DE),*
  - *Elettra – Societa Sincrotrone Trieste (IT),*
  - *Deutsches Elektronen-Synchrotron DESY (DE),*
  - *MAX-Lab Lund University (SE),*
  - *Grand Accelerateur National d'Ions Lourds GANIL (FR),*
  - *Paul Scherrer Institut PSI (CH),*
  - *FOM-Institute for Plasma Physics Rijnhuizen (NL),*
  - *Max-Born-Institut MBI (DE),*
  - *Hahn-Meitner-Institut HMI (DE),*
  - *Science and Technology facilities Council STFC (UK)*
- **EU 15:** Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxemburg, Nertherlands, Portugal, Spain, Sweden, United Kingdom.
- **EU 12:** Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, Slovenia.
- **FTE:** Full Time Equivalent
- **IP:** Intellectual Property
- **K&TT:** Knowledge and Technology Transfer
- **PG:** Pilot Group
- **RI:** Research Infrastructure

- **WP:** Work Package

Abbreviations of Scientific Domains

- **AANP**: Astronomy, Astrophysics, Nuclear & Particle Physics
- **BLS**: Biomedical & Life Sciences
- **CDT**: Computation and Data Treatment
- **EN**: Energy
- **ES**: Environmental Sciences
- **MS**: Material Sciences
- **SSH** : Social sciences and Humanities

4 Framework of the Study

4.1 Background and Objectives

The main purpose of the ERID-Watch project is to assess certain key aspects of the efficiency of Research Infrastructures in Europe, their performance in terms of scientific exchange and public-private transfer and to contribute to an increase of public investment efficiency for European Research Infrastructures by benchmarking and the extraction of best practise examples. This approach includes the exchange of experiences and policies in existing Research Infrastructures. The extent to which Research Infrastructures are open not only for scientific but also for industrial communities was examined, as the basic necessity of the knowledge-based development of the modern European Society follows from this openness. Due to their unique opportunities, RIs play an important role in this process. European RIs were invited to take part in ERID-Watch by sharing their good and bad experiences. The study, which focused on Research Infrastructures, not on the institutions which host the infrastructures, was conducted on a voluntary basis.

Work Package 1 of this study is devoted to identifying and benchmarking “Good Practices” within the daily work of a Research Infrastructure, for example in the areas of Technology Transfer, Human Resources and Legal Environment. To do so, a broad and deep insight into the RI landscape is needed. WP1 tried to develop this insight through extensive face to face interviews with RI representatives. As the European RI landscape is very diverse – ranging from seagoing and polar Research Platforms to Synchrotrons to large databases in different scientific domains - not all questions were applicable to all RIs. This explains why a benchmarking analysis with complete information about all infrastructures turned out not to be feasible. Nonetheless, this report tries to draw a thorough picture of a major part of the European Research Infrastructure landscape. The report cannot be seen as a fully representative study of all RIs in Europe, but as stated before, this is not the aim – the objective of this project is to show best practices in several areas.

4.2 Introduction

An overall number of at least 600 Research Infrastructures (RIs) is assumed for Europe. For ERID-Watch, 53 of these RIs from 16 countries of the European Research Area (ERA) were interviewed. Additionally, one RI from the United States was interviewed for the Synchrotron Case Study and special interviews for this study were also conducted with additional synchrotrons in Europe.

Although the project is called “European Research Infrastructure Development Watch,” not all information could be gathered at the RI level, as some information as well as the organisation of TT and HR is maintained only at an institutional level. Also, it should be kept in mind that

RIs are seldom built to serve two markets with different demands: the market of industrial users as well as the market of scientific users.

Basically, Research Infrastructures' market of users is divided into two parts – the scientific market and the industrial market. It cannot be said that the RIs are not market oriented; rather, one could say that both markets seem to have different demands and most of the interviewed RIs' core focus is on the scientific market. Their market orientation lies within the scientific community where the demands are for example the uniqueness of the RIs. Up until now, both markets could not be put together and served at once with the same means. This may explain why it is relatively seldom the case that an RI has half industrial and half scientific users – it is much more likely that RIs mainly serve just one of these markets.

4.3 Methodology

The WP1 Final Benchmarking Report is based on information which was gathered mainly during face to face interviews with several representatives from different Research Infrastructures. Basically, the report is based on two parts:

1) General face to face interviews with RI representatives, and
2) Interviews with Synchrotron representatives.

For the sample of interviewed RIs, the clear European dimension combined with the number of external users was relevant for choosing the RIs. Other criteria were the type, the country and the scientific domain of the RI. All EIROFORUM and ERF members were interviewed.

For the interviews during the field work, two documents, a Pre-Questionnaire and an Interview Guideline, were used. The study was conducted on a voluntary basis and also the information was given on a voluntary basis – some information was crosschecked with other reports as well as information from the web.

For special parts of the Final WP1 report, for example the Synchrotron Case Study, additional interviews were conducted with a representative selection of Research Infrastructures. For these interviews an Interview Guideline for Synchrotrons and a Questionnaire for Industry was used.

An attempt was also made to complement the results of the face to face interviews with two web questionnaires in the areas of Human Resources and Technology Transfer. These questionnaires were developed and sent to representatives responsible for Human Resources and Technology Transfer at RIs in Europe. Unfortunately, the response for this method was much too low to be useful for this study. Furthermore, the minimal results obtained added nothing new to the study, though they did reaffirm the results of the first two methods.

4.3.1 Scope

As stated in the Deliverable D1 in the 2005 EU survey, conducted in the years 2004-2005, about 742 Research Infrastructures in different scientific fields in Europe were registered. The new survey, published in July 2007, assumes at least 598 validated research infrastructures in Europe. Nevertheless, it is reasonable to assume a total number of at least 600 Research Infrastructures in Europe (taking into account small, medium and large ones).

The categorisation of the examined Research Infrastructures in scientific domains was done according to the ESFRI-Roadmap.

4.3.2 Focus

Work package 1 - the Benchmarking activities and good practices selection - consists of an evaluation of the profile of European Research Infrastructures. According to the Description of Work of the ERID-Watch project, there were several objectives to be evaluated during analysis. First, best practices should be identified and benchmarked in the areas of know-how and technology transfer, sub-contracted tasks to industry, financial partnerships, human mobility and resources, and the legal environment. Secondly, the questionnaire used during several face to face interviews should give an overview of the aforementioned fields in the RI operation. Finally, the case study on synchrotron use focuses on the usage of synchrotron radiation for industrial purposes.

In November 2006, at a very early stage of the project, it was suggested that using common questionnaires for WP1 and WP2 would have several advantages. This approach was adopted, and an ongoing exchange between the three interviewers of the two WPs ensured the quality of the interviews.

4.3.3 Timeframe

The timeframe of WP 1 during the whole project is divided into three phases:

- Preliminary phase: Scope and Definition, summed up in D0 and D1
- 1st working phase: Broad Survey and Basic Conclusions, summed up in D2
- 2nd working phase: Refining of data and Recommendations, summed up in D3

4.3.4 Reliability of the results

This report displays an analysis of all interviewed RIs. However, one must take the following into consideration:

– the number of RIs interviewed in the aforementioned thorough manner constitutes 8% of all estimated existing 600 RIs. Not taking the small ones into consideration, reduces the data base by half to ca. 300, which would raise the percentage of considered RIs to 16%.
– participation of RIs could not be achieved fully proportionally across all countries and scientific domains studied
– not all questions in the documents could be answered by all Research Infrastructures with the same degree of detail

– an attempt was made to check the accuracy of numbers and information given, but often information of the searched for kind had not been published before and was thus hard to find or simply non-existent.

Therefore, the numerical results of this study cannot be seen as being fully-fledged representative figures. Rather, they have to be taken as semi-quantitative indicators for the qualitative issues of this study.

4.3.5 Data collected

Two criteria were selected for the definition of the sample of RIs in this study:

1) The **clear European dimension** in the work of the RI; and
2) The **number of external users** compared to staff of the RI (more than an average of 20% external users).

Additional criteria for the study's sample were:

3) The **scientific domain** (according to the ESFRI roadmap). The domains should be represented roughly proportionally to their percent value in the ESFRI roadmap.

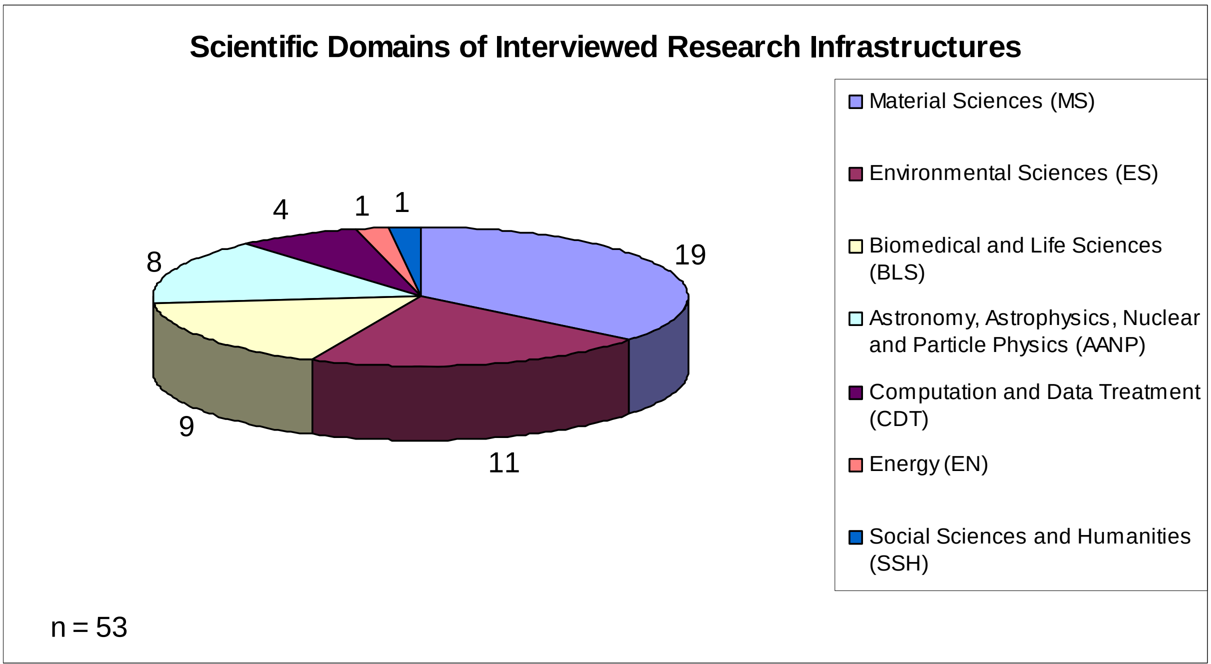

Figure 1 Scientific Domains of interviewed Research Infrastructures

4) The **nationality –** Interviewed RIs should originate from all 35 states within the European Research Area (ERA) and should be represented in this study in a sense of proportion, if possible. In contrast to the EU survey, RIs operated by intergovernmental organisations were not classified in this study under their host country, but rather as "EU".

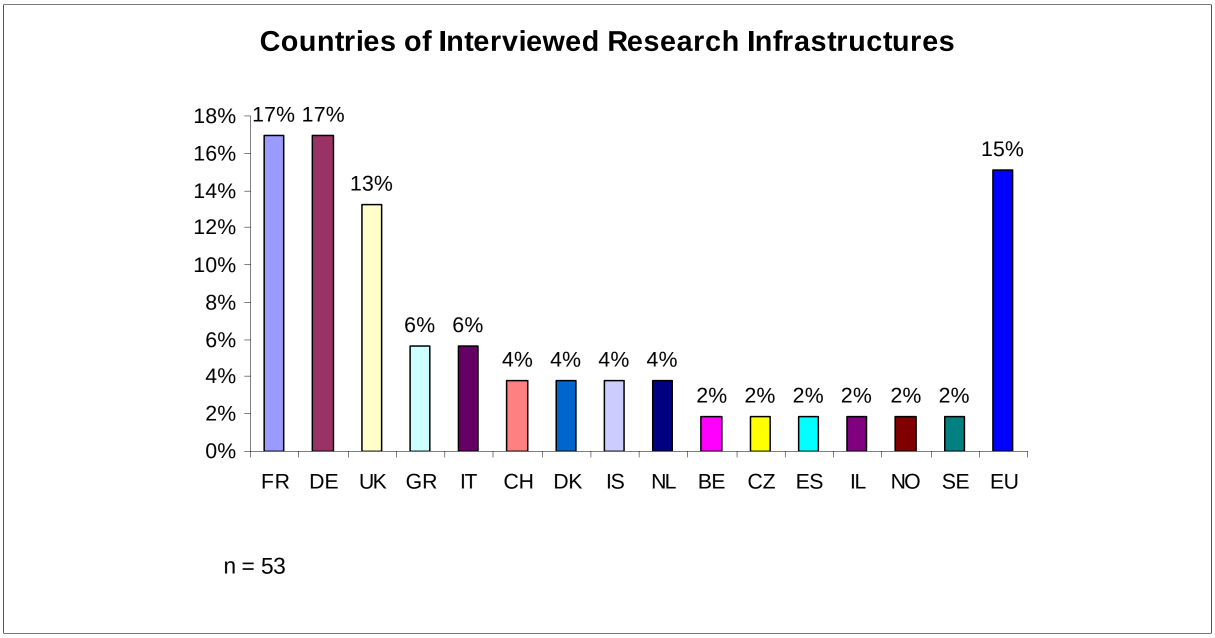

Figure 2 Countries of Interviewed Research Infrastructures

5) The **type of RI** (single-sited, distributed or virtual). This study tried to consider the different types of RIs roughly proportionally to the respective percent values in the 2005 EU survey.

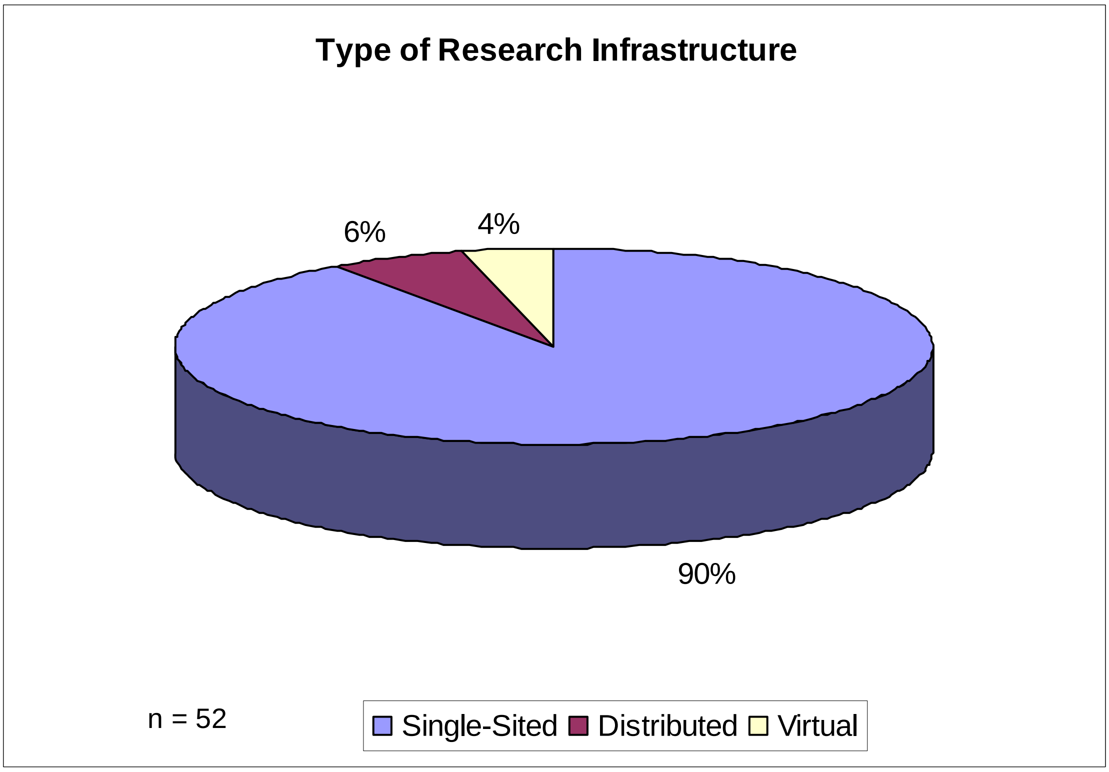

Figure 3 Type of Research Infrastructure

Interviews were conducted with Research Infrastructures active in all scientific domains, of all different RI types, and originating from 15 European countries, as well as with infrastructures classified as European that are operated via the participation of several EU member states. All in all, by the 24th of August 2008, 38 institutions had been interviewed and information on 53 research infrastructures hosted by these institutions had been gathered. The participation was made on a voluntary basis and even if an RI participated, it was not obliged to answer all questions. That means that several questions have not been answered by all and not all parts of the analyses could be performed with a complete set of information. See the list in the annexes for details about the sample of ERID-Watch WP1.

Figure 3 shows that the overwhelming majority of interviewed RIs, namely 90%, are single-sited. According to the European Science Foundation's 2007 report, approximately two-thirds of all European RIs are single-sited. While the figures in this study may be somewhat over-representative of single-sited infrastructures, they certainly are in keeping with the general trend for European RIs. The remaining RIs are either distributed among several sites or virtual, i.e. based on digital databases. A glance at Figure 4 shows that the under-representation of RIs from the scientific domains of Computer and Data Treatment and Social Sciences and Humanities may have played a direct role in the under-representation of virtual infrastructures, whereas the over-representation of RIs in the Material Sciences domain may have led to the overly large share of single-sited RIs in the study.

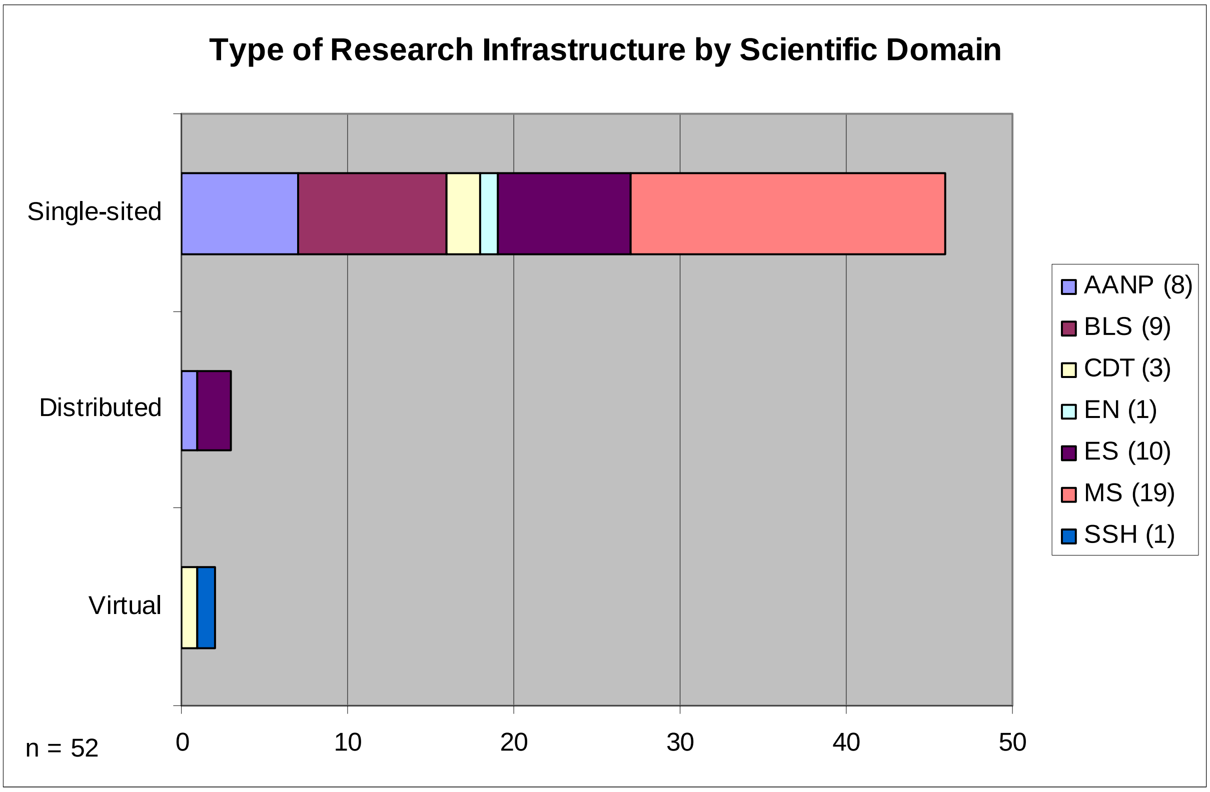

Figure 4 Type of Research Infrastructure by Scientific Domain

5 Acknowledgements

This report concludes the ERID-Watch WP1: “Benchmarking and Best Practices”. The work of this WP was conducted with the help of all ERID-watch partners and RI operators from all over Europe and the US, as well as other stakeholders in and around Research Infrastructures. Especially we would like to thank all interviewees within the Research Infrastructures and organisers of these interviews.

6 Conclusions

6.1 Conclusions on RI General Information and Organisation

Commonly shared and agreed definitions seem to constitute a major problem in the evaluation of different types of RIs. Concerning the origin of users, it has to be stated that across all European RIs the data base is very diverse with large informational gaps.

This problem is not so relevant in the case of stand-alone surveys. But it becomes very important for guaranteeing consistency in the comparison and integration of results from different studies in this field.

6.1.1 RI General Information

Four different types how RIs are organised were found during the interviews:

- **1) Main Research Institution hosting one Research Infrastructure:** 5 out of 53 institutions interviewed are of this kind.
- **2) Main Research Institution hosting several Research Infrastructures:** More than half of the examined institutions are of this type. However, the numbers of infrastructures which are hosted by the institution vary significantly – from two to more than ten infrastructures. Examples of institutions hosting more than 10 RIs are: DESY, CERN, ESA, AWI.
- **3) Main Research Infrastructure hosting one major piece of equipment:** This type of organisation was found in 8 institutions, for example at Soleil. The Soleil Synchrotron for example is one big piece of equipment which constitutes the RI. French RIs made up the majority of this organisational type.
- **4) Main Research Infrastructure hosting several major pieces of equipment:** These made up the smallest group of interviewed RIs – only 3 of this type were found, among them the Copenhagen Animal Research Unit. As the number of RIs in this category is so small, no further statement is possible about the spread of countries or scientific domains.

Five of the interviewed institutions could not be categorised in that way, as not enough information were available to ensure a solid categorisation. The above described characterisations are illustrated by Figure 5.

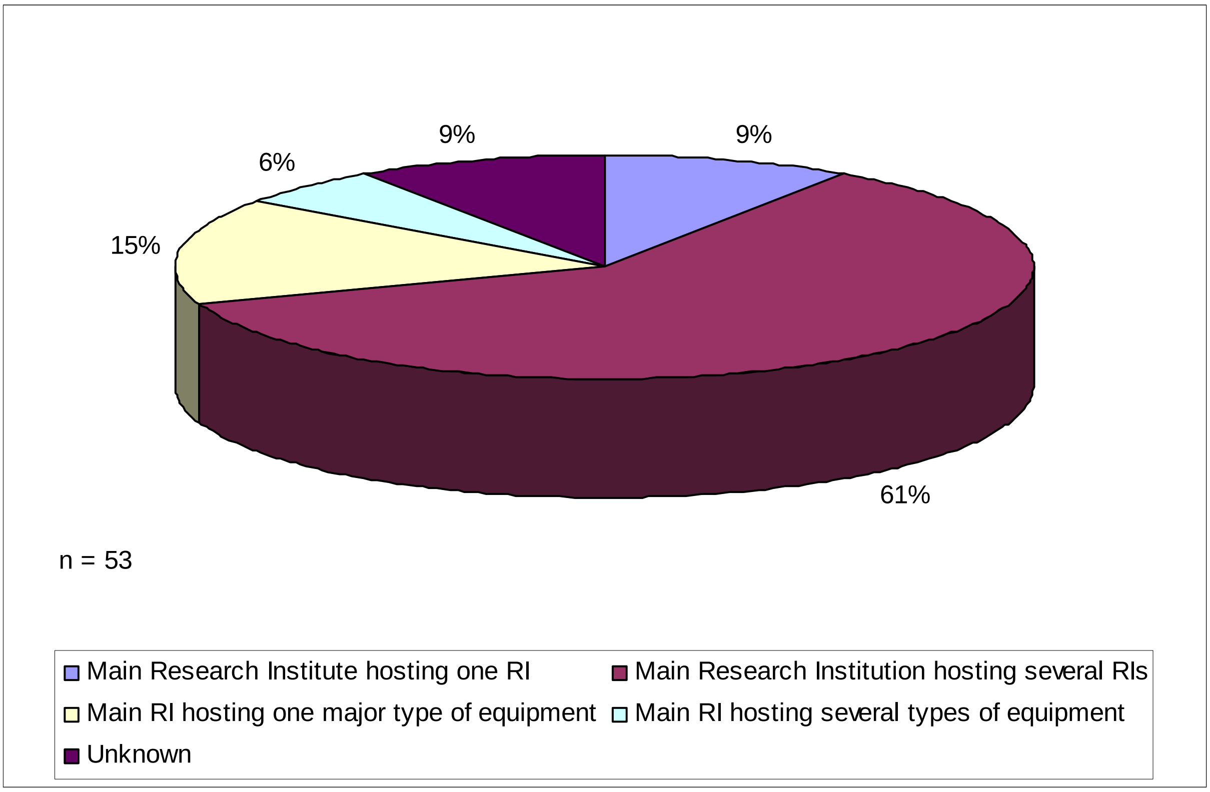

Figure 5 Organisational Structures of Interviewed Research Infrastructures

Figure 6 gives an overview of the organizational structure of the interviewed research infrastructures categorized by scientific domain. The category of "Main RI hosting several pieces of equipment" can only be found in the domains of Material Sciences and Biomedical and Life Sciences, while the category "Main institution hosting several RIs" is predominant in the scientific domains of Astronomy, Astrophysics, Nuclear & Particle Physics, Biomedical and Life Sciences, Environmental Sciences and Material Sciences.

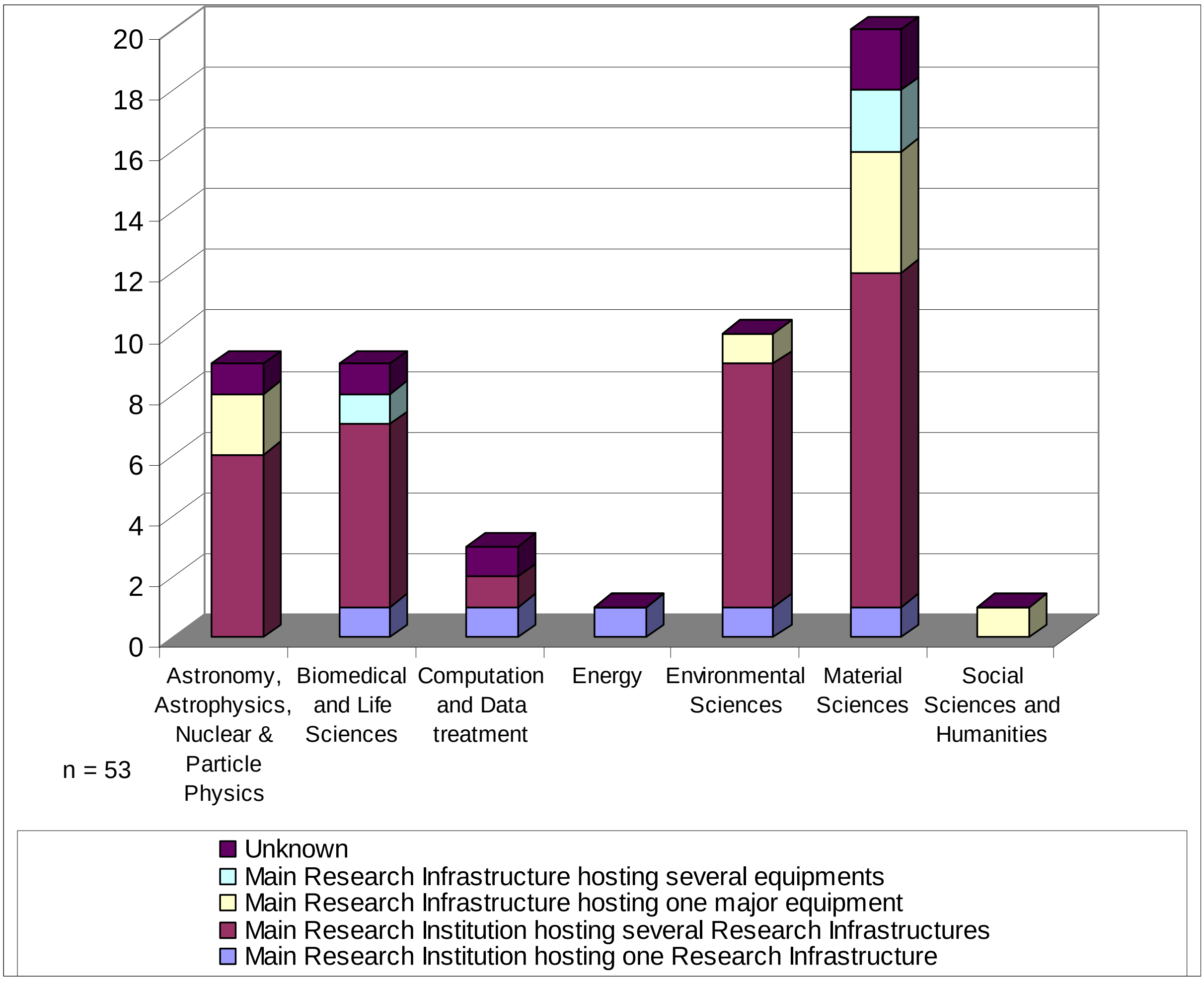

Figure 6 Organisational Structure of Interviewed Research Infrastructures by Scientific Domain

6.1.2 Umbrella organisation

Umbrella organisations mostly exist on an institutional level. This means that the institution, not the infrastructure, is part of an umbrella organisation. From the 38 interviewed institutions, nine (24%) institutions are integrated within such an umbrella organisation (seven of which are situated in France or Germany), for example the Helmholtz Association, CNRS, or FOM.

The large majority of the RIs (76%) are not integrated within any umbrella organisation. Seven of those infrastructures belong to university departments or institutions, but in these cases, the universities are not seen as umbrella organisations. Whether an institution is integrated within an umbrella organisation seems to be independent of the type or the scientific domain of the institution.

6.1.3 Age of the Infrastructures

The age of the interviewed RIs varies significantly, some date from as early as 1750.
A high number of RIs in the environmental sciences (e.g. research vessels) were built in the 1980s (56%), while in the 1990s 44% of the newly built RIS belonged to the Biomedical and Life Sciences. Of the ten interviewed Research Infrastructures that were built in the last eight years; 50% were Material Sciences RIs and 20% Biomedical and Life Sciences RIs. The number of total established RIs increased every examined period.

An illustration of the distribution of foundations of RIs across the scientific domains is given in Figure 7.

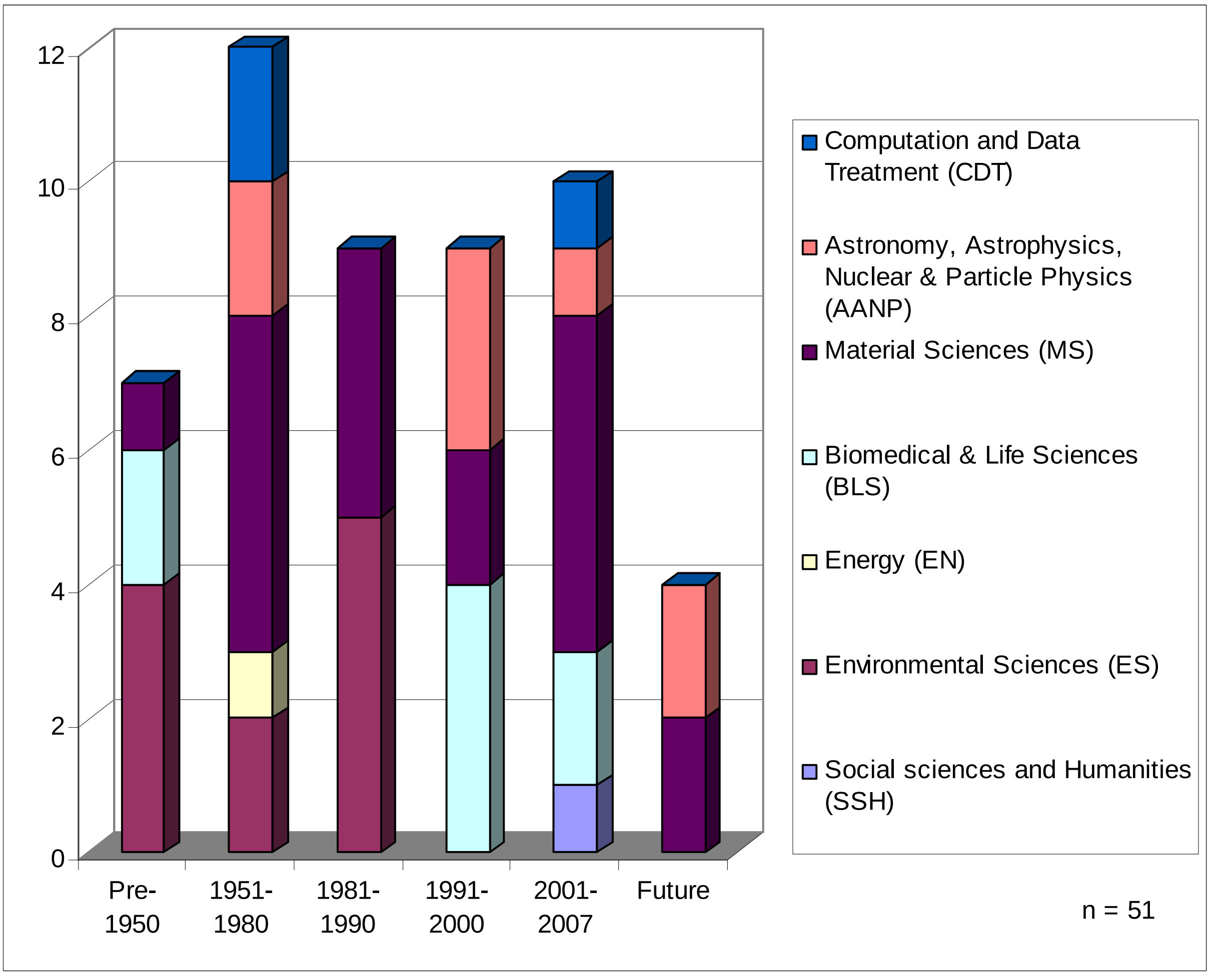

Figure 7 Founding Years of Interviewed Research Infrastructures by Scientific Domain

6.1.4 Legal Status of the interviewed institutions

Nearly half of the institutes can be categorized as research institutes, agencies or university attached department under public law. Figure 8 shows how the legal structure is distributed across the scientific domains

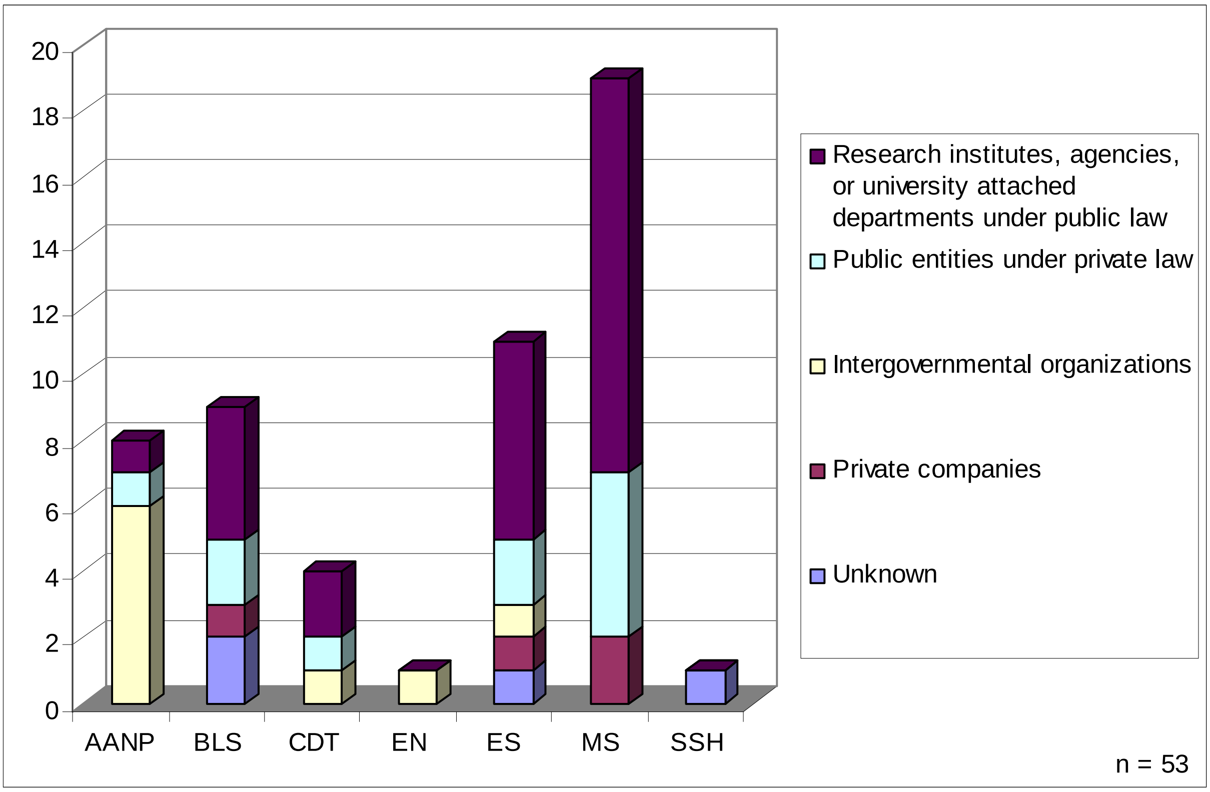

Figure 8 Legal Structure of Interviewed Research Infrastructures by Scientific Domain

6.1.5 Users of the interviewed institutions

Only about 60% (32 RIs) of the interviewed infrastructures could provide data on the distribution of industrial and scientific usage. Of these, six have no industrial users at all. This stands in contrast to the EU strategy of connecting science and industry according to the Lisbon process. As shown in Figure 9, 14% of the total reported usage in these 32 RIs is allocated to industrial users. This might seem a high average, but it is distributed very unevenly, as only four infrastructures have a very high share of industrial usage, namely 90%, 60% and twice 30% (one each from Material Sciences, AANP, Environmental Sciences and Biomedical Sciences).

The number and the home countries of visiting scientists at RIs are seldom collected within the RI and seem to have minimal importance with regard to the connection between RIs and industry.

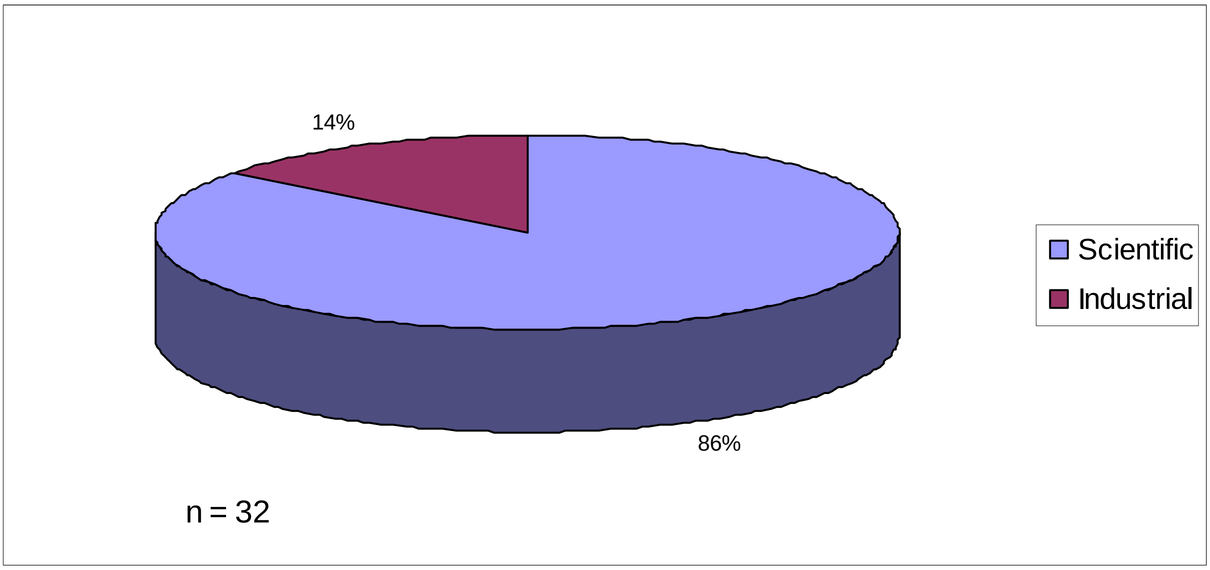

Figure 9 Users of the interviewed Research Infrastructures

6.2 Conclusions on Know-How and Technology Transfer

6.2.1 General problems & remarks

In general, the policy regarding Intellectual property (IP) varies between institutions and countries and is mostly directly connected to the financial situation of the TT department. This makes it difficult to attempt a benchmarking dependent upon key figures. Additionally, it should be taken into account that a classical TT office charged with the tasks of patenting/licensing, R&D cooperation, spinouts and services does not make sense for all scientific domains and organisational forms of RIs. This applies, for example, in the social sciences, where no technological inventions which could be developed into patents are made.

A problem often mentioned in this chapter is the difficulty in comparing all research infrastructures based on simple key figures. There are several fundamental factors which lead to totally different environments in different RIs, including the character of research carried out, the scientific domain and the potentially addressed industry branches as well as the type, the legal environment and the TT policy of an RI.

A central issue as regards TT policy is the duality between IP protection and the traditional open science approach of public research. Institutions, funding agencies and governments have to be properly aware of the different advantages and drawbacks of these two basic models.

Another overall problem is determined by the extreme discrepancies in TT approaches taken, not only among different scientific fields but also within the same field. Firstly, this lack of common standards leads to a wasting of resources, as partners meeting for the first time or on a new issue always have to “reinvent the wheel” to define their contractual relation. Secondly, this circumstance makes it totally confusing for newcomers to the public TT business, like e.g. from the EU12, to define and organise their own TT approach. A set of commonly used standards could simplify the process.

It is quite hard to find appropriate key figures to compare all different RIs. But the concentration should lay on a few key figures which are clearly understandable. Moreover, these key figures should be based on reliable data which are easily gathered. For this reason, the following data are proposed for this purpose:

- **Number of patent applications/year** for the last three years on average: this key figure is used internationally, easy to gather and at least provides an idea about the innovation arising from an RI.
- **Number of total patents held:** this number depends on the financial possibilities of the institutions and also is hard to compare between all scientific domains. This figure is also used internationally and easily gathered. It may indicate the relevance of patents for the RI and its specific market.
- **Number of licences given** as well as the numbers of licences given the last three years on average: Like both of the key figures listed above, information about licences is easily gathered and internationally comparable.
- Licence income annually for the last three years on average: This is another internationally used key figure.

- **Number of spin-offs** over the last ten years which were still active three years after being established: Also an internationally used key figure. It could be difficult to obtain the number of spin-offs which were still active three years after they were established, but spin-offs are key know-how transporters, so this number should be used.
- **Number and volume of industrial co-operations**: This number is easily gathered and is a clear indicator of the volume of an institution's industrial contacts.

For a more precise definition of the state of the art for Technology Transfer in different scientific fields, these key figures have to be supplemented with further information. This includes especially

- the existence of a **TT strategy** for each RI and/or its hosting institution
- the definition and use of **IP and TT standards**
- the **funding and manning** of TT units
- the respective **national frameworks** regarding legal, organisational and tax regulations as well as funding schemes dedicated to TT aspects
- the use and role of **TT networks**

The final aim for a TT policy will be a cultural change which allows for the entry of a breath of entrepreneurial spirit into the academically dominated RI community and which guarantees that the mere administration of innovations and patents that currently dominates TT activities is shifted towards a proactive licensing and business development. This case could very well be aided by the inclusion of relevant key figures and verbal descriptions of innovative effects into applications and reports for the funding of scientific projects and institutions. This does not mean changing all research to short-termed applied tasks, but guaranteeing that inventions and corresponding innovations are not ignored and have the chance to be transferred to the market in any type of research – be it an applied or a more basic type.

Last but not least, a more successful TT, whose potential is indicated by patent applications and whose success is proven by license income and contracts and its licenses or co-operations with industry, still requires the commitment of the researchers. Some institutions already began measures towards this change years ago and tried to integrate the researcher into the TT process. But only a few institutions have thus far established rules about the handling of rights and compensations for patents and licenses in favour of the researcher.

6.2.2 TT organisation

The Technology Transfer Offices or Responsible Persons are mainly attached *as a department or directly* to the director's office (25 RIs or about 50% of the 51 interviewed infrastructures). Looking at the sizes of the RIs' TT offices, the following size distribution at 51 interviewed infrastructures, shown in Figure 10, was found:

- Of 51 interviewed infrastructures, 19 had TT offices with a medium (12) to large (7) size. Offices with three to well below ten employees are considered of medium size, while the large TT offices had about 10-13 employees.
- Three infrastructures using external professional TT companies have been counted as a separate group. Regarding the degree of professionalism, these companies have to be seen as at least equal to the internal large or medium TT offices.
- 17 infrastructures had either a small TT office (10) with one or two employees or a TT responsible person (7).
- 12 infrastructures did not have a TT office or even a person responsible for TT concerns.

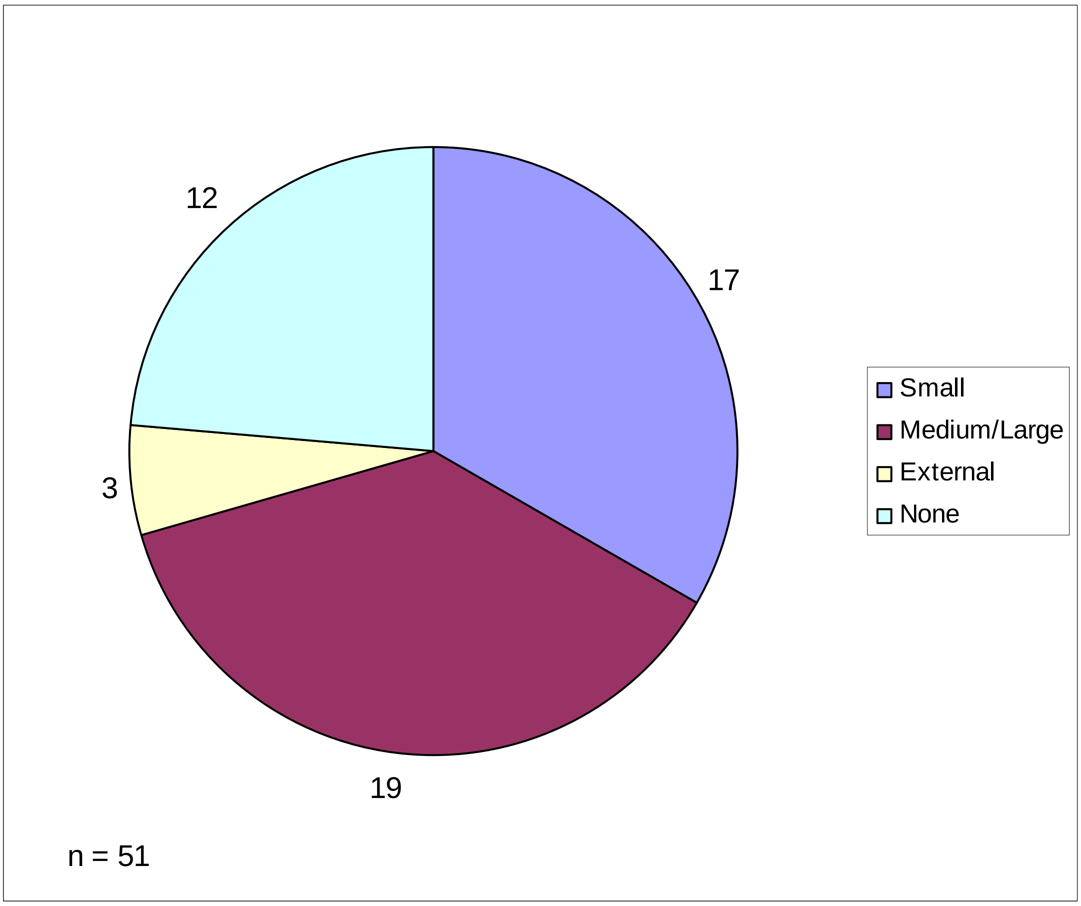

Figure 10 TT Office Size

The number of staff (FTE) per TT-office differs quite a bit between the different scientific domains. As mentioned above, the smallest TT offices have only one staff member, while larger ones have up to thirteen people working for TT. The fact that TT is given different priority at different institutes is demonstrated by two centres in the same scientific domain that perform very similar research: the first has one TT staff member and the second has thirteen people working for TT. Even if one of these centres had twice as many staff members as the other one, there would still be a ratio of 6.5 FTE to 1 FTE.

Technology Transfer offices perform very diverse tasks within the RIs: Patenting and Licensing, (R&D) Cooperations, Spin-offs as well as other services. This diversity of tasks shows that even two TT-offices well equipped in terms of personnel can not be compared based solely on certain key figures, as different main focuses may exist within the work.

An analysis of the level of activity of these different types of TT offices in Figure 11 shows that as patents are concerned, none of the different TT office size varieties are far from the average of generating 0.43 patent applications annually per 100 FTE. Amazingly, the RIs with small or even no TT offices rank above average, higher than those with medium to large TT offices. There was also one RI that reported using an external TT company (which was purposefully left off the chart below), and it reported just 0.27 annual patent applications per 100 FTE.

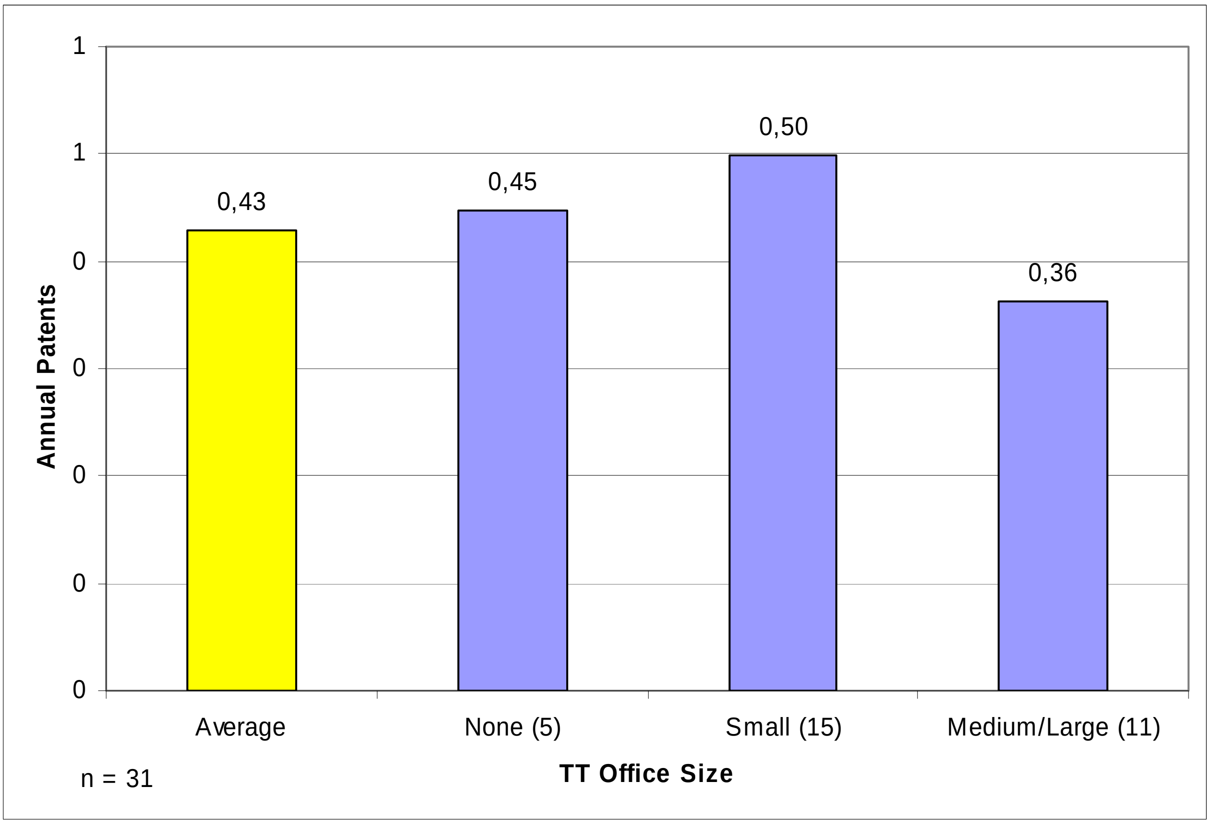

Figure 11 Annual Patent Applications per 100 FTE in relation to TT office size

But a look at the annual license income in Figure 12 tells a totally different story. Here, the medium to large TT-offices show significantly greater annual license income than their smaller counterparts. Those interviewed RIs without a TT office do not generate such income at all – although they give some licenses. This is a clear indicator that RIs with a small TT office or with none at all concentrate only on patenting and have no resources for doing the intense business of looking for industrial license partners. However, the latter is the only way to generate money from IP rights. Thus, many of the RIs with small or no TT offices effectively just burn money when they engage in the matter of handling IP rights. They would perhaps be much better served if they would drop this field of activity. Even better would be an upgrade towards a larger TT unit with more resources or hiring a professional external company for this kind of business. External companies are not *per se* better than internal TT offices, although the one RI using an external TT office reported annual license income of 30,303 € per 100 FTE and other similar examples are known to the authors. This is certainly not representative, but it does underline that one has to use a professional approach in IP marketing in order to have commercial success.

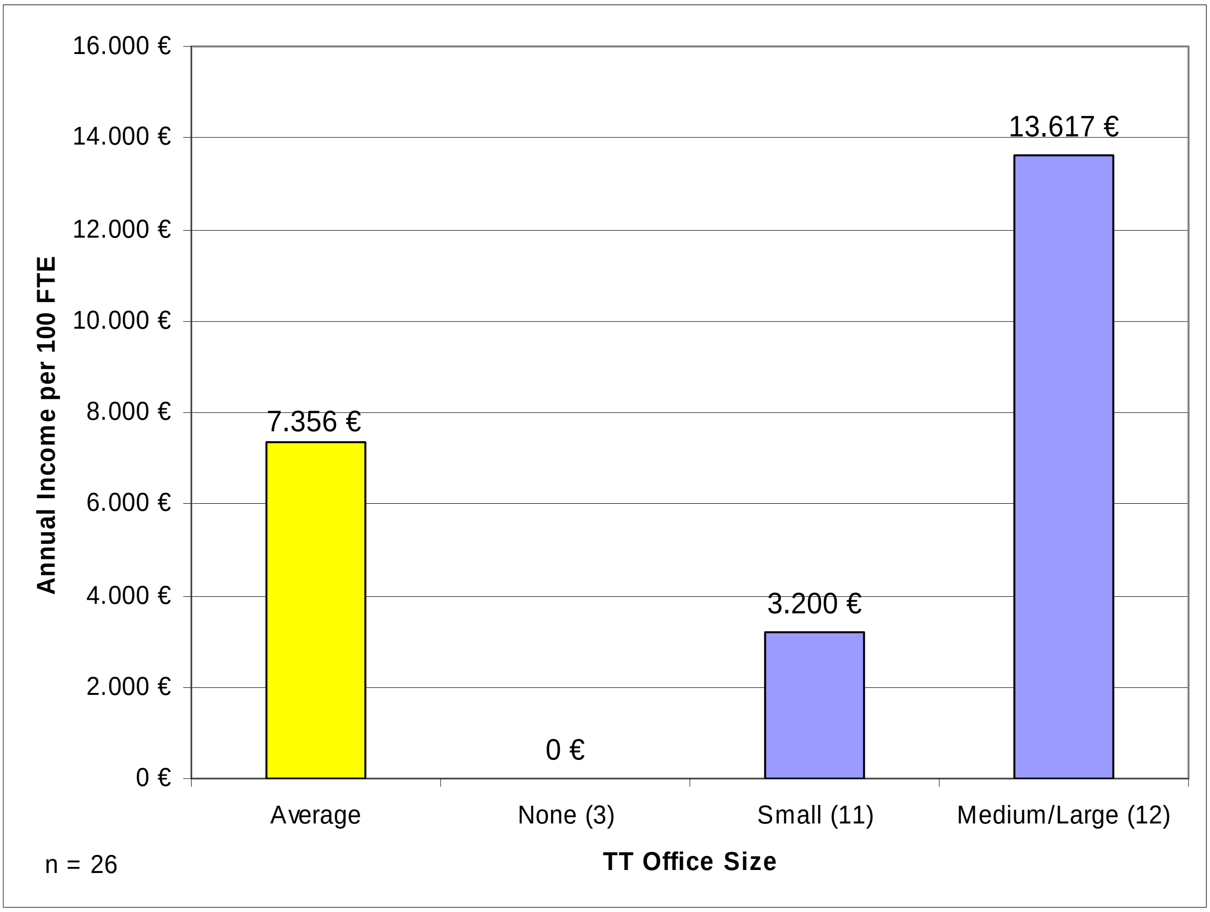

Figure 12 Annual License Income per 100 FTE in relation to TT office size

6.2.3 TT funding and income

The main funding source for TT offices is the general budget of the institution. 23 of the 51 infrastructures (45%) state that they generate no income from their commercial activities with industrial partners and only a minority of seven infrastructures (14%) manages to obtain 50% or more of the money spent in this field from royalties or payments for contract research. Even those infrastructures with income from commercial activities often do not organise TT as a profit centre. Consequently, these TT offices are also fully dependent on the central budget, and any commercial income disappears more or less unnoticed. Without feedback between commercial income and TT activities, commercial success does not gain any importance for people acting in the TT units, and they are also deprived of the chance to reinvest gains from e.g. licensing directly back into business. Better would be a TT budget decoupled from the central budget's restrictions and profit-oriented, which would make success visible and provide adequate freedom of action to the TT unit.

6.2.4 Services offered

For some of the infrastructures, industrial usage is not an issue at all, as they are doing very basic research or do not have the opportunities to give industrial users time to use their RIs. But 33 of the 51 interviewed infrastructures (65%) stated that, in principle, they offer services to industry.

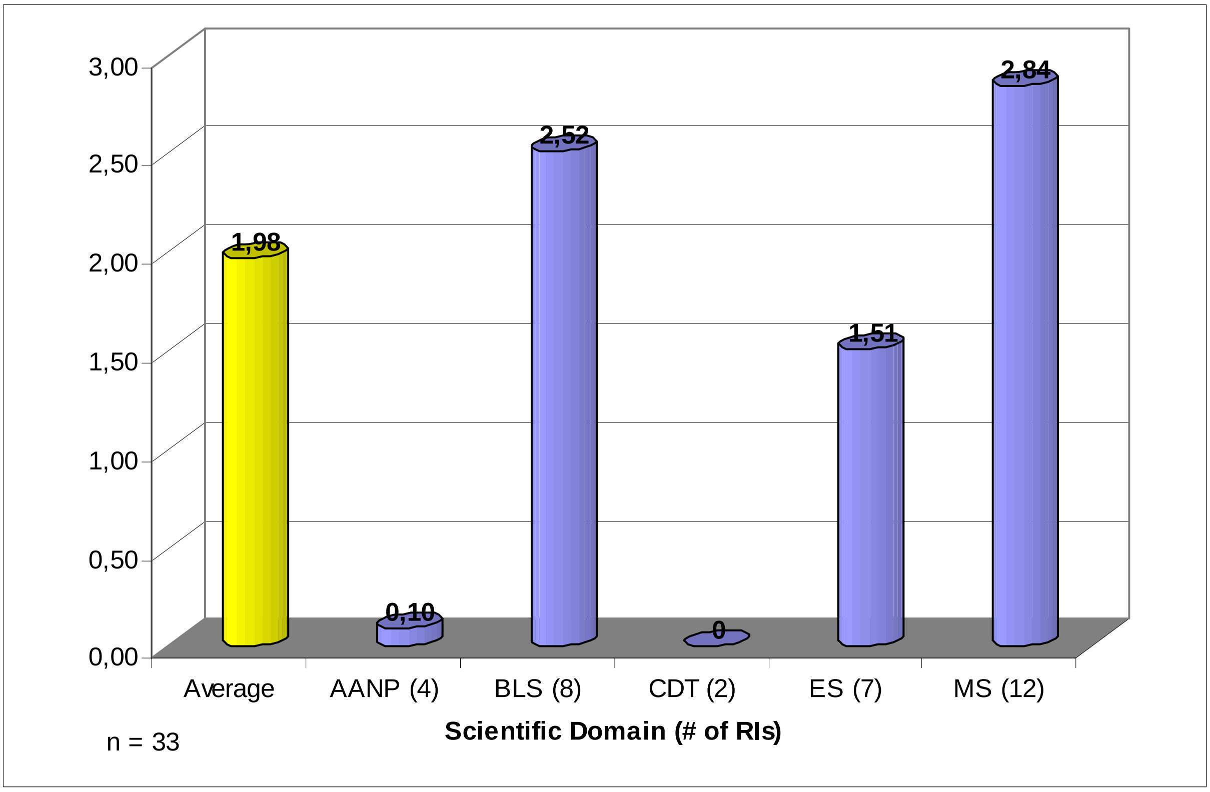

Figure 13 R&D Contracts with Industry per 100 FTEs

A glance at Figure 13 reveals that the ratio of industrial research contracts per 100 FTE is quite high in the domain of Material Sciences and the Biomedical and Life Sciences. The domains of Environmental Sciences and, even more so, Astronomy, Astrophysics, Nuclear & Particle Physics are below the average. A cross-check with the information in the following chapters shows that engaging in patenting or licensing does not seem to be imperatively linked with the industrial usage of the infrastructures. As Know-how and Technology may be spread through various channels, the importance of this finding should not be underestimated. It means that even those RIs with a low profile in IP rights have the chance to transfer their know-how to industry with commercial success. But adequate services have to be identified and actively offered to industry. This issue is addressed in more detail in the chapter about industrial use of synchrotron radiation. Finally, it has to be stressed that these relations with industry have to be in mutual compliance with the principles of responsible partnership.

6.2.5 Patent applications & patents

The number of patent applications per year is a basic number in the area of TT indicating the inventive potential, but this number is dependent on the specific patent policy, the scientific domain, and the budget of the institution and should therefore be used carefully. The annual number of patent applications per 100 staff members of the institution is high in the domain of Astronomy, Astrophysics, Nuclear & Particle Physics, as Figure 14 shows. Biomedical and Life Science as well as Environmental Sciences institutions also lie above the average, while Material Sciences is somewhat below.

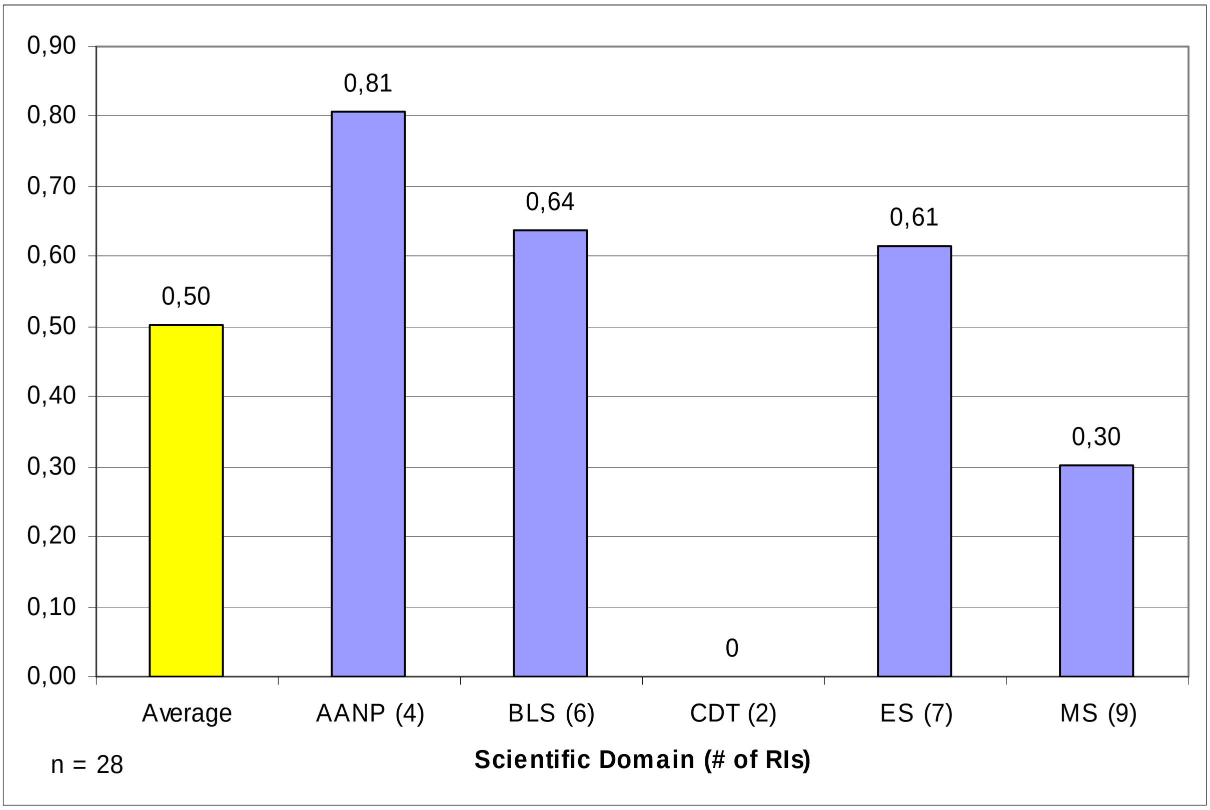

Figure 14 Annual Patent Applications per 100 FTEs

It is typical across all scientific domains that most of the institutions have no patent applications or at most one or two per year, and a small number of institutions have large numbers of applications.

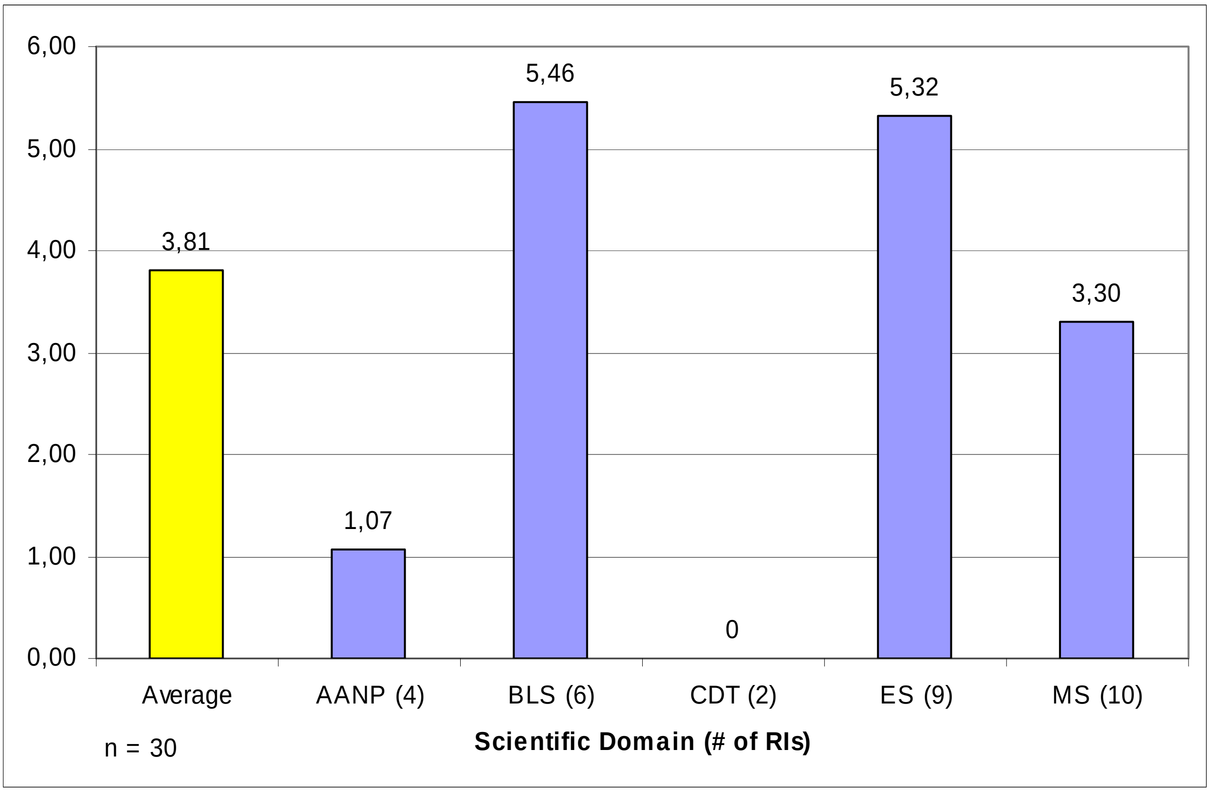

Figure 15 Total Patents held per 100 FTEs by domain

The number of total patents held at the end of 2006 is shown in Figure 15. A drastic change is seen in the domain of AANP, now far below average, which is in complete contrast to its top ranking concerning the number of applications. Reasons for this change may be that these RIs from the AANP domain do not hold their patents and applications very long, but instead transfer or drop them quickly. Naturally, the small size of the sample must also be taken into account when considering this discrepancy.

A linkage between country and the number of patents held is visible. Out of the countries where several institutions were interviewed and had such information available, Germany has the highest relative possession of intellectual property rights with an average of 7.56 patents held per 100 FTE in its infrastructures. This is followed by the UK with 3.49 patents held per 100 FTE. However, in many countries, only a few institutions were interviewed or able to provide information on this subject. Therefore, these results are not really representative; nonetheless, it should be noted that in Germany and the UK, there is a high tendency to keep IP rights in the RIs. It is good advice to share such tendencies and the underlying strategies across countries and even scientific domains. The individual RIs may very well profit from the sharing of experiences regarding the different approaches for transferring an RI's know-how to industry. This could be organised via existing or new networks for K&TT from scientific institutions.

Moreover, these networks may be used to create joint tools and even platforms for marketing IP rights and know-how from RIs.

6.2.6 Licenses & license income

About half of the interviewed infrastructures made no statement about this topic. Of the 26 infrastructures that did provide information, many of them simply reported that they had not given any license**.** On average, just over 20 licenses were annually given in the last three years in these infrastructures - that means only ca. 0.8 licences for each infrastructure per year. The individual figures ranged from zero to twelve licenses per year. All in all, just over one new license contract annually per 1,000 FTE is a really low figure, which indicates that giving licenses is currently not the core route for technology transfer from RIs. The income generated annually via licenses in is on average 16,434 € per 100 FTE, which equals 164 € per full time employee. This is far below 1% of the cost for RI personnel, without comprising any other costs.

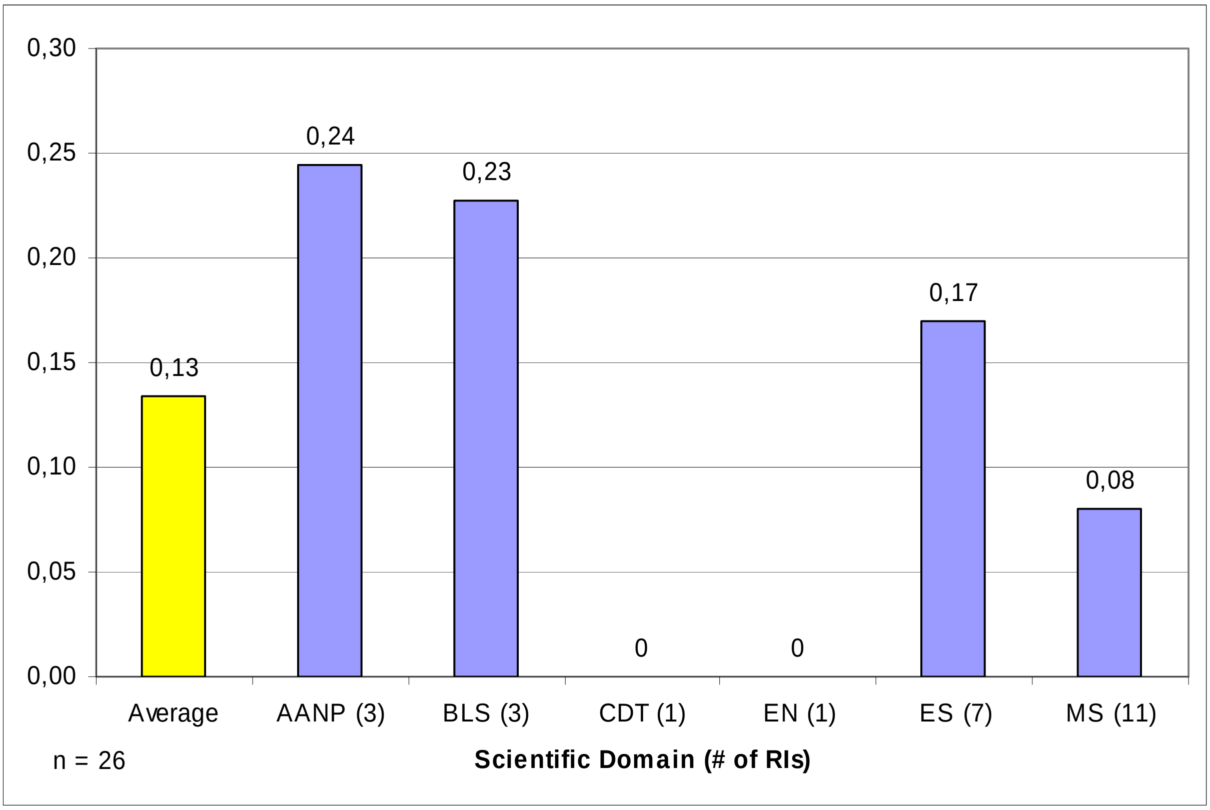

Figure 16 Average Number of Licences given annually per 100 FTE

An interesting feature is the fact that RIs in the AANP domain give many more licenses than their low number of patents obtained would seem to indicate. This might be attributed either to RIs giving out know-how licenses without IP rights as their basis or to selling patents and applications instead of keeping them. On the other hand, the comparison of income shows that RIs from the AANP domain do not receive much money for the commercialisation of their IP. Because of the small number of RIs in question, this is not an absolute statement, but it typifies the existing tendency in many RIs to be very reluctant when it comes to demanding cash for their own inventions. However, as stated above, this is mandatory for commercial success in technology transfer. This means that without a market-oriented price scheme, K&TT would be done more cheaply at RIs via publications and open science. However, it is doubtful that companies in many industry branches would build new product lines based on basic know-how which is completely available to the public and has no protection.

6.2.7 Spin-off companies

Spin-offs could be found in all domains except for CDT, Energy and SSH, which could be explained by the small sample in these domains. 16 of 51 infrastructures provided no information about this topic, another 12 infrastructures have had no spin-offs and 23 reported having at least one. The number of spin-offs per institution with infrastructures is normally less than ten. Only three institutions have more than ten, while one institution reports upwards of 80 spin-offs.

The most spin-off companies per 100 FTE are found in the domain of AANP with 2.74 per 100 FTE, followed by Biomedical and Life Sciences with 1.75 per 100 FTE. All other domains are below the average of 0.95 per 100 FTE. This is significant for the Environmental and Material Sciences domains, but might be attributable to the low number of interviewed RIs for the Energy and CDT domains.

This study does not need to prove the high value of spin-off companies, which is well-documented. But it must be stated that such spin-offs from scientific institutions need sound advice and staunch support right from the beginning to enhance their chances of ultimately succeeding as a real company. The potential founders of these new companies are generally scientists or engineers with an academic background. The support of the RI where they are working needs to be assured. This does not mean that all RIs should offer advice or even venture capital themselves, but an RI's TT office should promote existing opportunities for new entrepreneurs. Moreover, the complete set of tools, from consulting to financing, has to be made available for those who want to create a new company with an idea from within an RI. Providing this set of tools is not the task of the individual RI but of the whole society.

6.3 Conclusions on Human Resources

A remark on the (lack of) completeness of the data beforehand: in general not all RIs keep data on Human Resources at the same level of detail. Also, only few distinguish staff data between the different RIs, thus it often was difficult to get information about the number of staff working for one RI. So, quite a few questions could not be answered by all RIs, which often prevented a full comparison across the whole range of interviewees.

The recruitment of scientific personnel in nearly all institutions is done in cooperation between the Human Resources department (or in smaller institutions between the administration) and scientific groups. Human Resources administration is a task carried out on institutional level, at least, that was the case for all institutes who could answer this part of the interview.

6.3.1 Origin, exchange, and training of staff

Data on the national origin of staff were largely unavailable. Only a few, among them most of the EIROFORUM members, could provide numbers as they are concerned about a fair origin of staff from their member countries. The origin of the users does not appear to depend on the size or average number of users of the infrastructures, nor on the scientific domain.

No special programs for the exchange of industrial and public staff members could be found during the interviews. Some institutions do not really care about the exchange while others already have been thinking about a way to handle an exchange, but no special programme has been developed. At the moment most institutions do not gather information about the last employer of their staff having been industrial or public. Data were mainly estimated by the interviewees. In the scientific area it was estimated that only a very small percentage had industrial experiences – mainly the idea predominated that once someone has left academia towards industry no return is possible.

The majority of the interviewed RIs offer some sort of training for their staff – some in cooperation with external organisations. Generally, this training is job specific, such as diving lessons for marine researchers or animal caretaking training for animal laboratories, though more general training opportunities, such as foreign language classes, are also offered.
The smaller institutions (with less than 100 staff members) do not commonly organise training courses, independent of scientific domain or country. Apprenticeships for non-scientific staff, for example gardeners, are only offered by 13 RIs.

6.3.2 Number of Employees

As Figure 17 shows, the huge bulk of employees can be found in the scientific domains of Material Sciences, Environmental Sciences, and Astronomy, Astrophysics, Nuclear & Particle

Physics, (with MS leading the field with 9022 employees, followed by ES with 8133, and AANP with 6725).

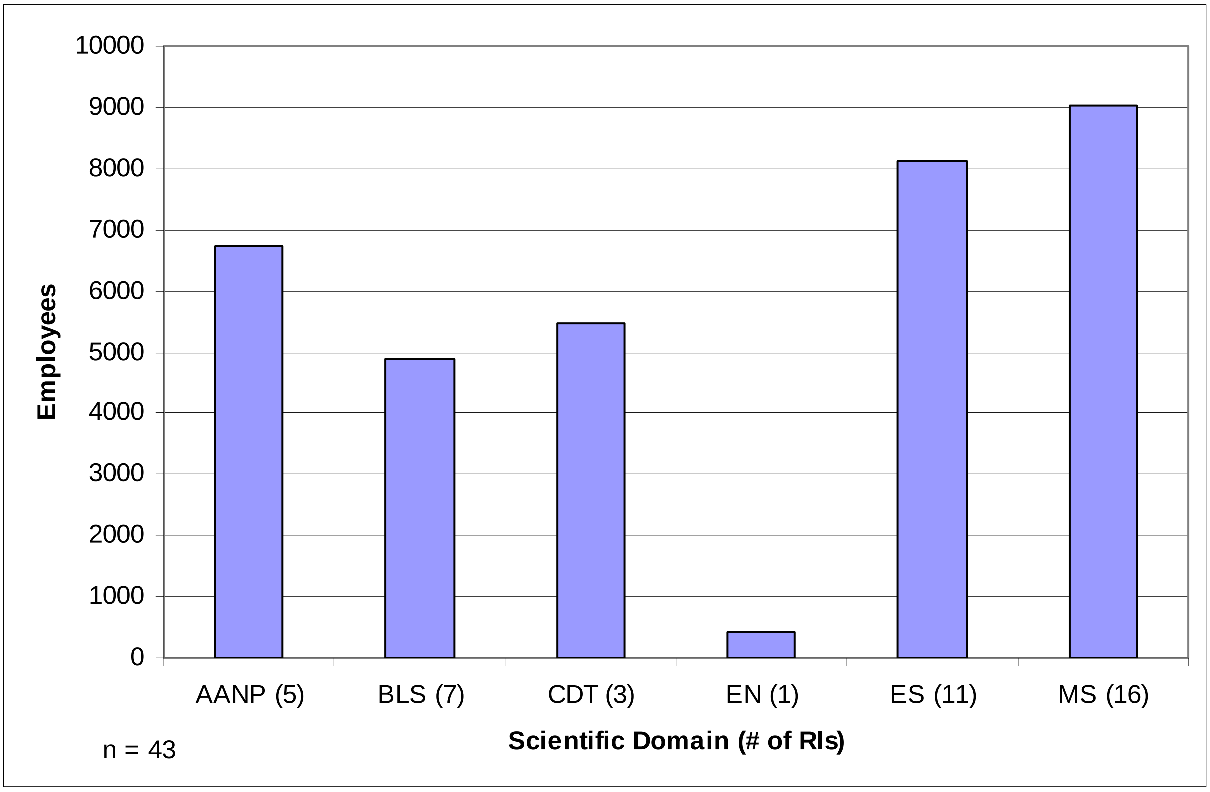

Figure 17 Total FTEs at Interviewed Research Infrastructures by Scientific Domain

Although MS shows the highest total number of employees, it is only next to last in the count of which scientific domain shows the highest number of employees per institute. Here the field is led by CDT and AANP with the largest institutions. An average interviewed institution has approximately 733 staff members (based on 43 infrastructures from 32 institutes).

6.3.3 Type of Contracts

65% of the staff of the interviewed institutions has permanent contracts. The two scientific domains of Material Sciences and Astronomy, Astrophysics, Nuclear & Particle Physics lie significantly above this value with 89% and 72% respectively, as can also be seen in Figure 18. Only in the Biomedical and Life Sciences and in the Environmental Sciences there are freelancers.

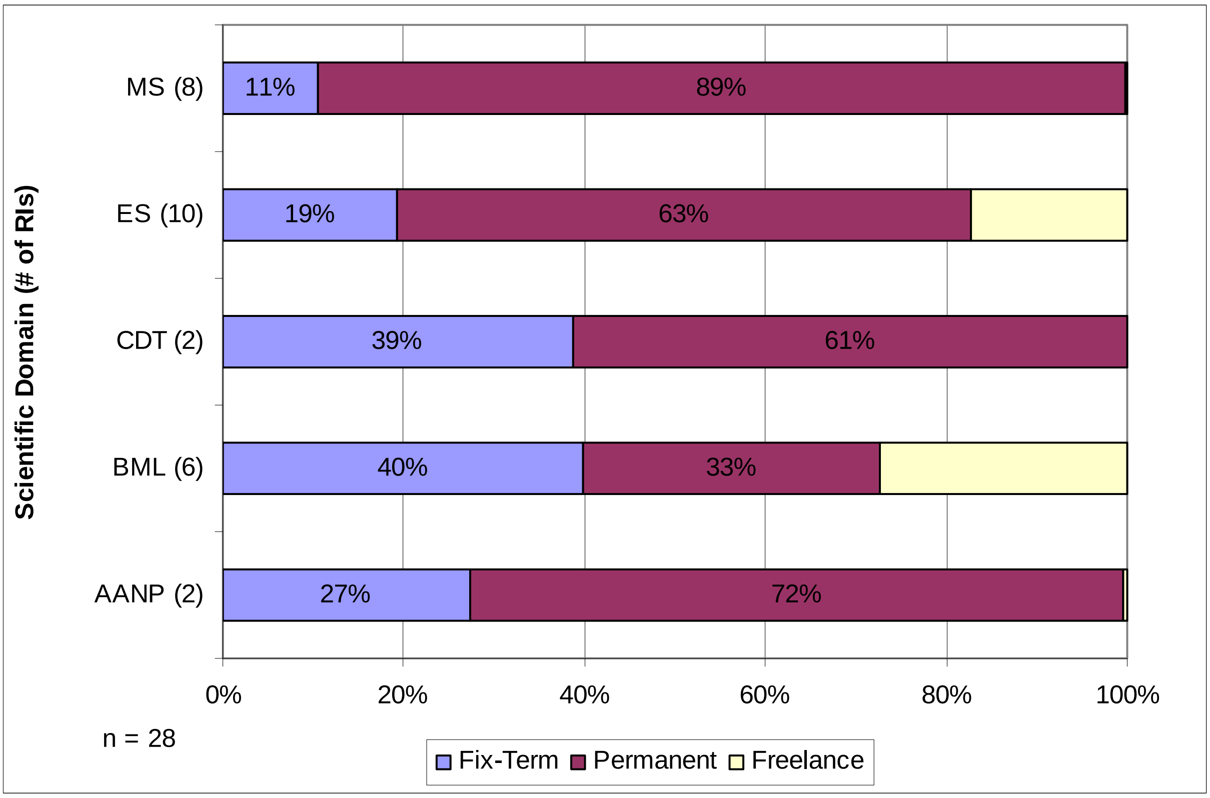

Figure 18 Types of Employment Contracts by Scientific Domain

6.3.4 Problems and consequences

Three major problems were often mentioned during interviews:

- Fixed-term contracts
- Low salaries
- Difficulties to find appropriate staff

The problems may occur as single problems, but may also be connected with each other. Especially in Germany the problem of fixed-term contracts was also mentioned as often only two or three years contracts are given. Especially for running a complicated infrastructure this can present a major issue. In one special case it was mentioned that the education to use the infrastructure takes nearly two years. Furthermore, in this case, also the level of the salaries was clearly perceived as a disadvantage – the institution was concerned about the future quality of their infrastructure. It was generally agreed that it is especially hard to find senior personnel with fix-termed contracts.

In addition to the response that salaries are too low in general, it was mentioned that salaries in nearly all institutions are lower then in comparable industry position. Within some countries, where, for example, the employment rate is comparably high this was mentioned as problem on the one hand. On the other hand it was argued that some people choose the lower paid academic job, precisely because it comes with the greater freedom of designing their own work, and the salary is only a secondary consideration. But this becomes problematic in countries or cities where the living costs are so high that choosing an academic career may be a real financial problem during the first years. But nearly all interviewees agreed that the level of salaries is another major reason why usually “once industry, always industry” holds. With only one or two exception no Research institution is able to keep on the same salary level with industry. Even within Europe different salary levels within the academic world constitute a problem – national levels can differ quite a bit and only a few want to go back to the country where they earn less. Some interviewees were concerned that the ever-widening gap between industrial and academic salaries might endanger the quality of future science.

Also it was argued that it is difficult to get senior or more experienced staff even from other European countries because of the negative effects on people’s pensions and retirement plans. E.g. in Germany, the additional pension system of German public service only comes into effect after five years of service.

Some institutions made the first attempts to solve some of these problems: to attract also non-national staff members one institution pays an additional 450€/month for short term contracts while another institution offers more than a third more vacation days as a small compensation for lower salaries. Others are paying additional excellence or other allowances to offer interesting salaries to their staff.

6.4 Conclusions on Industrial Usage of Synchrotron Radiation

Across the synchrotrons we interviewed, all of them wanted to increase industrial usage and are in the process of addressing this issue in varying ways. We offer a summary below of what we found on the topics Price System, Annual Turnover, Industrial Usage, Customer Fields, Industry Service and Marketing. Recommendations are given in Section 7.

6.4.1 Price System and Annual Turnover

All synchrotrons make a distinction between published research, where the research results are openly published for general scientific gain, and proprietary research, where the results are kept confidential and used privately for monetary gain. This distinction is applied to all users. Published research is generally free.

The price for 1 hour beamtime ranges from 100€ to 930€. The average sales price is 313€[4]. Five interviewed synchrotrons named the price for one hour of service - it ranges from € 100 to € 175. The U.S.-based NSLS charges $100/hour (ca. € 70). Three institutes charge additional or higher fees for Mail-In Service in the field of Protein Crystallography.

The average annual turnover from industrial use ranges from € 50,000 to € 2.5 million. The institutes with the two highest budgets also show the highest annual turnover from industrial usage. However, for the rest of the institutes, a similar correlation does not hold. The mean average annual turnover in the seven institutes which could provide these numbers was € 659,286. The lowest turnover percentage was 0.3% of the budget at an institute with a budget of 30 million. The sum of the total annual turnover of seven responding synchrotrons is €4,615,000. More than half of this total was achieved by just one institute.

6.4.2 Industrial Usage and Customer Fields

Across the synchrotrons, there is often a wide difference in the amount of industrial usage. Beamtime hours given to industry ranged from 219 to 3700, which equals a percentage of 0.2% to 12% of total working hours. Since all but one European synchrotron experienced less than 5% industrial usage, the American-based NSLS registers the second highest industrial usage of beamtime among the ten synchrotrons in the study with 5.6%.

The number of users ranges from 4 to 50 per year; often those users visit more than once. The NSLS lies at the upper end of this scale with ca. 47 companies visiting ca. 154 times per year. All but one synchrotron reported that the majority of their customers come form the pharmaceutical area. The other synchrotron reported “Chemistry and Energy” as the field from which most of its customers come.

[4] Additional information on the calculation of the average: two institutes provided the lowest and highest prices for which their services are available; for these, we took the average of these numbers without knowledge of how many hours were in fact sold at each price level, because that information was not given. The others stated an average price themselves.

For the future, all but two institutes expect an increase in industrial usage, but hardly anybody expects an increase above 10% of the total usage. All institutes agree that, seen globally, the industrial usage of synchrotrons will experience an increase. Life Sciences, closely followed by Chemistry and Energy, are seen as the field with the most potential for the future. One institute sees the greatest potential in Electronics. The way this is evaluated by the institutes is, of course, influenced by how they are positioned towards the market. Some institutes are oriented toward measurements for pharmacy, whereas others specialize in other fields such as Microelectronics.

In general, the favourite synchrotron method is X-Ray diffraction, which is used primarily by customers from the Life Sciences field.

6.4.3 Industry Service

All European synchrotrons offer rapid access for industrial customers. The NSLS is in the process of implementing it. It is interesting that although everyone sees rapid access as an important demand of industrial customers, the NSLS already shows quite a high volume of use by industrial customers (5.6%) without having rapid access implemented yet. Nevertheless, this is also regarded as very important in the few assessments we received from industrial users, but obviously there are other factors for success.

Being able to offer service to users is generally regarded as most important, especially if one wants to draw in more (local) SMEs, which was stated as a goal in several cases. Services offered can include general assistance by a beamline scientist, experimental setup, and analysis of the measurement results. Dedicated beamlines for industry are not very widespread and the opinions on their usefulness vary. Most institutes do not have a beamline established exclusively for industry, though in some cases certain beamlines are only used by industry. There is one model where a beamline is financed by industry and a research institute. This model also exists at the NSLS in the form of the Participating Research Teams (PRTs). One European institute reported negative experiences with a beamline designed for industry, since the industrial needs changed faster than construction of the beamline could be completed.

Two thirds of the institutes have special service groups for industry that liaise between scientists and industry. In one case, an external company was founded to better service the long-term, large customers. Half of the service groups have a link to a technology transfer group of their mother institutes.

6.4.4 Marketing

Obviously, at the moment there is a rather indirect approach towards promoting industrial services. This can be concluded from the fact that a lot of institutes stated that networking and going to scientific conferences was an important marketing instrument. This approach appears to reflect the view that a potential customer will be impressed by the scientific achievements of an institute and immediately convinced of the quality of the product. These potential customers then have easy points of access by being able to talk directly to the right people within the framework of the conference. This reflects the belief that institutes offer an excellent research programme which industrial users can tap into.

But a lot of institutes also seem to have reached a point where they set out to try a more direct method of marketing synchrotron radiation in the following ways:

1. Starting with a survey of the market and identifying possible customers and their needs.
2. Trying to make their product offer more transparent.
3. Developing strategies to communicate their product offerings to a designated clientele of potential customers. Among these strategies are informative and attractive websites, product catalogues, special industry service groups, flyers and free tests.
4. Enlarging the service connected with the offer of synchrotron radiation. These services should include the permanent presence of a beamline scientist, offering experimental set-up for the uninitiated, and carrying out the analysis of the data.
5. Trying to solve the problem of communicating the possibilities of synchrotron radiation and better understanding the needs of industrial users. For this, it is important to have specialized members of a service group, or at least someone who has the time and capability to “speak the language” of both the scientist and of the customer.

Excellent scientific publications by the researchers using the synchrotron are seen as an important indirect marketing effect. General visibility and reputation are assumed to help industrial usage. This was also found in a report carried out by a consulting company (see Annex, p. 90), where it was found that industry and the research infrastructure mutually gain in standing from a relationship with each other: “This relationship acts as a two-way ‘marketing’ process with both the industrialists and the (…) facility proud to be associated with each other as a sign of ('branded') strength of British scientific research."

The most important marketing instruments are using a website for visibility and marketing and going to workshops and conferences to meet and network with industry members. These conferences are considered to offer possibilities for effective contact between scientists and industry. Networking is in general regarded as the most important marketing instrument.

There is a general awareness that one could try and draw in SMEs, but only with offers of service. In the selling of synchrotron radiation, it seems especially crucial to recognize analogies between fields in order to be able to offer the right solution. Thus it is vital that experts from different fields work together: the scientists with in-depth knowledge of the methodological possibilities and the marketing and business people to mould it into a sellable product geared towards the needs of the market. It cannot be assumed that industry knows what beamlines are and what their potential uses are. Some scientists at the institutions believe that because the synchrotrons are such superb instruments, industrial users will come on their own, but to be interesting to industry, one has to know what they want. Or to cite one of the interview partners: "Ferrari and Mercedes might be nice cars, but maybe I just need a small car to drive to work daily".

This conclusion is in accordance with the general perception that the marketing of the beamlines has to be a joint effort between marketing/business representatives and scientists, or by people with a combination of these skill sets that can act as a liaison between science and business.

6.4.5 Growing market vs. competition for customers?

All but two institutes expect an increase of industrial usage of their synchrotron in the future, but hardly anybody expects industrial usage to rise above 10% of the total user time. All agree that, seen globally, the industrial usage of synchrotrons will experience an increase. But the number of synchrotrons throughout Europe is growing as well. Consequently, the question arises whether synchrotrons should perceive each other as rivals for attracting industrial customers. There are voices stating that the overall market for industrial use of synchrotron radiation will not grow adequately: "*Now the market is getting more competitive: more actors,* *but the cake is not getting bigger. It cannot be our goal [among the synchrotrons] to destroy the prices, the only winners then are industry!*"

On the other hand, others seem to be completely unconcerned by the increasing number of synchrotrons and recommend considering the following points: public and nationally financed research institutes are not allowed to enter into a price competition which might leave one of them in a disadvantaged position. Furthermore, synchrotron radiation and its wide palette of related products could provide each synchrotron with the opportunity to specialize in a slightly different profile, thereby drawing different sets of customers.

For SMEs, it might be more important to contact and reach a synchrotron in the same geographical region and to be able to buy modular products and service (buying only what they really need and receiving help in determining what they really need). For these cases, the competitive factor might not be as important. On the contrary, it might be worth considering engaging in some "networking among synchrotrons", since synchrotrons obviously encounter many of the same issues regarding industrial usage.

A regular exchange of information on these topics or attempting to combine efforts to find solutions to common problems might be beneficial to all. Ultimately, the aim should be the expansion of the overall market, with each synchrotron finding its own position via its unique profile.

7 Recommendations

7.1 Recommendations on RI General Information and Organisation

R-RI-1: Develop and apply a simple, but comprehensive long-term scheme to register key data on all relevant areas, like Users, Technology Transfer and Human Resources.

The lack of available and comparable key figures was a main theme found in all areas under inspection in this study. But, to ensure a high quality in running Research Infrastructures all major results and problems should be made comparable. A long term comparison of key figures at least in the own scientific domain will facilitate the evaluation of new and existing methods and approaches.

R-RI-2: A scheme to register the users in all European RIs should cover the categories internal user, external scientific user and external industrial user and the origin from at least the member state, European Union and other countries.

Only about 60% (32 RIs) of the interviewed infrastructures could provide data on the distribution of industrial and scientific usage. The number and the home countries of visiting scientists at RIs are seldom collected within the RI.

R-RI-3: Create and expand European Networks of RIs and use them for the exchange of key figures and best practice in managing RIs.

Exchange of information about key figures and processes has to be organised in a lean and efficient way. Instead of setting up totally new structures for this, the combination and interaction of existing projects, like ERA-Nets, is preferred for the aim of distributing and cross-checking uniform standards and best practices towards European-wide accepted standards.

R-RI-4: Develop and work with "Corporate Identity" of Research Infrastructures for internal and external purposes (Human Resources and Industrial Liaison).

One-face-to-the-customer transports any message about offered products better to customers and helps to get customers' attention. The European RI landscape is hugely diversified. To get an orientation in such a landscape unique profiles can serve as landmarks.Finally, it could be argued that a Corporate Identity additionally has beneficial internal impact on staff motivation.

7.2 Recommendations on Know-How and Technology Transfer

R-TT-1: Develop and regularly revise a clear vision and strategy for K&TT.

This strategy has to

- *define the focus of pro-active K&TT vs. the Open Science approach,*
- *address all possible channels for K&TT in an adequate manner,*
- *state what measures for pro-active K&TT will be taken.*

R-TT-2: Develop and apply a simple, but comprehensive long-term scheme to register key data and best practice information for all relevant K&TT processes on the RI level.

An overall problem is determined by the extreme discrepancies in the TT approach not only among different scientific fields but as well within the same field. Firstly, this lack of common standards leads to a wasting of resources as partners meeting for the first time or on a new issue always have to "reinvent the wheel" to define their contractual relation. Secondly, this circumstance makes it totally confusing for newcomers in the public TT business, like e.g. from the EU12, to define and organise their own TT approach. A set of commonly used standards could simplify the process.

R-TT-3: Use a professional and sufficiently staffed TT office with clear processes, clear responsibilities and a dedicated focus on licensing.

There is a clear indicator that RIs with a small TT office or with none at all concentrate only on patenting and have no resources for doing the intense business of looking for industrial license partners. However, the latter is the only way to generate money from IP rights. Thus, many of the RIs with small or no TT offices effectively just burn money when they engage in the matter of handling IP rights.

R-TT-4: Organise your TT business with a separate budget in a profit-oriented way.

The main funding source for TT offices is the general budget of the institution. Even those infrastructures with income from commercial activities often do not organise TT as a profit centre. Consequently, these TT offices are also fully dependent on the central budget, and *any commercial income disappears more or less unnoticed. Better would be a TT budget decoupled from the central budget's restrictions and profit-oriented, which would make success visible and provide adequate freedom of action to the TT unit.*

R-TT-5: Identify services that may be offered to industry in mutual compliance with the principles of responsible partnership and market these services in a pro-active manner.

Engaging in patenting or licensing does not seem to be imperatively linked with the industrial usage of the infrastructures. As Know-how and Technology may be spread through various channels, the importance of this finding should not be underestimated. It means that even those RIs with a low profile in IP rights have the chance to transfer their know-how to industry with commercial success. But adequate services have to be identified and actively offered to industry. It has to be stressed that these relations with industry have to be in mutual compliance with the principles of responsible partnership.

R-TT-6: Use networks to exchange strategies, experiences and standards in K&TT among RIs.

It is good advice to share tendencies about patents and licences and the underlying strategies across countries and even scientific domains. The individual RIs may very well profit from the sharing of experiences regarding the different approaches for transferring an RI's know-how to industry. This could be organised via existing or new networks for K&TT from scientific institutions.

R-TT-7: Transfer innovations and know-how to industrial partners by licensing to receive royalties at market conditions, while keeping the ownership of IPR.

Many RIs tend to be very reluctant when it comes to demanding cash for their own inventions. However, this is mandatory for commercial success in technology transfer. This means that without a market-oriented price scheme, K&TT would be done more cheaply at RIs via publications and open science. It is doubtful that companies in many industry branches would build new product lines based on basic know-how which is completely available to the public and has no protection.

R-TT-8: Support potential spin-off companies with consulting and financing early and use all professional means available.

Spin-offs from scientific institutions need sound advice and staunch support right from the beginning to enhance their chances of ultimately succeeding as a real company. This does not mean that all RIs should offer advice or even venture capital themselves, but an RI's TT office should promote existing opportunities for new entrepreneurs. Moreover, the complete set of tools, from consulting to financing, has to be made available for those who want to create a new company with an idea from within an RI. Providing this set of tools is not the task of the individual RI but of the whole society.

7.3 Recommendations on Human Resources

R-HR-1: Develop and apply a scheme to register key data on Human Resources in all European RIs. It should cover at least the categories: number of employees, national origin of staff, previous employer(s) = industrial or scientific, training.

To ensure a high quality in running Research Infrastructures HR problems should be taken seriously and have to be solved with a long term perspective in mind. Data on the national origin of staff were largely unavailable. At the moment most institutions do not gather information about the last employer of their staff having been industrial or public. Data were mainly estimated by the interviewees.

R-HR-2: Offer exchange programs for industrial and public staff members.

This could actually be beneficial to all sides: Company members could go back regularly into "the loop" of academic knowledge exchange and thus update their scientific basis, while scientists would get the chance to be exposed to the more product-oriented world outside the proverbial ivory-tower. It would have the side effect that it might make it easier for staff to move back and forth between industry and academia throughout their career..

R-HR-3: Support further efforts to modify existing payment systems towards performance oriented salaries, e.g. by offering incentives for scientists to counterbalance low salaries and fixed-term contracts.

Some interviewees were concerned that the ever-widening gap between industrial and academic salaries might endanger the quality of future science. To attract also non-national *staff members one institution pays an additional 450€/month for short term contracts while another institution offers more than a third more vacation days as a small compensation for lower salaries. Others are paying additional excellence or other allowances to offer interesting salaries to their staff.*

R-HR-4: Create a modular and standardized social security system on national and European level to ease mobility between Research Infrastructures throughout Europe.

It was argued that it is difficult to get senior or more experienced staff even from other European countries because of the negative effects on pensions and retirement plans. If people fear to loose (part) of their pensions and other social security it stands to reason that they will not be inclined to change workplaces. The European RIs with their already high degree of networking via European projects, umbrella organisations and national an EC administrations should use these platforms to create such a system and, thus, offer a pan-European social security system as a concrete incentive to researchers.

7.4 Recommendations on Industrial Usage of Synchrotron Radiation

A lot of the recommendations that arose from the case study on industrial usage of synchrotrons have bearing on RIs in general, and thus emphasize e.g. the issues of transparency via uniform statistics and the importance of a unique profile.

R-CS-1: Maintain a service group or at least a designated person for industrial liaison to secure a communication channel between industry and science

The institute with the largest turnover has the largest service group, whereas the one with the smallest turnover does not have any service group at all.

Science has to understand industry in order to be of use to it. A productive conjunction of both worlds needs people whose job profile includes cultivating a common language for the communication between those worlds.

R-CS-2: Use uniform statistics for recording beamtime, type of use, users and customer fields to achieve more transparency.

During the project it became evident that parameters are counted in different ways in many institutions. Even simple key figures often had to be clarified and adjusted before they could be used in this study. For future comparability of efforts and results this has to be changed.

Moreover, across the studied European Synchrotrons it was uniformly stated that often measurements at beamlines for companies' applied problems are done via scientific users, like universities, without the synchrotron knowing about the fact that company research is carried out.

R-CS-3: Offer fast and easy access for industrial customers.

All European Synchrotrons offer rapid access for industrial customers. This is a common best practice.

Industry stated that they need "Fast access to beamtime (within a few weeks)", because in an industrial setting, usually, time is much more at a premium than money.

R-CS-4: Carry out market analyses to be able to respond to the individual needs of different customers.

Marketing strategies have to differentiate between local SMEs or the large (maybe further away) companies. To use an analogy of one of our interview partners: "Ferrari and Mercedes might be nice cars, but maybe I just need a small car to drive to work daily"

R-CS-5: Build a unique own profile by offering modular, fine-tuned service geared towards customer needs.

Results of market analysis have to be mapped on each specific synchrotron's possibilities to create its individual offer to industrial customers.

In some fields a more detailed or different support is needed than in others, as industry stated that they need the "Possibility of measurements on short notice and subsequent scientific discussion of the results" and sometimes even "A reactive assistance 24h/day, 7 days/week in case of trouble".

R-CS-6: Continue and expand networking at conferences to address potential industrial users.

The majority of synchrotrons answered that they consider networking as the main marketing instrument. Networking for them means going to (scientific) conferences, meeting people, and developing ideas in conversations where experts from different fields come together.

"It really is a People-to-People business."

R-CS-7: Combine an indirect marketing approach with a direct approach according to own profile.

The institutes with the largest turnover (extensively) use the whole range of marketing instruments.
The institutes with the smallest turnover usually engage in less marketing activities.

R-CS-8: Further develop networking among synchrotrons to jointly achieve complete market coverage for the industrial use of synchrotrons.

"Now the market is getting more competitive: more actors, But the cake is not getting bigger. It cannot be our goal [among the synchrotrons] to destroy the prices, the only winners then are industry!"

As it is not the aim to quarrel about some niches of the market (pieces of the cake) but to explore and use the whole market (cake), only a co-operational approach will guarantee that the full potential of this market for industrial synchrotron use can be addressed.