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# Study on better cooperation between Research Infrastructures and Industry

## A final report to DESY, EU-Projekt Baltic TRAM

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The study was paid by DESY within a remit of the project Baltic TRAM funded by the Interreg Baltic Sea Region Programme 2014-2020 with the funds of the European Commission, Directorate-General for Regional Development.

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# Executive summary

In March 2017 DESY commissioned this short study on better cooperation between Research Infrastructures (RIs) and industry to encourage better interaction between industry and RIs (which in the context of this study were understood as analytical facilities). The study was paid by DESY within a remit of the project Baltic TRAM funded by the Interreg Baltic Sea Region Programme 2014-2020 with the funds of the European Commission, Directorate-General for Regional Development.

Governments make major investments in scientific research infrastructures (RIs) of variable scale both located at universities and/or research institutes as well as as stand-alone facilities. Although their main goal is to advance scientific knowledge, a question of benefits to society are becoming more and more important. One way to benefit the society is by engaging private companies in the use of RIs. Some of the enablers that encourage the use of analytical facilities by industry are services provided by these facilities, which could range from scientific consultations on specific problems to experimental design, sample preparation, data collection, analysis and interpretation. Guarantying fast access to the facilities and providing fast services without disrupting the normal schedule of the facilities is also an advantage. There are different models enabling industry's access to research infrastructures. For example, through owing their own instruments at RIs, scientific work provided by RIs, publicly funded industrial access, membership access, proprietary access. The last mode can in turn have different options such as case based paid access, access via industrial liaison officers at the universities linked to a particular RI, or access via commercial analytical research organisations. Some of the examples of these modes of access are described in this report.

To attract users from industry, the RI managers have to be able to offer terms and conditions that are attractive, or at least acceptable to industrial partners. Once an experiment or a service is under way, it is important for the researchers at the facilities and the industry to pursue the same goals. A balance between pushing for scientific publications as a result of the experiment versus a result to be commercially applied needs to be assured. The two sides should also be able to speak the same language. Interacting effectively with industry requires special knowledge and special personal attributes. Outreach needs to be pursued via constructive interactions with individuals, for example, at conferences that are attended by engineers (as opposed to ones that bring together academic scientists).

Despite numerous attempts to encourage companies to use research infrastructure of various size and purpose, numerous barriers have been noted that affect industry access to research facilities. Therefore, the ways in which the industry-RI usage can be organised and optimised are on the agenda of many policymakers as well as operators of research infrastructure and analytical facilities. To ensure stronger linkages between the research facilities and their users, efforts need to be placed in creating a fruitful interaction and collaboration area. These can be ensured through one of the three modes:

1. **Single-facility dedicated programme**. Within the RIs, it is advantageous to have a dedicated, named programme or an initiative for promoting and managing interactions with industrial users. The scope of this effort can be modest, but its presence provides a gateway and a "one-stop shop" for activities that will differ significantly (in terms of scientific/technological substance, and in terms of rules and procedures) from the purely scientific, academically oriented work of the RI. Examples of such programmes include ISIS Collaborative R&D programme in the UK; the nSoft programme at the NIST Center for Neutron research in the USA; and InSitμ at the Cornell High Energy Synchrotron Source (CHESS) also in the USA.
2. **Multi-facility dedicated programme**. To reap the benefits of several facilities together, encourage stronger cooperation between the facilities and at the same time offer a wider service package to the user groups – and especially companies – a dedicated access programme can capture several RIs and analytical facilities together. Examples here include LINX project (Linking Industry to Neutrons and X-rays) in Denmark; and a new pan-EU initiative ATTRACT as a

collaboration and partnership of European science leaders working together to create new companies, products and jobs.

3. **Access through intermediary structures**. A new interface which is becoming more and more popular in Europe is an intermediary approach to linking research and analytical facilities with companies. Excelsus Structural Solutions (from Belgium) and Colloidal Resource (from Sweden) are two examples of private companies which act as intermediaries between industry and advanced analytical facilities based at large RIs.

In order to ensure that industry-RI cooperation is running smoothly and is bringing mutual benefits, it is crucial to set the right internal and external conditions in place.

Looking from within (i.e. **internal considerations**):

- The right people as managers of the infrastructure's industry liaison programme are important. The programme has to be staffed by persons who strongly believe in its goals, and who have the real-life experience and expertise in dealing with the kinds of technological problems that are encountered in industry.
- Most RIs have graduate students, which can be problematic in case of industry-linked projects. Creative solutions have to be found for engaging students, e.g. providing a portion of student financial support from industrial partners.
- It is self-evident that the type of research that is performed at a RI has an effect on the likelihood of successfully establishing an industrial liaison programme. Thus, it is helpful if there is already a record of research in areas linked to a particular research infrastructure.
- It is also worth considering the ways RIs are managed. If senior managers have sufficient open-mindedness, flexibility and autonomy, they are more likely to authorise and foster an industry liaison programme which initial steps are likely to be difficult, which may need to be re-focussed based on initial experiences, and which will bring novice users into the laboratory.

Looking from outside (i.e. **external considerations**):

- Funding agencies play an important role with regards to the research infrastructures. Most commonly, the establishment of a collaborative programme for industrial users arises from the initiative of highly motivated individuals with a RI. However, it can happen that the funding agency takes the lead. In many countries, agencies and ministries that are responsible for science acknowledge that their role is not limited to promoting national scientific excellence, but extends to strengthening economic growth, competitiveness and job creation. It must be remembered that agencies depend for their budgets on parliaments, for whom economic issues are of central importance. Successful collaboration with industrial partners provides "success stories" that fusing agencies greatly appreciate.
- Funding is a central issue whenever the establishment of an industrial liaison programme is considered. In general, it is unrealistic to expect that such a programme be self-supporting based on financial contributions from the companies that use it.
- Involving independent from RIs intermediaries can speed up the process of linking private users (especially small- and medium-size companies) with analytical facilities (of different sizes). Having specialised, dedicated and highly motivated staff at the intermediary companies is a key to their success.
- Focusing on a limited number of subjects and techniques but offering a full package is another important factor in ensuring the service provided by the intermediary company is spot-on.

Technology transfer departments exist in several research facilities. This, however, does not necessarily guarantee the delivery of full analytical services to the industrial customers. At the same time, there are yet not too many dedicated intermediary companies offering complete analytical services to the industry. Foundation of more intermediary companies is an opportunity to cover more and more fields of expertise and to act as a true bridge between industry and RIs.

# 1 Introduction

This report presents the results of a small study conducted by Technopolis Group Baltics for DESY, EU-Project Baltic TRAM. This study was commissioned and paid by DESY within a remit of the project Baltic TRAM funded by the Interreg Baltic Sea Region Programme 2014-2020 with the funds of the European Commission, Directorate-General for Regional Development. The work was performed in March-May 2017.

## 1.1 Introduction

In all industrialised democratic countries, governments make major investments in scientific research infrastructures (RIs) of variable scale both located at universities and/or research institutes as well as as stand-alone facilities. Their goal in doing so is two-fold: to advance scientific knowledge and to provide benefits to society in areas such as health, security, environmental protection and, notably, economic prosperity.

It is widely acknowledged that, in modern economies, technological advances have their origins in basic scientific research. Thus, governments can have a reasonable expectation that infrastructure investments – even such esoteric fields as cosmology or elementary particle physics – will eventually (and, perhaps, indirectly) contribute to improvements in the quality of life of their citizens. But there is a more direct way for society to benefit from publicly-funded RIs: their utilisation by private companies can benefit from measurements, analysis and expertise at the research facilities. The ways in which this direct interaction mode can be organised and optimised are on the agenda of many policymakers as well as operators of research infrastructure and analytical facilities.

## 1.2 The changing role of research infrastructure facilities on a global innovation landscape

Research infrastructures is a topic high on the European Union agenda and national policymaking. For example, it is one of the major topics in the EU framework programme for Research and Innovation, Horizon 2020. The main priorities of the programme are to promote the world-class infrastructures, to facilitate the researchers' access to the infrastructure in a fair, transparent and open way; deploying the e-infrastructures; and to foster the innovation potential of research infrastructures "with a focus on instrumentation and on reinforcing international cooperation with strategic third country partners"[1]. Within the context of the European Union, the aim to strengthen the network and performance of research infrastructures is strongly linked with other priority areas of the union, such as the smart specialisation strategy and the general aims of the Commission, namely the strengthening of Europe's global competitiveness, the creation of new sustainable jobs and the promotion of growth.

One of the main reasons is that the research infrastructure facilities are crucial to the advancement of science in all scientific fields. It is only with these research facilities that one can make material visible or carry out pioneering experiments. By linking facilities to a large infrastructure network, researchers can bring about an exponential increase in the number of observations and experiments that are carried out. The network generates far more research results than could ever be achieved by all the individual groups together. Research facilities are not only of crucial importance for acquiring new knowledge, but have also contributed to a more efficient way of working in the world of science and can be a focal point for multidisciplinary research. As this kind of research infrastructure facilities bring together people, knowledge and investment, they have a crucial role in contributing to economic development on both national and regional level.

There is a recognition of the critical economic role played by research facilities in directly supporting the private sector in improving its product and process innovation and indirectly through for example the impetus to instrument suppliers or the agglomeration effects one sees in areas around big facilities.

[1] The Research Infrastructures Work Programme;
http://ec.europa.eu/research/participants/data/ref/h2020/wp/2016_2017/main/h2020-wp1617-infrastructures_en.pdf

According to Bozeman[2] this is in line with the central assumption of the cooperative technology policy paradigm, which emphasizes the active role of government and university in providing technology and science results in cooperation with the industry.

Major technology businesses simply cannot afford to build and operate large-scale facilities privately, but can contribute through targeted co-funding and derive enormous benefit from access to the specialist facilities and researchers working there. These centres have a very visible impact on the competitive position of users and suppliers, and with an intensity grant-based research programmes struggle to match.

Many countries have spent a substantial amount of money on research infrastructures in the last decade, while the implementation of current roadmaps will require further significant investments into the future. At the same time, the competitiveness can be gained if there is a strong synergy of research infrastructures with not only the science community (performing the basic research activities) but these opportunities have been actively used by the industry as well.

The Working Group on innovation highlighted the need to view and include the industry as a full partner of RI in order to complement each other in the bid to achieve better results when undertaking joint R&D projects and programmes focused on advanced technologies and innovation.[3]

Although one of the preconditions for the establishment of most of the research facilities is the accessibility to the business community, there is currently still a considerable gap between the usage of the facilities by the science and by the industry. There is an increasing expectation of the commercialisation, easily understood results of the scientific work done at the research infrastructure sites, more pressure put by the policy makers.[4] However, on the other hand, the cooperation levels with the industry remain low. A question emerges on what could be the optimal cooperation level of industrial users and the research facilities. A recent study based on the example of Hungary has suggested that the industry usage of research infrastructures meant for basic science (the “desired level”) could be in the range of 5% and in the range of about 10% for those which are more meant to be for the applied research.[5] The study also points out that the used innovation method and the organisational structure of the research infrastructure play a crucial role in closing the university-industry cooperation gap.

It must be noted, however, that there are multiple factors that can potentially influence this type of cooperation levels between industry and research facility.

The level of cooperation linkages between the research facilities and industry, despite being often desirable on the policy level, has remained low when compared to the level of use of RIs by the science community.

## 1.3 The context of this study

The aim of this study was to examine further the factors that influence this level of cooperation, outlining the encouraging factors as well as barriers. The study focused on the issues of the industry interest and potential gain of using Research Infrastructure (RIs) for the industry, among other things looking into what motivates companies to engage in this cooperation and which aspects they consider favourable when starting this kind of cooperation. Where possible aspects of the cross-border collaboration between industry and RIs were taken into account. Organisational setup of research infrastructure and the innovation system were also considered, more specifically examining the role of intermediary structures in improving the level of cooperation between industry and RIs.

[2] Bozeman, B., 2000, Technology transfer and research policy: a review of research and theory; *Research Policy;* http://calitc.pbworks.com/f/TechTransferStudy.pdf

[3] European Strategy Forum ESFRI on Research Infrastructures Working Group on Innovation Report to ESFRI 2016 Available from: https://ec.europa.eu/research/infrastructures/pdf/esfri/publications/wginno_final_report_032016.pdf

[4] Huzair, F., & Papaioannou, T. 2012. UK Biobank: Consequences for Commons and Innovation. *Science and Public Policy*

[5] Deak, C., Szabo, I., 2016, Assessing Cooperation between Industry and Research Infrastructure in Hungary; *Technology Innovation Management Review; https://timreview.ca/article/1001*

This study was prepared based on a desk research as well as a number of telephone interviews with representatives of various RIs in Europe and North America.

- Desk research captured existing studies, reports and other literature on the subject of the RI-industry collaboration and the determining factors of the success of this collaboration;
- Interviews with the representatives and users of the various analytical research infrastructure facilities were used to further elaborate on the characteristics of a successful collaboration between research facilities and industries and to examine the determining factors, the success models and useful tools based on the hands-on experience of these people.

The authors thank all the contributors for their time and valuable input provided during the study. The team was assisted by Johanna Vallistu who conducted parts of the background desk research.

# 2 The industry interest for cooperation with research facilities

## 2.1 Benefits of the research facilities to industry

There is a clear industry interest to use research infrastructure and analytical facilities especially if the facilities are designed with specific industry needs in mind and in light of the changing landscape in Europe as more facilities are waking up to the benefits of forming partnerships and interacting with analytical facilities.

Companies can benefit from their interactions with RIs in a variety of ways:

- Performing measurements and analysis as part of the development cycle for a product or process (for example, establishing the atomic structure of a candidate drug molecule)
- Conducting exploratory research based on a new idea (for example, testing a new coating for metal part that is to be used in a demanding physical or chemical environment)
- Solving a problem that has emerged in connection with an existing or future project (for example, unwanted structural flexing in welded parts)
- Addressing a serious problem on an emergency basis (for example, structural failure of a component).

Depending on the nature of the interaction, various types of cooperative arrangement can be envisaged. For example, large drug companies that routinely use X-ray measurements for proprietary structural and functional analysis of molecules may choose to build and operate a proprietary beamline at a synchrotron source. These companies will make long-term investments in hardware and personnel. Some of their employees will qualify as experts in beamline operation (indeed, they will, most likely, have performed their doctoral work at a synchrotron laboratory). In such a relatively straightforward case, minimal support or engagement from the RI will be needed, and the collaboration will be based on full-cost recovery for beamtime and other services.

More significant challenges emerge when the potential industrial partner is a small- or medium-sized company, does not have an established track record of working with a RI, and when the designers/engineers may not even be initially aware that the RI offers capabilities that they could benefit from. These are the cases where innovative, creative, proactive steps need to be taken in the context of a programme devoted to seeking out and facilitating interactions with industry.

To accommodate the requirements from the users, some special arrangements may be needed:

- As already mentioned, larger companies may simply “buy into” a part of the RI. While the expense may be considerable, they can use the resource that they own in any way they choose
- The RI can devote part of its resources (e.g. a particular beamline and its instruments) to industrial use on a full-time basis, possibly recovering some of the resulting costs via subscriptions to an industrial liaison programme. In such an arrangement, the customary review processes can be bypassed. Necessarily, this mode of operation limits the type of measurements that can be made (for example, small-angle scattering) but it has the benefit of allowing “novice” industrial users to learn about, and to try out, new techniques
- The RI’s review process can be adapted to explicitly include “technological pertinence” (or a similar formulation) in addition to “scientific merit” as a criterion for evaluating proposals
- A “rapid access” mode can be established for quick services that can be made using existing equipment and minimal manpower needs. This mode bypasses the standard proposal and review process and, because of this, cannot exploit more than a small (not more than 5%) of the RI’s total measurement capabilities. A potential mechanism that can be used is the “discretionary equipment time” that is usually at the disposal of the laboratory’s director (or, sometimes, of the manager of an individual equipment). The use of this mechanism must

necessarily be limited, but it can be especially useful in preliminary phases of a project, to establish basic feasibility

- When feasible, a "sample mail-in" mode can be implemented for routine measurements that can be easily and quickly carried out by the facilities' staff, without any need for the presence of a company's personnel. An example of this is powder diffractometry, in which important structural information about a material can be obtained by scattering neutrons or X-rays from an amorphous powdered sample. The resulting data (raw and/or analysed) can be sent to the users electronically.

## 2.2 Barriers for industry to access RIs

Despite numerous attempts to encourage companies to use research infrastructure of various size and purpose, numerous barriers have been noted that affect industry access to research facilities.

These barriers can be administrative barriers like the large expenses to use the facilities, travel costs, hotel costs, bureaucracy and sometimes the large distances to travel to these facilities. Staffing and expertise plays another major role, particularly when a large number of experienced researchers are needed for one experiment. Sometimes the necessary experienced staff are not readily available especially as some of the experiments need to be run 24 hours/ day for a period of time. Therefore, staff have to be hired on short-term contracts to monitor these experiments and these staff might not necessarily have the required experience.

The scientific barriers are the complexity of the experiments, which can sometimes lead to unique results, the need for complex data analysis which can still be linked to staffing, the lack of knowledge around the experiments, the lack of quality control around available analytical equipment, challenges with full control over the experiments etc. One of the major obstacle for getting access to the large-scale facilities is the application process and a peer review system based on scientific quality of the proposed experiment rather than technological quality or industrial relevance.

Some other problems concerning the usage of RI by industrial companies are the legal problems that can arise from differing interests of researchers and companies in the areas of confidentiality, publications, IPR issues, no standardisation of data formats and protocol. The area of confidentiality interestingly is exactly what makes it difficult to keep track of work done with industries as most of the commercial work carried out by RI for industries is not made public.[6] The Science Link project outlined a lack of knowledge about applications of synchrotron and neutron radiation in the companies, as well as the perceived high cost of measurements for SMEs as primary reasons that may deter companies from using the services of large-scale RIs.

The need for more effective processes such as the co-innovation approach has been suggested as well as the need for a cross disciplinary cooperation and the development of a business model that would have a more commercial focus towards the research activities of the RI. Having an innovation advisory committee would help with reaching out to the industry and the public sector. The three main barriers identified by the respondents of effective cooperation between RI and industry were again the "difference goals and expectations between industry users and RI, the administrative, legal and fiscal burdens connected to working with RI and the main on being the perceived disconnect between research and market needs."[6] Some of the suggestion on how to increase cooperation by the respondents were "new funding mechanisms, mediation schemes, dedicated access rules and human capacity building." In the report on the consultation on long-term sustainability of research infrastructures it was noted that the RI innovation potential is widely untapped since both RI and industry do not fully perceive the benefits of collaboration.[7]

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[6] David Malmsström & Jonas Gurell Synchrotron radiation for industrial applications: 2014 Report No: 11582 ISSN: 1403-848X Available from: http://www.metalliskamaterial.se/globalassets/4-fakta/bilder/synkrotronljus.pdf

[7] European Commission, 2016. Report on the Consultation on Long Term Sustainability of Research Infrastructures. Available from: https://ec.europa.eu/research/infrastructures/pdf/lts_report_062016_final.pdf

## 2.3 Enablers for industry to access RIs

There are different models enabling industry's access to research infrastructures. These, for example, through owing their own instruments at RIs, scientific work provided by RIs, publicly funded industrial access, membership access, proprietary access. The last mode can in turn have different options such as case based paid access, access via industrial liaison officers at the universities linked to a particular RI, or access via commercial analytical research organisations. Some of the examples of these modes of access are described in the next section of this report.

Some of the enablers that encourage the use of analytical facilities by industry are services provided by these analytical facilities. These could range from scientific consultations on specific problems, to experimental design, sample preparation, data collection, analysis and interpretation. Guarantying fast access to the facilities and providing fast services without disrupting the normal schedule of the facilities is also an advantage. An example of a 'basic' service at the large RI is, of course, "beamtime" or any other unique facility or equipment. The introduction of techniques that are not readily available in home laboratories, the use of higher intensity X rays and conducting studies in a "time resolved in situ manner" as some of the benefits to the industry that they provide and by making available a synchrotron facility for research use a "wide range of experiments relevant to the consumer products sector"[8] can be an additional enabler. But that alone is rarely sufficient. Often, special-purpose hardware must be provided, for example, equipment to generate controlled stresses, to maintain samples at a stable (but adjustable) temperature, etc. In addition, industrial users will typically need assistance in interpreting experimental data. The opportunity to access special-purpose software packages, set up a collaboration with experienced staff, access grants and get quick innovative solutions to tasks will lead to strengthening the connection to the research facilities. These services, however, all entail costs for the RI and must be taken into account when setting up an industrial collaboration programme.

To attract users from industry, the RI managers have to be able to offer terms and conditions that are attractive, or at least acceptable to industrial partners. Normally, access to large-scale RI resources requires the submission of a detailed proposal that is reviewed on the basis of scientific merit (and other criteria such as technical feasibility and the scientific track record of the proposers). In most cases access to university-based analytical facilities also requires a written request for services. In case of paid access, users usually do not need a proposal for a peer-review to guarantee access to the facility. But even in cases like that, knowing how to prepare successful proposals is important as it helps industrial users to better understand the language of the research facility. The preparation of successful proposals is a skill that academic scientists acquire over many years of training and experience. Moreover, the proposal processing process can be a lengthy one. Even if no new equipment has to be fabricated, it is not unusual to have many months' elapse between the time when an experiment is first contemplated and when the facilities become available. Furthermore, even a proposal can be turned down, given that RIs are usually heavily oversubscribed or researchers have other commitments in place. For industrial users, whose needs are often pressing, the unfamiliar procedures and the delays can be frustrating or even unacceptable.

Once an experiment or a service is under way, it is important for the researchers at the facilities and the industry to pursue the same goals. A balance between pushing for scientific publications as a result of the experiment versus a result to be commercially applied needs to be assured. In all cases, the collaboration between a RI and a private company must be governed by a user agreement that defines the responsibilities and commitments of both parties. There are two distinct categories of agreement: for proprietary and for non-proprietary use of the RI. Usually, the latter agreement is very similar to that one that applies to scientific/academic users. Research infrastructure leaders and scientific personnel have a strong preference for conducting research in the non-proprietary mode that they are accustomed to. An open environment where results, problems and ideas can be openly discussed with

[8] Elizabeth J. Shotton, Leigh D. Connor, Alexandre Dias, Anna B. Kroner, Claire Pizzey, Tobias Richter & Jitka Waterman Industrial applications at Diamond. Synchrotron Radiation News Vol. 27, Issue 3, 2014. Available from: http://www.tandfonline.com/doi/full/10.1080/08940886.2014.908698

all colleagues has obvious advantages, and it is much simpler administratively to provide “beams” (and other services) without laborious, detailed cost accounting. Furthermore, tricky intellectual property rights issues can be bypassed. A complication can arise when the distinction between the two modes is not easy to make. Normally, the ultimate criterion is whether or not the results will be published. However, some research that is done with industrial users will simply not be publishable because it will not be seen as sufficiently relevant to answering important scientific questions. In that case, and in order to maintain the simpler non-proprietary nature of the work, the company’s personnel will be asked to write a report on the work that was done (and to provide access to the experimental data). This report can be made available to anyone. One of their major selling points various intermediary structures offering access to the research facilities is the high level of confidentiality they offer in their work and the fact that they are not interested in the publication of results.

A special feature of the world of industry – seldom encountered in the academic context – is its occasional volatility. It can happen that a collaboration between a RI and a private company can vanish overnight because of decisions made at corporate headquarters. A company may be subject to sudden unexpected economic difficulties (even bankruptcy), a merger, a buyout, or a drastic change in business strategy. The senior company managers who make these decisions most likely have no knowledge of the technical issues that motivated the collaboration. There is little that can be done to deal with such contingencies, but their possibility needs to be taken into account when setting an industrial liaison programme. One solution to deal with such volatility comes with the services provided by intermediary companies offering their infrastructure and experimental services to private companies. The intermediaries can buy out a certain number of hours at the research facility and handle the commitment of the private user at their own risk.

The two sides should also be able to speak the same language. Interacting effectively with industry requires special knowledge and special personal attributes. Outreach needs to be pursued via constructive interactions with individuals, for example, at conferences that are attended by engineers (as opposed to ones that bring together academic scientists). Interactions are effective when these happen frequently and purposefully. Persistent but targeted marketing of their services by calling, meeting clients, interviewing, preparing reports and written documents, holding workshops and seminars prove to be effective. Bring the users and the facilities together, being close and offer individual commitment as well as paying close attention to their needs can be the most powerful engagement tool.

# 3 Creating the right interface for RI-industry interactions

To ensure stronger linkages between the research facilities and their users, efforts need to be placed in creating a fruitful interaction and collaboration area. These various ways of meeting the needs of the industry are discussed further in this section. There are numerous examples of such initiatives, some of which have been looked into more detail during this study.

## 3.1 Single-facility dedicated programme

Within the research infrastructures, it is advantageous to have a dedicated, named programme or an initiative for promoting and managing interactions with industrial users. The scope of this effort can be modest, but its presence provides a gateway and a "one-stop shop" for activities that will, in many cases, differ significantly (in terms of scientific/technological substance, and in terms of rules and procedures) from the purely scientific, academically oriented work of the RI. Having a link to the programme on the RI's internet homepage demonstrates a readiness to respond to the needs of industrial users. Information, documents (e.g. template user agreements) and success stories can be linked to the programme and followed over time.

### *3.1.1 ISIS Collaborative R&D programme (UK)*

Over the years a wide range of companies has used ISIS instruments. This was achieved via the ISIS user programme or directly through commercial access. The user programme has proven to be rather arms-length; whereas the commercial access has been rather costly and technically demanding. As a result, the ISIS Collaborative R&D (ICRD) programme[9] has emerged blending the positives sides of both. The aim of the ISIS Collaborative R&D programme is to enable UK based research and manufacturing industries to have access to and use the ISIS neutron and muon beams for industry related research. The programme instruments are used by a wide variety of sectors ranging from the nuclear and aerospace sectors to pharmaceutical and chemical companies. The programme is envisioned as an easier way for the industry to use ISIS with fast track access provided via an industry ISIS collaboration. As there is an additional underlying aim to be of economic benefit to the United Kingdom, the ISIS beamtime is offered as an in-kind contribution to the partnership agreement with the industry, while the industry partner from their end have to provide a sound proposal, an estimate of the economic benefits from their end to both themselves and the United Kingdom and report regularly on their achievements towards this. Companies are expected to join the programme and sign a Collaborative Research Agreement (CRA) with the Science and Technology Facilities Council (STFC).

The benefits of joining the programme according to ISIS are:

- Beamtime is free at point of use
- Beamtime may be obtained very quickly
- Criteria for doing the experiment is its potential economic benefit to the UK
- The results remain confidential during the period of the experiment and the subsequent data analysis.
- For each experimental proposal, a company must demonstrate it has deployed in-kind matching funding to the cost of the ISIS beamtime supplied[10]

An additional benefit of joining the programme is that commercial confidentiality is assured as well as full control over intellectual property. Two weeks is the maximum time within which companies that have applied for beam time will get a response to their request.

[9] http://www.isis.stfc.ac.uk/apply-for-beamtime/industry/isis-collaborative-randd-programme12567.html

[10] Science and facilities research council ISIS webpage, http://www.isis.stfc.ac.uk/apply-for-beamtime/industry/isis-collaborative-randd-programme12567.html

Feedback suggests that the scheme has expanded the range of companies which have traditionally used ISIS facilities and encouraged smaller size companies to reap the benefits of this RI.

### *3.1.2 nSoft (USA)*

nSoft[11] at the NIST Center for Neutron research is a membership-based consortium in which companies work together to strengthen their knowledge and capabilities for using neutron science to benefit their corporate research and product development programmes. There are currently nine member companies. They are primarily large corporations (e.g., Pfizer, Dow Chemical, Toyota) and include, notably, Saudi Arabia-based Aramco. A multi-part research and training programme was defined, with the participation of the members, to run from 2012 to 2019. The emphasis is on capacity building for companies, not specific product- or problem-oriented measurements. Within the laboratory, nSoft benefits from exclusive use of a dedicated neutron spectrometer, so it does not have to compete for resources with other academic or industrial users. The use of other instruments can be arranged as needed. Scientists and engineers from the nSoft member companies interact extensively with laboratory personnel and with academic users of the reactor-based neutron source. The annual membership fee is $25,000 which allows the programme to be self-supporting at NCNR. A generic Cooperative Research and Development Agreement (CRADA) is signed by members. All of the work is conducted in an open, non-proprietary mode. Companies that wish to follow up their nSoft work with proprietary measurements can do so, under a separate, full cost recovery, arrangement.

### *3.1.3 InSitμ (USA)*

InSitμ[12] at the Cornell High Energy Synchrotron Source (CHESS) began in 2014, when the U.S. Office of Naval Research (ONR) agreed to provide funding to promote the use of the Cornell University's CHESS synchrotron by industrial users. There is a specific scientific/technological focus: using X-rays to design and validate models of condensed materials. In industry, such models are critical for understanding the response of materials to external factors such as stress, vibration, high temperatures, etc. The main use of the ONR funds is to provide salaries for experts who are motivated and capable of working closely with industrial scientists and engineers. They also perform outreach activities (for example, seeking out potential users at industry-oriented conferences). Companies that decide to perform measurements at CHESS receive assistance from InSitμ staff for tasks such as preparing proposals for beamtime allocation, experimental design, using the technical facilities (e.g. apparatus that creates controlled strains, temperatures), analysing and interpreting data and, if appropriate, in transitioning from non-proprietary to proprietary measurement modes. Via InSitμ, users from participating companies can make connections with CHESS staff, as well as Cornell faculty and students, to jointly understand and solve industry-relevant problems.

### *3.1.4 Schull Wollan Center (USA)*

The Schull Wollan Center[13] at the Oak Ridge National Laboratory (ORNL) was established in 2016, as a follow-on to the Joint Institute for Neutron Sciences (JINS) which, since 1998, was a collaborative programme of ORNL and the University of Tennessee. One of the key motivation for re-orienting the JINS was to strengthen access by industrial companies to the two state-of-the-art neutron sources at ORNL: the high flux reactor HIFR and the accelerator-based spallation source, SNS. The Center has a small core group of motivated staff members who perform support and outreach functions. The Center's budget is minimal, however, and these individuals have other responsibilities at ORNL, from which they draw their salaries. The staff members can provide information, advice and assistance (technical, administrative, practical) to companies that are interested in using the neutron sources. An important function of the staff is to enable contacts to experts in the laboratory who are in charge of the wide diversity of neutron scattering instruments, and also to other experts at ORNL in domains other that neutron science. Access to the sources and instruments is available in a variety of modes:

[11] https://www.nist.gov/nsoft

[12] http://insitu.chess.cornell.edu

[13] http://swc.ornl.gov

proprietary and non-proprietary, rapid access, sample mail-in. To use the facilities, companies must sign a "User Agreement"[14]. In non-proprietary mode, there is no charge for beamtime. The facility is fully accessible to non-U.S. scientists and companies.

## 3.2 Multi-facility dedicated programme

To reap the benefits of several facilities together, encourage stronger cooperation between the facilities and at the same time offer a wider service package to the user groups – and especially companies – a dedicated access programme can capture several RI and analytical facilities together.

### *3.2.1 LINX project (Denmark)*

Linking Industry to Neutrons and X-rays LINX[15] is a cooperation between government, industry and universities in order to develop an industry portal for Danish companies to improve their R&D capability by exploiting the potential of advanced neutron and X-ray techniques. It is a social partnership between the research facilities at the University of Copenhagen, the Aarhus University and the Technological University of Denmark DTU, 15 industrial partners, two Danish regions, and Danish Industry. To optimise work, the three universities have divided tasks among themselves: the University of Copenhagen will primarily work with small-angle scattering, Aarhus University with crystallography, and DTU with imaging. Innovation Fund Denmark invested 50m DKK in this social partnership with a key goal to allow the Danish industry to derive maximum benefit from the techniques for materials research. Further investment from the 15 companies in the form of funds and experienced workforce.

This project was preceded by a smaller scale pilot project NXUS (Neutron and X-ray User Support) at the University of Copenhagen that had a budget of 4m DKK. This project was supported by the Capital Region of Denmark, the Faculty of Science and the Faculty of Health and Medical Sciences at the University of Copenhagen. During 2013-2015 they completed ten projects with Danish companies within pharmacology, biotechnology and food sciences. Similar pilot projects ran at the Technical University of Denmark and Aarhus University.

LINX has an active secretariat which role is to match the industry that has a problem it wants to solve with the relevant research group. Numerous activities are planned. In addition to projects, these will include trainings, shared or pooled PhD students, portal (with contact to experts, tools for simulation, modelling and visualisation) and facilities (i.e. big scale, small scale at the universities, facilities at industry, offices, meeting rooms).

Free evaluations are provided to potential industry users – mainly small and medium-sized enterprises – with the aim of discussing how the available technologies can be used to analyse and provide solutions to identified problems and share the potential benefit to the SMEs of using the facilities. The budget structure of each LINX project will be exactly the same where 1/3 of the budget is for internal activities (man power), 1/3 is dedicated for large-facility beamtime and 1/3 is planned for Contract Research (CR) which will be conducted at the universities. The first 2/3 will be covered by 50% by the grant, while CR will be paid 100% by the company.

### *3.2.2 ATTRACT (EU)*

A new pan-EU initiative ATTRACT[16] seeks to use science to create an economically powerful ecosystem across Europe. It is a collaboration and partnership of European science leaders working together to create new companies, products and jobs. The founding organisations are CERN, ESO, EMBL, ESRF, ILL, Aalto, ESADE and the European X-ray Free-Electron Laser facility in Germany. It is designed as a partnership of the public, private sector with labs, SMEs, industry and universities all working towards developing new imaging technologies and high performance detectors with new services and products

[14] www.ornl.gov/partnerships/user-agreement

[15] http://www.linxproject.dk/projects.html

[16] http://www.attract-eu.org

and ensure that they move out of the laboratories and into the market. The aim is for scientists, students, entrepreneurs and investors to work together, invent new services and products, and attract new investment to the sector.

The initial funding is to come from the European Union and subsequently in 2019 EU funding will be scaled up and raised from other sources including the private sector. A funding instrument called "Mini" ATTRACT which is in two phases will help Horizon 2020 to deliver innovation by streamlining the value chain from the development of technologies towards their market application. Phase 1 (2017-2018) with €20m EC funding will comprise of calls seeking to identify a wide scope of technologies which will be selected based on their potential to be beneficial to the industry, their scalability and implementation possibilities; while Phase 2 worth >€30m will take it to the next level by leading those technologies selected in Phase 1 to the level of industry development. This will be followed eventually by "Maxi" ATTRACT which would already be a self-sustained initiative.[17] In Phase 1, €18m will be used to fund 180 breakthrough projects (with €100,000 grants) based on the reviewed short few-page proposals and max €2m will be used to administer the calls(s). The proposals will be selected by an independent scientific advisory committee. Funded projects will have 12 months to develop their ideas/prototypes for the next funding stage.

According to Markus Nordberg[18] (CERN DG-DI-DI**)** the approach in ATTRACT is unique because:

- It is focused, technology domain-specific but touches industries and products worth over 100b USD per year
- It is a bottom-up approach, scientific instrumentation development work being used as the engine for innovation
- It is run as an international scientific collaboration or experiment, incorporating industry as partner
- It engages cross-disciplinary involvement and engagement, including young innovators and entrepreneurs
- It aims at generating an open access Innovation Depository

## 3.3 Access through intermediary structures

A new interface which is becoming more and more popular in Europe is an intermediary approach to linking research and analytical facilities with companies.

### *3.3.1 Excelsus Structural Solutions (Belgium / Switzerland)*

Excelsus Structural Solutions[19] is a private company which acts as an intermediary between industry and advanced analytical facilities based at large Research Infrastructures. It has an office in Brussels (Belgium) but its primary operation is from the Paul Scherrer Institute (PSI) synchrotron facility a large federal research centre for natural and engineering sciences in Switzerland. The company was created in March 2012 as a spin-off from PSI and has five staff. After just a few years of operation, they have master service agreements with 16 companies.

It offers easy and affordable access to unique synchrotron-based characterisation tools to enhance the selection, development and manufacturing of high-quality (bio)pharmaceutical products. Their services range from scientific consultation on specific problems, to experimental design, sample preparation, data collection, analysis and interpretation. Their final product is a detailed scientific report. They have developed analytical services specifically optimised for industrial applications targeting large, medium and small companies – primarily in the pharmaceutical and chemical sectors. For example, they can perform quantitative phase analysis of phases at trace level (<0.1%wt) in

[17] http://www.bo.infn.it/sminiato/sm16/04_Giovedi/Sera/01_Bertolucci.pdf

[18] www.attract-eu.org/uploads/3/8/0/4/38044307/attract_intro.pptx

[19] http://www.excelsusss.com

formulated drugs. Since the company is based in Switzerland, there is a majority of Swiss and European companies among their customers, but samples can be efficiently and rapidly shipped from anywhere in the world. Thus, the company has customers in North America and Asia as well. One of their major selling points is the high level of confidentiality they offer and the fact that they are not interested in the publication of results.

### *3.3.2 Colloidal Resource (Sweden)*

Colloidal Resource (CR)[20] is a private company which started its operation in 2005 and is based in Lund, Sweden. The company has a team of innovation experts with background in chemistry who realise that taking chemistry as a starting point can help solving problems faced by product development in various companies. Their vision is to act as a true bridge between academia and society.

The core business of CR is consultancy, experimental projects and education. They talk to industrial clients on a daily basis aiming to introduce them to a solution to their industrial or scientific problems with the help of the facilities of different scale. Being located in Lund close to MAX IV facilities; the company's experts take companies also to the university laboratories. Their strong belief is that it is much easier for industry to get acquainted with the facility on a smaller scale, understand the benefits of the facilities and various instruments to their business and this way get ready to have an experiment at the large Research Infrastructure. To educate companies about RIs, Colloidal Resource also organises courses. For example, together with MAX IV the course is prepared on the formulation science to give the attendees background on general scattering, about X-rays, lots of examples of what the users can get and also allow some hands-on time at the instrument at the University of Lund.

Company's other attempt to help increase the usability of analytical facilities is to engage in various Horizon 2020 funded project aimed at that topic. For example, project EUSMI (European infrastructure for spectroscopy, scattering and imaging of soft matter) will start from 1 July 2017 and run until June 2021. It will allow both industrial and academic users to visit RIs as well as university laboratories. Users will get their travel, accommodation and measurement time for free. CR will act as an Industrial Liaison Officer in this project.

As the forms and type for engaging industry with the research facilities are so different and multi-faceted, it is important to find the right balance between different available options and to create such conditions which will encourage and increase the interaction.

[20] http://colloidalresource.se

# 4 Conclusions – setting the right conditions in place

## 4.1 Internal considerations

It would be difficult to overstate the importance of **having the right people as managers** of the infrastructure's industry liaison programme (or technology transfer programme as it is called in some facilities) – especially in the sensitive initial phase. The programme has to be staffed by persons who strongly believe in its goals, and who have the real-life experience and expertise in dealing with the kinds of technological problems that are encountered in industry. Thus, a background in an appropriate field is an advantage, for example, materials science, mechanical or chemical engineering. But, just as importantly, the programme staff should be interested in solving industrial problems and understand (and even partake of) the special standards, concerns, attitudes, and even language, that apply in industrial settings, and that differ in significant ways from those of the purely scientific, academic environment. These can relate to issues such as the need to obtain results as quickly as possible, to value pragmatism over theoretical rigor, to minimise administrative procedures.

Industrial liaison / technology transfer managers may not have the same opportunities as other staff members to engage in publication-quality research, which could impact their careers. They must be willing to perform outreach to potential users at conferences and other gatherings where top-level scientists are rarely present. They have to devote a significant amount of time to educating and training their industrial counterparts, to helping them design experiments, to assisting them in data-taking and data analysis. A potentially beneficial strategy for them is to work with industry on a part-time basis, possibly drawing their main salary from having other responsibilities in the laboratory. This, in turn, depends on the existence of a certain flexibility in the management of the RI.

In most RIs **graduate students have important roles** (among others, as a source of sheer research manpower). This can be problematic in the case of industry-linked projects, which may not provide an opportunity for doing thesis-level research. Creative solutions have to be found for engaging students, e.g. providing a portion of student financial support from industrial partners.

It is self-evident that the type of research that is performed at a RI has an effect on the likelihood of successfully establishing an industrial liaison programme. Thus, it will be helpful if there is already a **record of research in areas linked to a particular research infrastructure**. Furthermore, the essential scientific character of a facility may make more (or less) adaptable for industrial use. X-rays provide an instructive example. Large synchrotron sources have dozens of beam lines that can be operated simultaneously in a variety of modes. At any given time, one or more of these can be used for industry-linked work. The new, highly innovative X-ray laser at Stanford, USA (LCLS) produces a single beam. It is not surprising that there is a strong imperative to reserve its use for the most scientifically valuable projects, ones likely to generate "*Nature*-quality" publications.

It is also **worth considering the ways RIs are managed**. If senior managers have sufficient open-mindedness, flexibility and autonomy, they are more likely to authorise and foster an industry liaison programme which initial steps are likely to be difficult, which may need to be re-focussed based on initial experiences, and which will bring novice users into the laboratory – users who will sometimes make mistakes and will require special consideration and support. For these reasons, RIs that are directly linked to universities may possess an advantage over ones that are tied directly to funding agencies. It is simply a fact that most large RIs are oversubscribed for scientific use. Dedicating scare resources for applied work will always require a special vision and effort.

Special procedures need to be adopted for industrial users. Often, the problems that they are trying to solve are not linked to high-level theoretical concepts and thus would not qualify for access to the instruments based on pure scientific merit. Industrial researchers and engineers are not normally proficient at writing proposals (which academic scientists learn during many years of training) and they are unwilling to face the prospect of being turned down (which most academic researchers are familiar with). Often, their need is immediate: for example, they have to urgently understand why a component is failing. For these reasons, it can be useful to **create a separate approval track for**

**industrial users**, or to dedicate a small portion of the infrastructure's experimental facilities for their use, bypassing the normal review/approval process. This practice is in place at most large-scale Research Infrastructures and should be maintained.

## 4.2 External considerations

It goes without saying that **funding agencies play an important role with regards to the research infrastructures**. All programmes that are undertaken under the aegis of a RI must be authorised and approved by the appropriate funding agency. Most commonly, the establishment of a collaborative programme for industrial users arises from the initiative of highly motivated individuals with a RI. However, it can happen that the funding agency takes the lead. In many countries, agencies and ministries that are responsible for science acknowledge that their role is not limited to promoting national scientific excellence, but extends to strengthening economic growth, competitiveness and job creation. It must be remembered that agencies depend for their budgets on parliaments, for whom economic issues are of central importance. Successful collaboration with industrial partners (especially small- and medium-size companies) provides "success stories" that fusing agencies greatly appreciate.

**Funding is a central issue** whenever the establishment of an industrial liaison programme is considered. In general, it is unrealistic to expect that such a programme be self-supporting based on financial contributions from the companies that use it. Full cost recovery is the norm in the United States whenever a RI is utilised in a proprietary mode (there are other requirements as well) but few companies are likely to agree to this arrangement, at least in early stages. If the programme is set up as a membership consortium (as is the case for InSitμ at CHESS), a fixed annual fee may be charged, just to make sure that companies are fully committed and will participate in the planned activities. Ideally, a funding agency will provide funds for the programme, thus demonstrating commitment and providing a measure of stability. Alternatively, the RI itself can provide in-kind support (salaries, equipment, space, utilities, etc.).

The utilisation of U.S. government facilities for conducting proprietary research is subject to a high-level political imperative: economic activities should be driven by market forces, and public funds should not be used in a way that would provide an advantage to any individual company. Accordingly, the proprietary use of public research infrastructures, while allowed (and, indeed, encouraged) is subject to "full cost recovery". The corresponding rules and procedures are mandated by the funding agency, and are specified in detail on each facility's website. While these differ somewhat among the facilities, the following requirements are standard:

- A Proprietary User Agreement and a Statement of Work must be submitted for review by a special-purpose committee. The type and amount of facility resources must be specified in detail. The review/approval process parallels that for non-proprietary research, and may take weeks or months to be accomplished. The proposed work has to be approved by the local representative of the funding agency.
- The cost of using the facility reflects all of the resources that are to be utilised. Typically, this is computed on a per-hour rate, which may depend on the type of instrument that is used. The charges are reviewed and revised on an annual basis. Set up and take down charges may also be applied. By way of an illustrative example, at Brookhaven's National Synchrotron Light Source, the charge is $412 per hour (for comparison, the salary and benefits of a company engineer are on the order of $100 per hour). There may be additional charges for any needed parts or supplies.
- Advance payment for use of the facility is required.
- Infrastructure staff provide services associated with providing beams and keeping instruments operational but they do not add intellectual value to the research activity itself.
- Even though companies do not release their detailed data or findings, they are required to prepare a general statement of the nature and value of the work performed. This facility may make this statement publicly available.

Except for established research pathways, it is difficult to envisage that utilisation by industry could be a consistent source of profits for a research infrastructure. In fact, modest investments may be required, especially when working with small and medium companies without an established track record of utilising state-of-the-art research facilities. In fact, modest investments by the facility may be needed, in the form of staff time and special equipment, special-purpose software. First-time industrial users typically approach the infrastructure with some hesitation and uncertainty, which makes it unlikely that they will make a significant up-front investment. One opinion is, therefore, that it would be difficult for a third party to profitably act as a paid go-between ("intermediary"). Having said that, already **well-functioning examples of intermediaries do exist** in Europe and have set a promising path for the RI-industry cooperation.

Having **specialised, dedicated and highly motivated staff at the intermediary companies is a key** to their success. They are making their industrial partners at ease in ensuring that they work as their trusted partner, they understand the science behind and can interpret a problem the company is facing. They also take the bureaucratic process of applying for the access to the research infrastructure away. Being specialist in specific instruments, the staff of the intermediary companies are able to speak both to the RI scientists as well as companies. They act as a true bridge.

One of the key motivators for an intermediary company is a financial benefit as opposed to the academic publications that the scientist at the research infrastructure think about. At the end of the day **it is a business that needs to generate money**. Having this financial incentive in place makes the staff think about finding a solution to the posed industrial problem and then look for another problem to solve.

Focusing on a **limited number of subjects and techniques but offering a full package** is another important factor in ensuring the service provided by the intermediary company is spot-on. That mean an industrial user comes with a problem; this is discussed with the intermediary who suggests techniques, prepares the samples, processed the data, analyses, prepares the information and discusses the results. At the end of the story there is a solution to the originally raised problem.

Technology transfer departments exist in several research facilities. This, however, does not necessarily guarantee the delivery of full analytical services to the industrial customers. At the same time, there are yet not too many dedicated intermediary companies offering complete analytical services to the industry. **Foundation of more intermediary companies is an opportunity** to cover more and more fields of expertise.

# Appendix A List of interviews

- Professor Lise Arleth, Niels Bohr Institute, University of Copenhagen; leader of LINX project
- Dr Fabia Gozzo, CEO, Excelsus Structural Solutions
- Dr Marc Obiols-Rabasa, Colloidal Resource
- David Moorman, Senior Advisor, Policy and Planning, Canada Foundation for Innovation
- Ronald Jones, Director of nSoft, NIST Center for Neutron Research
- Crystal Schrof, Manager, Scientific and Program Services Office, ORNL High Flux Isotope Reactor and Spallation Neutron Source
- Dennis Mills, Deputy Associate Laboratory Director for Photon Sciences, Argonne Advanced Photon Source
- Ke An, Lead Scientist, Engineering Materials Diffractometer, ORNL High Flux Isotope Reactor and Spallation Neutron Source
- Matt Miller, Associate Laboratory Director, Cornell High Energy Synchrotron Source
- Robert W. Schoenlein, Deputy Director for Science, Stanford Linear Coherent Light Source

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