

INSTITUTE INDUSTRY PARTNERSHIPS

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Abstract

To be successful, accelerator projects require close interaction with industry for design, engineering and construction. Partnership and collaboration between institutes and industry is a means to transfer knowledge and foster innovation in the private sector, while the public sector benefits from best practices, efficient use of resources and pooled knowledge. An overview of partnerships between institutions and industry is given with examples from active projects.

INTRODUCTION

The focus of this article will be on the interactions between research infrastructures involved with accelerator systems and industry. This report is not intended to be exhaustive and some aspects will be missing, however, the focus will be on broad but relevant items for improved institute-industry partnerships.

Many projects worldwide are facing similar challenges. Figures of merit for facility parameters are extreme as are the requirements placed on the used technologies. State of the art technologies are required within project contexts that have challenging timelines, budget constraints and the general lack of human resources. Some of these challenges are alleviated since many projects require similar techniques and technologies. This fact naturally leads to institutes cooperating together to find common solutions and maximising the use of resources. Similarly collaboration with industry provides technical solutions, access to human resources and a standardization of techniques.

The 2006 report of the European Strategy Forum on Research Infrastructures (ESFRI) has identified 35 major projects for the next 10 to 15 years representing an investment of 13.5 BEuro [1]. A significant fraction of this investment (5.2 BEuro) is associated with synchrotron light sources, free-electron lasers, heavy ion and proton facilities. Many of these projects will be developed in parallel and there will be competition for resources for their realization. Cooperation and collaboration between institutes and industry is essential for successful completion of these infrastructures. The development of free electron lasers alone is very demanding on available resources, since the nine planned facilities will be developed during a similar period of time.

PARTNER IDENTITIES

The identities of the partners determine the way the two groups interact. Both have distinct modes of operation determined by their source of funding, although both have areas of common interest related to their respective research and development strategies.

The Institute – A Research Infrastructure

The research infrastructure is a publicly funded entity built to carry out basic and applied research. The typical time for construction of a new infrastructure, e.g., a synchrotron light source or particle collider, can take between 5 to 15 years or more from concept to operation. The appearance of new projects is sporadic within a give country and can occur every 5 to 10 years. The irregularity of new national projects is a source of difficulty for small to medium sized enterprises (SMEs). Once built, the facilities provide a service to the scientific community for 15 to 25 years. During this period of operation the facilities undergo continual improvements and upgrades. This is beneficial to SMEs since the upgrades often require new developments and improved technologies.

The human resources required for construction are fairly different from those needed for the operation of the facility. For example, a substantial number of design engineers, civil, mechanical and electrical are needed during design and construction, but less so during operation. Relocation of people will arise during the ramp down of the project towards completion. The location of new infrastructures will also have an impact on project realization. On one hand, new infrastructures based at existing facilities can benefit from support laboratories and personnel, although a ramp up of project teams and relocations will still be required. Greenfield projects on the other hand need the formation of completely new teams and support infrastructures, such as engineering workshops or community services. Both situations require access to people and their mobility. Gaining access to experienced and expert people can be as challenging to a project as the technologies involved. In general the mobility of people from research infrastructures is lower than that of people in the private sector. Large laboratories can have sufficient resource capacity for small to medium sized projects. They are, however, often the location of large projects that still require large teams.

Industry

Industry is privately funded and needs income. Cash flow is important, as is the market. Profit is also important since it determines funds for sustained research and development and general growth of the business. Industries can practice basic research, but research and development is usually focused on applied and market driven items or topics. The project timescales in an industry are usually less than the project time scales of institutes. There is greater mobility of people within industry as a whole. Industry will apply standards, best practices and quality assurance. Industry can be a repository of expertise and knowledge and the value of its human capital can be high. By providing similar

components or services to several institutes common knowledge is gained to the benefit of all concerned. Industry can respond to project needs in various ways from providing commercial off the shelf items to support services. Given the specialised nature of accelerator based research institutes, the industries involved typically operate on a global scale, since this may offset the business difficulties that result from the sporadic nature of new project approval.

INSTITUTE – INDUSTRY INTERACTIONS

Institutes and industry may interact in different ways. (1) The institute is a customer and purchases a standard piece of commercially available equipment. (2) The institute studies and designs a component and industry builds to print. (3) The institute provides the specifications and industry builds as it knows best. (4) The institute is an end user and industry provides a turn-key solution, for example a complete injector. (5) The institute and industry partner and collaborate in the design, engineering and construction of a component. Industry can then series produce for the original institute and others. (6) The institute transfers technology and knowledge to industry.

Examples of technology transfer can take on many forms. It can be through the transfer of knowledge, documents and training, and the licensing of intellectual property. Two cases being the transfer of know how from the ESRF and ANKA for the construction of undulators to DANFYSIK, ACCEL and Babcock Noell. The INFN transferred technologies arising from particle detectors to the space industry. Daresbury Laboratory transferred knowledge of a ceramic anti-multipactor coating process to EEV (now E2V) for their high power klystrons. The Australian Synchrotron Project during its construction made the awarding of tenders conditional on involvement of local industry.

TECHNOLOGY TRANSFER

Technology transfer and knowledge exchange has been important for many years. The foremost reason is the general benefit to society and the fact that technology transfer triggers innovation and improves a country's long term growth. This is reason enough for governments to want a return on their investment. Funding of new projects both at national and international levels is increasingly conditional on the direct and indirect benefit to industry. Society benefits from academic and industrial partnership since technologies are spread to wider markets: cases being medicine, space science, telecommunications, nanotechnologies etc.

The transfer of technology and knowledge permits both the institutes and the industries to be more effective in their given research (whether it is basic, applied or market driven). Towards this goal research institutes can provide skills, intellectual property, access to facilities and money towards the growth of industry.

The process of technology transfer, however, is not easy. Knowledge is sticky and is disinclined to move. There are cultural differences between universities, research institutes and industry. The basic missions of the parties are different, with communication between them often ineffective and information flow difficult. There is also reluctance for people to provide new information or to accept new concepts. Mobility of people from research institutes to industry is low (in part this can attributed to a sense of job insecurity in the private sector). The lack of mobility inhibits the flow of expertise and know-how. Management and economic skills in science departments of universities and research institutes is not the highest priority, basic research and teaching is. Industry can also fear the loss of intellectual property and know-how to competitors.

Government Initiatives

Initiatives have taken by governments, institutes and industry, however, to made technology transfer easier. Governments can provide incentives through conditional or provisional funding of projects if industry is seen to benefit from the project. Governments can also provide tax benefits, funding support and grants to industry for their involvement in infrastructure development. The European Union through its framework programmes gives substantial support to industry and technology transfer; few examples will be given below. The association of innovation centres and science parks with major research infrastructures is another means of facilitating the interaction between public and private entities.

The European Research Infrastructures Development Watch (ERID Watch) [2] is a 6th Framework programme activity to increase public investment efficiency for European research infrastructures and to develop public private partnership. It is a good example of a programme aimed at improving technology transfer. Its aims are (1) to improve the private involvement in research infrastructures by identifying and benchmarking current practices to optimise private-public relationship, (2) to quantify and qualify the economic weight of existing and forthcoming research infrastructure markets in Europe (the ESFRI Road-Map), (3) to provide public authorities in charge of research infrastructure programmes with recommendations and (4) to make these recommendations known to all research infrastructure stakeholders on a wider European scale. First results indicate large differences in approach to technology transfer amongst different research infrastructures. Another important observation was the difficulty in hiring qualified personnel by the research institutes. The generally higher salaries and better employment conditions provided by industry preferentially attracts people. Partnership with industry would therefore seem a good means of accessing personnel for project activities. Results of ERID-Watch activities will be presented in October 2008 and further information can be found at in reference [2].

A 7th framework programme activity is the preparatory phase of IRUVX (an ESFRI project) [3]. The IRUVX-FEL consortium will join the FEL resources now in construction and planned in Europe into a unique research infrastructure. There are five starting partners (FLASH Germany, NLS UK, MAX-IV Sweden, FERMI@Elettra Italy, and BESSY-FEL Germany), two associates (SPARX Italy and PSI-FEL Switzerland) and two new (POLFEL Poland and ARC-EN-CIEL France). The preparatory phase is composed of eight work packages of which many deal with industry and one dedicated to industry. The scope of this work package is (1) to identify and organise long term collaboration between the consortium and industry, (2) to improve the economic impact of the consortium and the scientific exploitation of the facilities and (3) to coordinate the approach to industry to maximize the efficiency in the use of national resources.

Institute Initiatives

Research institutes often have an industrial liaison office. They can foster collaboration with industry from the start of a project. Education of scientists in management skills assists in bridging the communication gap with industry. Institutes can encourage mobility of scientists and support industrial sabbaticals. The organisation of workshops and maintaining open project databases further improves communication and information flow, as does the fostering of networks and having forums for discussion. In-kind contributions to projects can directly catalyse national institute-industry partnerships. This is true for projects both at the national or international level. In-kind contributions can permit industry to take an active role in supporting a project.

An important forum within the accelerator community is the European Industry Forum for Accelerators with SCRF Technology (EIFast) founded at DESY in 2005 [4]. Superconducting technology is a cornerstone of many projects worldwide. EIFast's mandates are to form a visible body to generate support for the realisation of scientific projects at the political level in Europe. To ensure a flow of up-to-date information about projects between research institutes and industrial companies. Support the members in gaining access to information channels and decision makers otherwise difficult to obtain and to promote involvement of industry in scientific projects - especially large projects - at an early stage. The forum has 45 members and routinely holds workshops. A workshop to be held during 2008 will address issues related to XFEL construction.

Industry Initiatives

Collaboration between institutes and industry as outlined in the fifth item above is a precursor to full technology transfer. Industry can facilitate technology transfer by safe guarding its human capital, by maintaining a high level of expertise, internal training of personnel and the transfer of knowledge within the company. Institutes often hesitate to embark on a collaborative project if they

perceive a large commitment of their own staff to training people in industry. This is especially true for projects that are under pressure. Industry should be willing to listen to the needs of institutes and implement changes. This may require customization and risk sharing beyond the normal process of product development. Industry can provide forums and workshops for discussion and training. Industry should also participate in government training schemes for university students, share knowledge and management skills. Industry is often effective in lobbying for projects and gaining political support at regional, national and international levels.

PARTNERSHIPS AND COLLABORATION

Partnership and collaboration is an intermediate step towards full technology transfer and knowledge exchange. It involves the early joint design, engineering and construction of accelerator systems. The use of resources, people, equipment and money is optimized for both the institute and the industry involved, resulting in streamlined execution of project tasks. The institute is the sponsor and first beneficiary of the collaboration, while the industry is open to customised activities, the sharing of initial costs and part of the risk. The institute uses its own resources in specialized areas in a cost-effective way and industry does the rest the work in its own specialized area also in a cost-effective way.

The benefits are numerous; the institute gets what it wants with no unexpected results since activities are performed jointly and communication is routine. The institute does not have to hire a large team and can focus on what it does best. This has the benefit that project tasks can have shorter durations, since expert personnel or large teams do not have to be formed, nor dismantled. During the collaboration both implicit and explicit technology transfer and knowledge exchange takes place. There will be both indirect and direct training of people with different backgrounds and the partnerships can stimulate people mobility. A very important facet of a partnership or collaboration is the preparation of industry towards a project since it provides critical knowledge of project scope. It gives industry time to hire and internally organise, allows optimisation of equipment use or purchase to be made on time as well as preparing industry in the use support infrastructures and finances. Collaboration also informs institutes of technological challenges, it reduces project risks, is both cost effective and time efficient. Overall general project management is more effective. In addition collaboration allows industries to work with other industries thereby catalyzing further cooperation that will persist beyond project completion.

Some examples from past projects are given below and illustrate the numerous ways partnerships and collaboration can form. The view point has been taken from the perspective of the institutes, this by no way excludes the fact that collaboration is a two way process and knowledge, training and intellectual property also

flows from industry to institutes as can be seen in many of the cases below.

Examples of Institute-Industry Collaboration

The Australian Synchrotron Project (ASP) was built with a small team that put the detailed design, project management, installation, commissioning and mitigation of risks into contracts for all major systems, excluding the magnets. The magnets were built by industry that was inexperienced in constructing accelerator magnets. The partnership was between ASP and CMS Alphatec/Buckley Systems. ASP provided significant technical support and knowledge to the industry. A magnetic measurement system based on a SLAC design was built at the industry and a SPEAR III magnet was used for tests. The benefit to ASP was a magnetic system for the storage ring that was to specification, on time and within budget. Industry in turn benefited from the new technology.

A perceived difficulty facing small institute teams when contracting out major systems is the lack of knowledge transferred to the team. In the case of ASP this was alleviated by collaboration during the commissioning phase of the systems by industry and institute personnel. The contractual commissioning of the systems was done with the assistance of institute staff, thereby assuring transfer of operational knowledge from industry to the ASP team. The project was successfully completed on time, within budget and to specification with a small team.

During the construction of SOLEIL several partnerships and collaborations were initiated. The collaboration between SOLEIL, Thales and Euromev resulted in the construction of the pre-injector linac. In this case industry re-organization had led to a dilution of technical know-how in linac construction. SOLEIL provided fresh knowledge by designing linac and mentoring the process during construction. The benefit to the institute was a linac built as desired and to specification, while industry regained technical knowledge and was able to test its development codes at the facility. Another example of collaborative development regards the construction of innovative 190 kW solid state RF amplifiers operating at 352 MHz for the light source. Industry partners were POLYFET and BBEF. The technology relies on robust rather than high performance transistors, in this case the technical expertise at the institute convinced the producer of the transistors to change the manufacturing process and aim for robustness. The changes to the transistors also meant that the combiners and modules, built by BBEF, underwent variations. This later industry was very open and reactive to changes in project scope and collaborative on all necessary tests. Technology transfer is being pursued in France and will rely on the original industries for module manufacture. The last example from SOLEIL concerns the construction of Varying Groove Depth gratings for beamlines. The partners were SOLEIL, Jobin-Yvon and Laboratoire Charles Fabry de l'Institut

d'Optique for multilayer coatings. The partnership relied on long-term relations between institute and industry people and resulted in state-of-the-art optics not available anywhere else. A joint institute-industry patent is being applied for in the case of a multilayer coating.

Daresbury Laboratory together with E2V jointly developed both a 1.3 GHz IOT and an associated high power amplifier. For the IOT, the institute provided the tube specifications and made the initial investment. E2V built the IOT and Daresbury personnel were trained in the use of the tubes, the institute also had preferential delivery times. The IOT is now commercially available. For the development of the 12 kW L-band IOT amplifier, the institute set the outline specifications of the plant to be in line with energy recovery linac requirements. A modest investment was made and again the institute had preferential delivery time. During the development Daresbury laboratory was able to use the amplifier on ALICE (the energy recovery linac prototype) and evaluate its performance. The amplifier is commercially available.

A long tradition of institute industry collaboration exists in Japan. As with the SOLEIL case, the following example is based on long standing personal relations between industry and institute personnel. In this case a high stability 50 kV power supply for a 50 MW C-band Klystron modulator was built. The partners were Riken/Spring8 and Toshiba. The institute provided extensive mentoring and the industry developed the key technologies that allowed an improvement by a factor 50 in output stability. Access to facilities at the research infrastructure for testing was essential for the development. Knowledge was both safe guarded and exchanged between partners through the use of non-disclosure agreements. The power supply is now commercially available.

In the following example government played a direct role by partially funding the initiative, the intellectual property was shared and successful project completion qualified the team to embark on further challenging projects of national importance. The Canadian Light Source (CLS) developed a remote control and integrated experiment management system for beamlines. The partners were CLS, the universities of Alberta and Western Ontario as end users, industries IBM for building enterprise and business systems and BigBangwidth for advanced optical switching networks and User Controlled Light Paths (UCLP) technology. The industries made the system robust and capable. The project was partially funded (75%) by government through Industry Canada (CANAIRES). This was the first remote access project for a synchrotron beamline using state-of-the-art UCLP technology. The benefit of the collaboration was an innovative remote access for users permitting greatly increased efficiency of beamline use: greater number of results for less time and money. All of the software developed is open source and available for exploitation by all the parties involved. Following success of project, CANAIRES funded a follow-up project ScienceStudio with the same partners. This project foresees a complete

experiment management system that will allow researchers to control and observe, from their home base, all aspects of research that must be carried out at specialized laboratories throughout Canada.

Instrumentation Technologies, an industry based in Slovenia, developed digital BPM electronics with SOLEIL and Diamond Light Source (DLS). SOLEIL was the original sponsor and give the initial concepts. DLS sponsored the all-in-one solution and gave guidance during the various development stages. A large scientific community of product users now exists that is composed of many laboratories. There is continual collaboration between the scientific community and the industry for improvements, implementation and new developments. The knowledge gained has been applied to new areas of accelerator interest: fast orbit feedback, multibunch feedback, low level RF control and single pass beam position electronics to name a few.

GENERAL OBSERVATIONS

During the course of a partnership problems may also arise. Some cases are given from the examples cited above. Industry may have to re-structure during project phase, leading to loss of key people or re-scoping of work. A partner may leave the collaboration or there may be delays or overspends. Small companies have difficulties covering development costs if sales are not guaranteed. Public funds can help but are burdened with paper work. The paper work associated with public funding can cause big delays. Partnership contract agreements may take significant time to set up. PhD's or post-doctorate students trained in industry can leave taking knowledge with them. Technological challenges can affect the project, in which case an alternative should be found or the project re-scoped. There may be difficulties in making common publications. This is usually associated with the desire to patent ideas. There may be the tendency to keep things secret or not to share intellectual property. The "Black-Box" syndrome is not good for institutes. The majority of these problems can be avoided by good initial planning including legal aspects

and intellectual property, effective project management, good leadership and communication.

CONCLUSIONS

Industry is capable and desires to participate in accelerator activities from the beginning. Partnerships and collaboration are a pre-cursor to more extended and formalised technology transfer. Institutes should plan for partnerships from the beginning of a project, since resource allocation and project management is then optimized. Collaboration builds a community and fosters accelerated response to new project requirements. Government initiatives catalyze the process but the effectiveness depends on relationships, mutual trust and an appreciation of cultural differences between industry and institutes. The key to successful collaboration relies on people that are project focused, highly motivated and trust.

ACKNOWLEDGEMENTS

The following people are gratefully acknowledged for providing material and ideas for this paper: E. Huttel (ANKA), G. LeBlanc (ASP), M. De Jong and E. Matias (CLS), M. Dykes and P. McIntosh (Daresbury Laboratory), D. Proch, K. Wurr and K. Henjes-Kunst (DESY), R. Walker and G. Rehm (DLS), P. Elleaume (ESRF), L. Palumbo and B. Spataro (INFN), T. Shintake (Riken/SPring8), J-M. Filhol, F. Polack and J-C. Denard (SOLEIL) and S. Webb (STFC).

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