Transfer of knowledge from science to industry – A process of translation?

Introduction

In this paper the business network view will be extended by the introduction of actor with another purpose than the business orientation of a firm – the scientific organization. The main purpose of a scientific organization is the production of knowledge. Few, if any, are questioning the role of science as such, but there is a large debate over the usefulness of science in industry, and how this usefulness can be increased by better transfer mechanisms. This debate is often unclear concerning what knowledge should be transferred, but in the case of the focal actor in this paper, the European Organization for Nuclear Research – *CERN*, the discussion revolves around transfer of different kinds of technologies. Thus, in this paper we analyze how technological knowledge is transferred from science to industry, and some of the difficulties involved in this task.

Technological knowledge is often considered to be universal in character, i.e. possible to transfer to and understand in a new contextual setting provided that the receiving person, or organization, has a certain technological expertise. Given this, the transfer of technological knowledge from science to a business network, for instance, should not be affected by interfering aspects such as language or cultural differences. It has been shown in numerous studies however, that when technological knowledge is transferred it is almost inevitably changed, or translated, into something different from the original form (Bengtson, 2003; Bengtson & Håkansson, 2006). The question raised in this paper is therefore; can a technology be coded, understood and evaluated *as such* in order to see its potentials used in another setting, i.e. is technological knowledge universal enough to be transferred from science to industry, and if so, how does such transfer come about? Our reasoning will be illustrated using what can be perceived as a great source of knowledge, CERN, and transfer of technology from this organization to industry.

The paper has the following disposition: We start by an introduction to earlier business research on science and its usefulness to business. Thereafter we discuss the phenomenon of knowledge transfer and comment on how it has been dealt with in research in general and in business network research in particular, followed by a presentation of the translation concept. We then discuss the methodological underpinnings of the study, describing the data that has been collected concerning both transfer of technology from CERN to industry and knowledge intense interaction between CERN and industry. After the case has been presented, the paper is ended by a discussion and some concluding remarks.

Previous research

The question of how research (or "science") interacts with industry is not a new one. What needs to be discussed, however, is when and how science can be of use for industry. According to some researchers, science and industry are very different and the benefits that industry *may* gain from science are not straight-forward. For instance, Langrish (1974) states that

> *"The relationship between university research and industry may well be a function of the degree of development of the area concerned. Once a new area has been established, the aim of science is to understand; the aim of technology is to make it work, and industry has been very successful at making things work without too much reliance on understanding. Industry makes use of the trained manpower supplied by universities. It also uses new techniques such as chromatography, developed in universities. But the new products and processes of industry seem to depend on a combination of existing technological concepts, economic pressures and empirical research with scientific understanding not being very relevant."*

According to the quote above, "science" and "industry" seem to be quite different creatures. The text, however, was written as an argument against the increased belief in society at that point that "more science" would inevitably lead to more innovations in industry (which are arguments that are commonly used today as well). Thus, the question of how research interacts with industry is old, and it has also been the subject of studies within the industrial network tradition before. For example, in a research report dating back to 1983, Håkansson et al. study the transmission of knowledge between research and industrial worlds. They summarize the situation in a figure showing both one way and interactive channels as illustrated in figure 1 below.

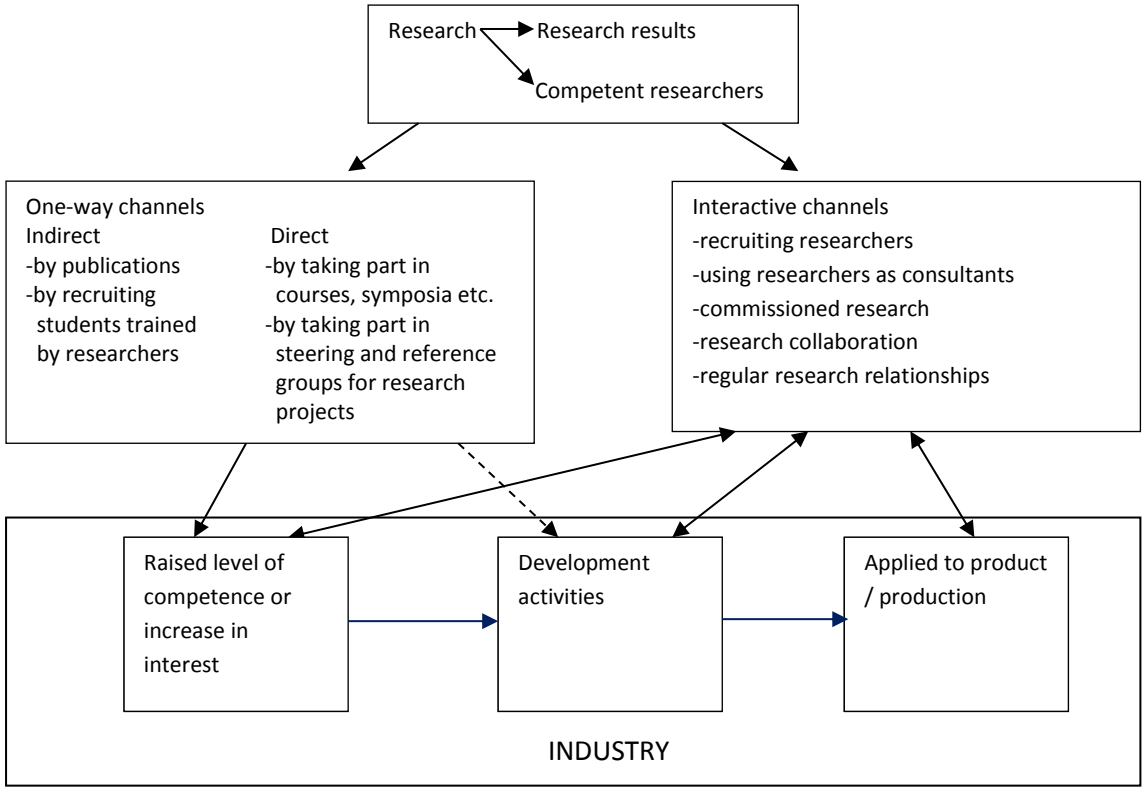

Figure 1: Knowledge transmission channels and their effects (Håkansson et al., 1983)

Research is claimed in the figure to lead to research results and to competent researchers, which can both be used in one- or two-way channels in relation to industry. The researchers divide the one-way channels into indirect ones, such as publications and recruitment, and direct ones, such as taking part in courses and meetings. The one-way channels are claimed to result in raised levels of competence or increase in interests in industry as well as some development activities, whereas the interactive channels are more likely to result in development and application in products / production.

Transfer of knowledge

Studying knowledge-related matters from a network perspective (cf. Ford (ed.), 1998; Håkansson & Snehota, 1995) technological knowledge can be seen as built in, individual and/or collective knowledge of both tacit and explicit nature of how resources can be combined in order to create value. According to Belussi and Pilotti (2002), many researchers claim that more and more knowledge is codified in society today, and that the scope of what can be codified is continually expanding, and that "the codification of knowledge is central to

the modern process of dissemination, transfer and retention of knowledge".[1]A common belief is that these solutions will be easy to transfer, and that the knowledge will in no way change on the way from one place to another. The knowledge is perceived as given (see figure 2).

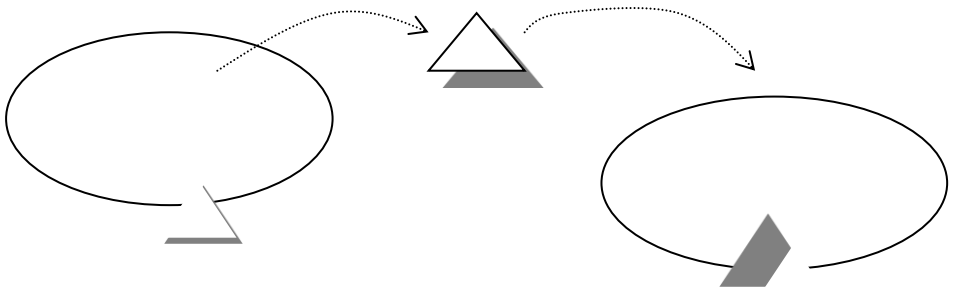

Figure 2: "Unproblematic transfer" of technological knowledge

If the codification is unproblematic, so should the transfer of knowledge be. However, research dating from the 1960s to contemporary investigations all point to the fact that people prefer to turn to other people for information rather than to impersonal sources such as documents, databases (Pelz & Andrews, 1966; Allen, 1977), organisational intranet or Internet (Cross & Sproull, 2004); which indicates that interaction and relationships serve a purpose for transfer of technological knowledge of codified nature also. In this paper we question what is being codified. Is it the same knowledge as was intended, just parts of it or something completely different? We also study what happens during the codification and ask whether there are tacit elements in codified knowledge. There are researchers arguing that it is difficult to separate tacit knowledge from codifiable knowledge (Muller-Merbach, 2007), but also that there are always tacit elements in what is believed to be codified knowledge (Jasimuddin et al, 2005). Dixon (2000) claims, for instance, that using technology to replace face-to-face conversation has had limited success.

We argue that what is believed to be codifiable is written down, but what is signified (the "meaning behind the words") differs between different receivers and between receiver and sender, which leads to a first translation of the knowledge. In the absence of a common

[1] Opposite to this, tacit knowledge is a subjective knowledge linked to the abilities that an individual possesses on the basis of practical experience (Belussi & Pelotti, 2002).

language a translation is needed in order for the parties to understand each other and the message that has been coded.

Latour (1986) depicts a translation model, where

> *"the spread in time or place of anything – claims, orders, artefacts, goods – is in the hands of people; each of these people may act in different ways, letting the token drop, or modifying it, or deflecting it, or betraying it, or adding to it, or appropriating it. The faithful transmission of, for instance, an order by a large number of people is a rarity in such a model and if it occurs it requires explanation"* (Latour, 1986:267).

This implies that knowledge will necessarily change when it "travels" from one person to another; or from one place to another. It does not mean, however, that translation by definition is negative for the outcome, nor does it mean that parts are always taken away when translations occur. It may very well be the case that things are added during the translation, and that the outcome is richer in some way than the original version. The only thing the translation implies is that you will never end up with the exact same thing once information (or knowledge) has moved from one place to another. Thus, translation can take place due to a number of reasons, and it can manifest itself in various ways, but a transfer without translation is difficult to find.

The concept of translation is, of course, commonly used within linguistics. Some of their thoughts have a bearing also on our discussion. If we for example look at Saussure's (1970:117) claim that a language is a system that can only be understood by starting from the whole and not from its parts, then translation will be a lot more complicated than is often considered. This means that a text cannot be translated word by word, without the translator understanding the content, and the context, of the whole text. Using Saussure's view of language, the benefits of dictionaries are marginal; in order to understand a negatively defined sign the context would have to be looked up. To complicate the matter further, Saussure also claimed that words are made up of two arbitrarily related parts; the signified and the signifying (1970:93*ff*). The translator therefore needs insight in not only the whole text of signifying words, but also of the whole system that is signified with words. Wittgenstein's (1953) declaration that not only the signifying and the signified, but also the practical circumstances where a word is used in order to achieve something has to be known, makes the task of translation even harder. Every time the codification, i.e. the technological knowledge,

is used in a new setting, a number of additional translations take place, and the message is further changed in an interaction between involved parties as indicated in Figure 3 below:

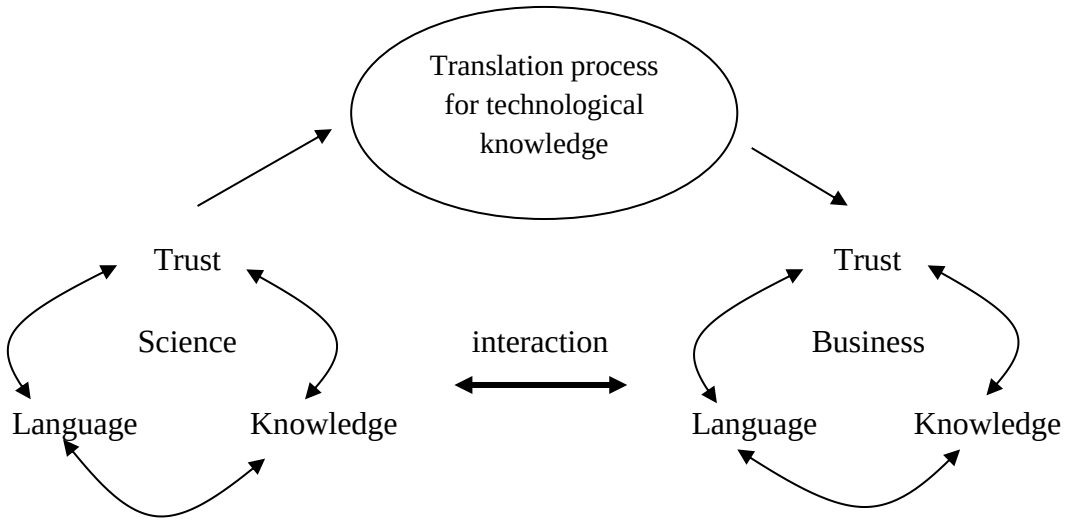

Figure 3: Potential interaction between actors in technological knowledge translation

There has been much research confirming that interaction in relationships is important for acquiring technological knowledge and for learning from it (Burt, 1992; Levin & Cross, 2004). This becomes reasonable if looking at technological knowledge transfer as a process of translation taking place between interacting parties. These types of translation processes will in the paper be analyzed using the model depicted in figure 3 above. Transfer of technological knowledge is achieved through a translation process involving two or more actors, in our case a science unit and a business actor. The result of the translation will depend on 1) the language used by each party, 2) the knowledge the actors have about each other, and 3) the amount of trust between them.

- **Language;** According to Håkansson (1989, p. 146); "The most important and also the most difficult problem (for transmission of knowledge between research and industry) is probably language. Knowledge development almost always involves language development in some form or other".
- **Knowledge;** We argue that it is easier to translate something if the intentions and use of the parties in the previous settings are known by the parties in the new setting. Knowledge about the other party is acquired through interaction with this party.

Within literature on knowledge exchange in relationships there is also considerable evidence that trust in the relationship affects knowledge exchange positively (Håkansson et al., 1983; Mayer et al., 1995; Levin & Cross, 2004).

- **Trust;** Håkansson et al. (1983) argue that mutual trust is a prerequisite for free and open exchange of knowledge, and that mutual trust generally is built gradually through cases of increased difficulty. Besides knowledge about and trust in each other the parties ties to other parties have an impact on the translation process and its outcome.

Study Design

When studying science and its interaction with business it is rather easy to imagine the interaction between an R&D-center and a business unit. The difficulties are larger when choosing a unit engaged in basic research. In order to make the contrast or gap between science and industry as large as possible we have chosen a scientific unit with little usefulness in application terms. We are studying the world´s largest particle physics centre – CERN - which was founded as a joint venture by 20 European member states in the wake of World War II.

The case is based on an extensive study resulting in a doctoral thesis (Åberg, 2013). Different kinds of data were collected during a time period of thirteen years, from 1999 to 2012. At the forefront, 99 interviews were carried out with people at CERN, in (predominantly) Swedish companies, and with physicists. In addition, a lot of observational data was collected during three extended visits at CERN. In order to strengthen the arguments from interviews and discussions, secondary data was used to verify dates and decisions. These secondary data consist of for example CERN annual reports (1955-2012), procurement reports, CERN Yellow reports (which are reprints of CERN articles, where everything related to CERN's interaction with society has been read), and reports on decisions made by CERN Council and the Finance committee.

When constructing the case described in this paper, one of the many companies that had been studied was picked out based on the amount of data available, its clearness in the transfer aspect, and based on the fact that its interaction with CERN has been pointed out by CERN as an example of a successful technology transfer (Bressant & Streit-Bianchi, 2005:41). In summary we choose this company case from the larger material available based on its perceived theory developing qualities (Eisenhardt & Graebner, 2007). For the description of

the Ericsson-CERN interaction, five interviews with people directly responsible for business with CERN at the firm and three interviews with people at CERN dealing directly with the Ericsson relationship and the project at hand, as well as secondary sources such as documents, reports and articles dealing exclusively with this relationship and this project have been of special value.

Transferring or Translating Knowledge – the CERN Case

Outside Geneva, straddling the border between France and Switzerland, the European Laboratory for Nuclear Research, *CERN*, can be found. Since the beginning of the 1950's, this research organization has been carrying out research within high-energy physics (HEP). The experimental research primarily consists of accelerating different kinds of particles in particle accelerators, and then smashing these particles together at predetermined places inside detectors. In order for this research to be carried out, the accelerators and detectors first have to be decided on, planned and built. Today's machines are quite large; the LHC[2] accelerator is 27 km in circumference and is built approximately 100 meters below the surface, whereas the detectors (for instance the ATLAS detector) are up to 25 meters in diameter, or the height of a six-storey building. In addition to being quite large, these machines also include a wide variety of high-tech instrumentation which has to be produced with minute precision. This research infrastructure cannot be produced at and by CERN itself, which means that a big number of firms are involved. Some of the aspects of CERN-firm interaction will be highlighted below, and the focus will be on potential instances, or loci, for knowledge transfer.

The Knowledge Transfer from CERN

Already quite early in CERN's history, emphasis was put on what the member states got back from financing CERN. Apart from the obvious scientific results, utility studies were requested and carried out. These studies focussed primarily on what supplier firms gained from their CERN contracts (Schmied, 1975; Bianchi-Streit et al., 1984). Both these studied showed a benefit from that contracts that several times exceeded the amount spent on the contracts, but

[2] The LHC accelerator is CERN's newest and biggest accelerator. It accelerates particles up to nearly the speed of light, after which the particles are made to collide at a certain point within a detector.

a report carried out a few years later (Abragam, 1987) was not equally positive. Instead it claimed that the contracts which resulted in increased knowledge for the firms were a small minority of all contracts (ibid.).

At about the same time as the Abragam report (1987) was published, attempts to formalize the interaction between firms and CERN resulted in the founding of the *Industry and Technology Liason Office* (ITLO) which was headed by Oscar Barbalat. As a long-term CERN employee with a keen interest in CERN-industry interaction, Barbalat was an obvious choice for the position. Later on the ITLO disappeared, but it was replaced with a more formal organizational unit, the Technology Transfer Office (nowadays called the Knowledge Transfer group), which started its activities in January 2000.

According to the knowledge transfer group (June 2013), there are a number of technology transfer opportunities from CERN[3]; R&D collaborations, service and consultancy, spin-off companies and licensing possibilities. Licensing is carried out through two main vehicles; the *CERN technology portfolio* and the *CERN easy access IP portfolio*. The technology portfolio lists CERN technologies that are available for licensing and/or research collaborations with industry, whereas the easy access IP scheme "involves making some of CERN's technologies available free of royalties, released only to partners who can best develop them to benefit the economy and society" (CERN website[4]). Contrary to the initial statements of the CERN convention, which claim that all discoveries at CERN should be freely available, more recently CERN has also decided to apply for patents of CERN technologies. At the end of 2012 CERN had 238 patents in total (*Knowledge Transfer 2012*).

In the next section we will look further into one of the channels for knowledge transfer from CERN to industry, namely through business –science relationships created by supply to the CERN infra-structure. We will start by explaining "the rules of the game" – the procurement procedures at CERN and thereafter move on to highlight one CERN-supplier relationship.

Procurement at CERN

Since the construction of the first accelerator at CERN, which was finalized in 1958, firms have been involved in supplying CERN with material. In the beginning the procurement rules

[3] http://knowledgetransfer.web.cern.ch/technology-transfer/external-partners/opportunities
[4] http://knowledgetransfer.web.cern.ch/technology-transfer/external-partners/easy-access-ip

were quite simple; procurement was based on lowest price alone (provided the technical specifications were met). This procurement method was deemed unsatisfactory by many member states[5], however, since it tended to favour the host countries France and Switzerland. In January 1994, new procurement rules were put in place that would put a larger emphasis on fairness between the member states with regards to procurement contracts.

If a firm from one of the member states is interested in delivering to CERN, there are several ways to come in contact with the procurement group. The first way is to contact them directly in order to be added to the list of suppliers. Every member state also has a representative called an industrial liaison officer (ILO) who acts as a connection between CERN and industry in his/her respective country. The ILO can also help out with contacts, interesting calls-for-tenders etc. Depending on how much time the ILO is able to spend on this role, as well as on how much time he/she can spend at CERN, the effectiveness of the ILO:s vary greatly.

Depending on the size of the procurement contract, there is a minimum of bids that have to be received. If a firm is already in the supplier database, and has delivered successfully to CERN before, they are likely to get invited to tender again – but any company interested in a certain contract can hand in an offer, and all calls-for-tenders are made publicly available on the procurement website. Questions are also welcome, and all answers will be made publicly available. According to the spokesperson of one firm, this also means that other bidders can figure out where potential problems with the contract may lie, as the question can be deduced from the answer.

Having won a contract before is no guarantee of winning again, but there may be advantages to knowing how to handle CERN contracts. On the other hand, it was also stated that knowing how technically complex the CERN environment is may add costs to a "more knowledgeable" bid; hence increasing the price and therefore the risk of not winning the contract. There are different kinds of contracts, from one-off contracts for standard products to long-term development contracts when new technologies have to be developed for new accelerators and detectors. It is obvious that both the length and the content of the contract affect the interaction between CERN and a firm. In the next section we will give an example of a CERN-supplier relationship.

[5] CERN has 20 full member states (June 2013): Austria, Belgium, Bulgaria, Czech republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Netherlands, Norway, Poland, Portugal, Slovak republic, Spain, Sweden, Switzerland, United Kingdom.

CERN´s Interaction with Ericsson

Experimental physicists, like the ones working at CERN, use enormous machines, which are assembled from products and components produced in industry. A certain amount of interaction between user, CERN, and producer, company, is thus needed especially in the development phase of a new machine. In cases of large and technically complex applications this interaction is often both intense and important for the technological outcome.

One example of such interaction was started at CERN in 1994 as a programme on optoelectronics, and the use of optical fibre to read out data from detectors, was launched. This development was part of the R&D needed for the new LHC accelerator (or rather, two of the detectors that were to be constructed for the LHC accelerator) that was under construction. Later it turned out that the Swedish cable producer Ericsson Network Technologies would provide optical fibre cables for the two big LHC detector projects – i.e. the detectors CMS and ATLAS. This cooperation, which we will look further into here, has been described by people at CERN as one example of a successful technology transfer. Initially, however, Ericsson Network Technologies was not one of the companies that CERN chose to establish close links to in order to find suitable products within the optical field.

Ericsson Network Technologies' most important regular customers are other Ericsson companies together with Telia, which has been a true technology driver for Ericsson Network Technologies, and Banverket. It is an old company with headquarters in Hudiksvall and around one thousand employees worldwide, out of which some eight hundred work in Sweden. Acquired by the Ericsson group in the 1920s, it has its roots in the company Sieverts Kabelverk that was founded in 1888 to produce copper cables for telecom and power networks. Today the copper cables have been accompanied by power cables and optical fibre cables, the latter being the product that is in focus here.

Developed in the 1970s, optical fibre cables are the younger brother of copper cables with the advantages of being able to transfer more data, whereas copper is better at keeping accuracy of data over long distances and in sharp curves where optical fibre has an disadvantage due to the fact that it relies on the reflection of light. Optical fibre cables are based on acrylic-covered glass fibres that are bundled around a central strength member and covered with a plastic coating or tube. For fibre production Ericsson uses two main suppliers: A Japanese

company that provides the glass and a Dutch company providing the acrylate. Some of the optical fibre that Ericsson Network Technologies use in their installations, however, is purchased from the American company Corning, with local European production in Germany.

It was this company, Corning, that in 1998 first made Ericsson aware of the developments taking place at CERN related to optical fibre. Ericsson then contacted CERN and soon found themselves engaged in what has been described by both parties as fruitful discussion. CERN described it from their angle; "(…) our problem was that the quantity we were talking about, the total volume that we would eventually buy was too small to really be interesting for a normal company. So if you would not have a company with an upstream interest, it would not work. And Ericsson had this interest. So we started discussing how to develop the cable together (…)". With their technical contact persons at CERN the Ericsson development team tried to develop a product that could be used in both the CMS and the ATLAS detectors, and even if there were other companies present at this stage, Ericsson was perceived as one of the most promising suppliers. As explained by one of the CERN people; "We also worked with another company on this, but basically they never delivered and Ericsson did. They were by far the most professional company".

Most of the development efforts concerning the Ericsson cables used on the two detectors was conducted in 1999. The cables for CERN were far from the standard products at Ericsson and there were special requirements concerning radiation, bending and, as it would turn out, installation. The testing of one of the requirements for the cables, the one concerning resistance to radiation, was new to Ericsson and they lacked the facilities to carry out these tests. Therefore the CERN people arranged for them to be tested at research facilities in Great Britain, Belgium and France, analysed it at CERN and reported the results to Ericsson. Since Ericsson employees received continuous updates on the results, they now know a great deal more about radiation reactions in their products, and can firmly argue that since CERN's requirements could be handled, their products should be suitable for, for instance, nuclear power plants.

The most intense contacts between CERN and Ericsson, however, concerned the installation, which turned out to be quite tricky as it involved a huge amount of cables, which had to be bent in special ways to secure signal traffic, installed in a limited space. Ericsson had one employee, an installation expert working at and with CERN, something that is described as

interesting from both parties. Parts of the installation were also made in cooperation with another company, Kabelschlepp, who made shelves to support the cables.

All in all CERN as a customer is described by Ericsson as very interesting, and the relationship more in terms of technical cooperation allowing for ideas, objections and solutions from both sides rather than a more traditional buying-selling relationship. As one of the Ericsson people declare; "This is not big business for us; it is more about the technological challenges. We are not losing money, but it is not important for our turnover. However, it is technically interesting and could have interesting spin-offs." Technically challenging customers are explained to be of great value to Ericsson nowadays since their large customer Telia, with its decrease in technical departments during the last twenty years, does not fulfil this function any longer as they use to. Compared to other customers CERN was also perceived as more open to suggestions, possibly as a result of their research profile. The fact that CERN is full of scientists made the cooperation closer and more detailed. It was perceived as important to give concrete answers to detailed questions.

So, the technology transfer from CERN to industry in the interaction described is rather of technological interaction and high demands, which is described by the CERN staff: "(…) we don't tell them what the trick is to this or that. But our requirements are a bit over the edge, and usually they can meet these requirements by simply anticipating what they would have done in any case. So they gain maybe one or two years in respect to the competition." A clear benefit from working with CERN according to Ericsson is the testing of their suppliers that is accomplished in the process. They describe CERN as something of a "worst case", and if things work at CERN, they will work everywhere.

Case Analysis and Discussion

This case demonstrates the importance of having knowledge about your counterpart and his abilities / needs in technology transfer situations. Initially CERN did not know of Ericsson Network Technologies and their ability to develop and deliver a cable that could be used in the new project setting. Ericsson was thus not part of the chosen firms that was first invited to the workshop arranged by CERN. Through their supplier / competitor Corning, however, they were presented with a journal article and hence the background information that they needed in order to find out about the efforts initiated at CERN. They also knew enough about their

own product, production facility and abilities to know that this was a good match for them from a development point of view. Later on they also learnt more about the needs of CERN. They also found out that the fact that they joined the project a bit late did not negatively influence their abilities to compete in the project since CERN by the time they engaged had become better at knowing and formulating what they actually needed function-wise.

The case illustrates that CERN was able to test the reliability of Ericsson early in the development efforts, and how they came to the conclusion that Ericsson was a trustworthy partner since they, especially in comparison to another company, always delivered the test product and delivered on time. Furthermore, CERN realized that Ericsson was a company with an upstream interest; meaning that they could trust Ericsson's intentions – there was something in the deal for them that made it interesting even if there was not a large amount of money involved. Ericsson also built trust in the people from CERN since they knew what they wanted and were able to discuss the technical matters openly and post detailed questions.

The case also demonstrates how a common language is developed through interaction between CERN and Ericsson. As they work together, their abilities and weaknesses become clearer and suggestions concerning how to solve various problems are given from both sides. However, we were also shown how the procurement structures at CERN result in few long-term relationships between CERN and industry. The restriction on relationships means that there is usually little room for mutual knowledge, common language and trust to be developed through interaction between the parties; let alone the problems with a multitude of national languages between the member states and within CERN.

Concluding Remarks

In this paper we argue that technological knowledge from science to industry is transferred through a translation process involving interaction between at least two parties, in our case between CERN and Ericsson. How large the task of translation is depends more on the parties involved in the "coding and decoding", i.e. on the sender and receiver or receivers, than on the technology as such. If the contextual and/or relational gap between the two is large, so is the task of translation. Thus, interaction serves as a learning tool in relation to knowledge that is built up between the two parties, in creating trust between them and for handling language differences. Both parties then function as a sender and receiver and both are able to modify

the communication in relation to the other party in order for him to understand. This is probably one of the reasons why so much knowledge transfer and / or technological development is done within established business relationships.

Whether a piece of knowledge, be it a product or a text etc., is to be considered codified or not therefore depends on the reader (or listener), in relation to the sender, rather than on the item as such. Is the person acquainted with the terminology used? Has he or she some former experience with the technology described? From what angle is he or she making comparisons if indirectly acquainted? Does he or she know the background of the person behind the document enough to know what meaning they give different symbols (words, components etc.)? Instead of focusing on the product, document, textbook or conversation as such, we need to focus on the people involved and on how and if they are related. In addition to the acquaintance between the people, the degree of tacitness in the translated document has to do with the interaction between the resource constellation at the place of origin and in the network of the person reading it. Are the signified objects the same as they are at the place of origin, i.e. are their position in relation to other resources the same?[6] Finally, if one, in order to understand a text, needs to be familiar with the signified objects' function in practical circumstances, the tacitness also has to do with the activities that are performed in relation to the technology, product or production method described in the document.[7]

[6] Cf. de Saussure´s definition of a sign.
[7] Cf. Wittgenstein (1953).

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