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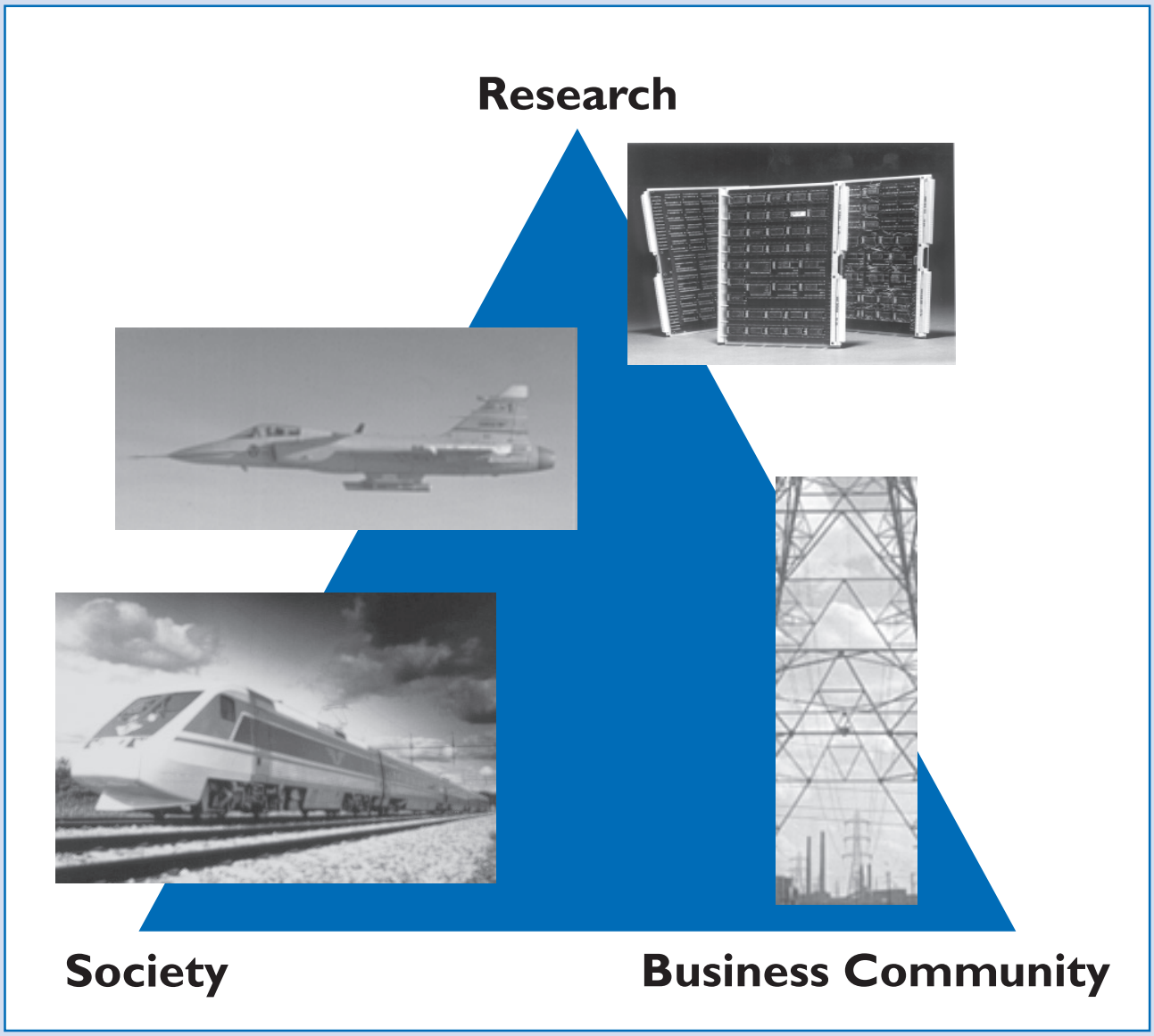
What we can learn from the telecom, energy, railway and defence sectors

Executive Summary
A report from the IVA *Cooperation for Growth* project



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Foreword

In many respects, Sweden is an unusual industrial nation. One specifically Swedish phenomenon often referred to is the cooperation that has historically existed between government, industry and academia. We sometimes refer to this as the *Triple Helix*. Examples such as the AXE system (exchange technology in the telecom field), HVDC (direct current transmission), X2000 (express train) and JAS (military aircraft) are frequently cited in debates about the positive effects of past cooperation between, among others, Televerket (Swedish Telecom) and Ericsson; ABB and SJ (Sweden's National Railway); Vattenfall (public energy utility) and ABB; and Saab and the Swedish Armed Forces. Sweden has held an unusually strong position internationally in the telecommunications, energy, railway and defence sectors. Thus, cooperation has led to growth.

The climate today for continued cooperation of this kind has, however, changed fundamentally. One main reason for this is deregulation and the subsequent restructuring that these sectors are currently undergoing. Alternatively, one could say that it is due to the restructuring and subsequent deregulation in these sectors. Regardless of how we view the issue, the question is whether in this new business landscape it is possible to find new forms of cooperation to promote a positive trend in technical and industrial development.

This paper is a report from the *Cooperation for Growth* project which is being run by the Royal Swedish Academy of Engineering Sciences, IVA, for the purpose of investigating whether it is possible to find new forms of cooperation (see *Appendix 2* in which the project is described in its entirety). This is an executive summary of a more extensive report published by IVA in 2003.

The report allows five researchers to express their views on historical trends. It is also intended to describe the essence of the discussions which to date have taken place within the project's various work groups. We would like to express our gratitude to the individuals who have devoted much of their time to analysing the material. The report editor is IVA's Head of Programmes Henrik Blomgren.

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Chairman
Cooperation for Growth, IVA

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1. Introduction

1.1 Restructuring and new rules: Deregulation

Deregulation of infrastructure-related industries is one of the factors that has caused the greatest changes in the Swedish economy over the past 20 years. In the wake of deregulation, monopolies have been broken up and exposed to competition, which in turn has led to the emergence of new players, changes among existing ones and numerous structural transactions. In short, deregulation is closely linked to restructuring and the creation of new rules. Few industries have undergone such dramatic change as the ones that have been deregulated.

In Sweden over the past 20 years such industries as taxis, the railway, energy and finance sectors, the post office and the aviation industry have all been deregulated, which illustrates the extent of deregulation in Sweden. In this study we have chosen to focus on the telecom, energy, railway and defence sectors. The defence sector cannot truly be said to have gone through the same deregulation process as the other sectors mentioned, but trends in this sector follow similar patterns and it can therefore be used for comparative purposes in relation to the trends in the other sectors.

1.2 The effects of deregulation on research and development

Many studies have been conducted on the effects of deregulation. Few, however, have focused on the topic of this report, namely, the effects of deregulation on R&D and how to guarantee long-term, positive technical development in the future.

Historically, sectors such as telecommunications, energy, the railways and defence have acted as powerful engines for technical development, not merely for advances within their respective sectors, but also in other sectors, and the growth of society in general. But what is the situation now after deregulation?

1.3 What we can learn from the past

In this study five individuals who are experts in their respective fields describe the progress of technical development within the telecom, energy, defence and railway sectors from a historical perspective and focusing on the effects of deregulation up to the present day. These individuals are Professor Bertil Thorngren, Stockholm School of Economics (Div. VI); Director Harald Haegermark, CHH Consulting; Professor Staffan Hultén, Stockholm School of Economics; Associate Professor E. Anders Eriksson and Fredrik Lindgren, both from the Swedish Defence Research Agency (FOI).

Early on in the project we tried to describe development based on the perspective that it should be possible to view development on different levels. Accordingly, we have, on one level, tried to find patterns in past cooperation within the sectors based on such things as the strategic decisions that have been made, what/who has been the driving force behind the processes and has conducted market/commercial analysis, role allocation between the players, and how these factors have changed over time etc. On another more technical/operational level, we have attempted to look for changes in input/output, quantitative as well as qualitative changes in R&D activity. On a third level we have looked for examples to illustrate differences and similarities. A few comparative examples that were frequently debated during the course of the project – but far from the only ones discussed – were examples that have become almost legendary today, namely, the AXE system (in the telecom sector), HVDC (energy), the X2000 (express train) and JAS (military plane).

Although the accounts presented here include elements of the initial discussion, the texts have also grown over time to include other aspects. There are a number of explanations for this. One is that aspects that may have initially been perceived as clear similarities between the sectors turn out not to be, and vice versa. The various accounts thus differ to some extent. Another explanation is that it has not been possible, in the time available, to obtain certain facts that would have been of interest to analyse. There is certainly room for additional research, e.g. a deeper analysis of the overall progress of publicly and privately fi-

nanced R&D in the defence sector. Another explanation is that we have been increasingly focused on the problem for which we are seeking an answer, namely, whether or not it is possible, with the help of lessons learned from the past, to find future models for technical development in deregulated markets. In this respect it was quite natural to allow our "archaeological excavation" to be guided primarily by the lessons we can learn as we look to the future. This means, however, that the historical accounts presented here are far from complete if they are to be considered in their own right. Yet another explanation, which is linked to the previous one, is that the authors of the texts have frequently had to "share" their observations/knowledge with their respective reference panels. The panels were and are still assigned by IVA the task of trying to develop proposals for conceivable future strategies/models to guarantee technical development. The composition of the panels can be found in *Appendix 1*.

The report is part of the *Cooperation for Growth* project, which aims both to analyse what is happening to R&D and technical development in markets that have been deregulated, and to disseminate information on results and experiences arising from this analysis. The project also aims to develop proposals for the roles that the various players can assume and what action they should take to ensure continued strong technical development (see the Project Plan in *Appendix 2.)* The project's timeframe is from 2002 to 2004 and funding is provided by, among others, VINNOVA (Swedish Agency for Innovative Systems), the Swedish National Rail Administration, the Swedish National Energy Administration, the Swedish Foundation for Strategic Research and the Vattenfall energy company. This report is a greatly condensed version of a larger report published in 2003 by IVA within the framework of the project.

It is our hope that this text will help to create a collective opinion of where we are and how we got here. This area is undeniably full of myths, and in order to move forward, it is certainly important to first draw a picture of the present situation and consider what we can learn from the past.

1.4 Issues to address as we move forward

The text in the following chapters raises a multitude of sector-specific questions that are dealt with in each chapter. For this reason, we do not intend to raise them here as well. It may, however, be worth mentioning a few general conclusions and issues of importance for the future that run as a common theme through the analysis.

One obvious pattern is the fact that the sectors being studied are all in the throws of a relatively dramatic *process of restructuring*. Common aspects of this process include increased competition, globalisation, multiple structural transactions, the emergence of new players and the splitting up of value chains, etc. It could be said that the innovation system today consists of a multitude of different players; a situation which naturally creates a new business landscape where markets are viewed in different ways and predicting the future is more difficult.

Shorter term, more limited and supplier-driven research

The situation described above has in turn had an *effect on actual R&D activity* in terms of *scope, content* and *who* is conducting it. It could be argued that there is a pattern in that the volume of research among the buyers, i.e. the operators, is getting smaller with a trend towards shorter term research projects; research today is subject to different kinds of practical/commercial evaluation than in the past. At the same time, increasingly the responsibility for development issues is being moved further back in the value chain, i.e. to the suppliers. The suppliers in turn in this climate are also making different kinds of practical/commercial evaluations than in the past. The combined effect is that the popular perception of historical, long-term cooperation between the dominant buyers and suppliers within the sectors discussed here, and within Sweden's borders, (e.g. Televerket–Ericsson, SJ–ABB, Vattenfall–ABB, FMV–Saab etc.) is not really present in the same way today. This is not to say, however, that the various sectors have all developed along exactly the same lines. Whether deregulation has been a positive force or not is another question that we do not expect to be able to answer here.

It should perhaps be added that factors such as scope, content and who is conducting R&D are not actually relevant as a general measurement of success. Success should instead perhaps be measured by the long-term results of R&D, e.g. in terms of competence, products in demand, export revenue, national prosperity etc. Of course, success is not something that can in any way be measured without considering size, content and who is conducting R&D, especially when looking at the long-term perspective.

Can the pursuit of vested interests and the existence of common problems promote cooperation?

It is interesting to study which factors seem to have been the driving forces over time for past cooperation as described here. The key factors appear to include the interaction of players pursuing vested interests – both Government and business/industry players – combined with common types of problems and a period of societal development. This indicates that the key questions to ask are *which types of vested interests and problems* exist today among players and what would enable them to work together in the future. In short: What sorts of problems do the government, industry and academia in their various guises have and consider it crucial to solve – today and in the future? Which vested interests prevail? And are there areas that overlap? In the text that follows there are examples of what the players have regarded as relevant problems both in the past and today, and how we can learn from similarities and differences.

This leads us to ask who the players are in the innovation systems of today and who they will be tomorrow. The restructuring, but also the deregulation in a rather direct way, not least through the emergence of new government organisations, have in many ways completely changed the "map" of the players. The texts presented here show that *the "map" of players today appears to be more complex*; it is larger than before and has different "coordinates." It is thus difficult today to isolate the issue that we are addressing and make it a purely Swedish, domestic one. The EU probably has a big role to play in the future. A common theme in the texts is that R&D in Sweden, within the sectors being analysed, needs to take advantage of the unique Swedish comparative advantages, while at the same time being focused and specialised in order to be competitive. This theme is perhaps an obvious one given the pattern that has emerged of an entirely different player "map."

The future = the past?

The old players have changed their guises and new ones have emerged. The total number of players is greater, but there are also entirely new types of players. Today it is not enough to merely talk about customers and suppliers, let alone only one of each. The following texts show that the player "map" in the future may be far more similar to the one that existed back during the infancy of the sectors that are now deregulated. This means that there is a lot we can learn from the past when there was a complex climate of *contemporary competition, cooperation and customer/supplier relations*. The new situation also points to the fact that the nowadays frequently used value chain metaphor is not necessarily a suitable means of describing the innovative system of the future. Essentially, this means that we need to ask ourselves which players will work together in the future and who, or what, will drive long-term development. The texts here suggest that both the Government and industry have a role to play, and examples are given of what could be done, albeit with perhaps different methods to those that were used in the past.

All of the above in turn points to the need for building new networks and the fact that *networking per se* is a crucial success factor for different players (the Government, industry, academia etc.), and perhaps for areas other than R&D as well. If it is not clear whether players in the system have found their roles yet, then networking is certainly a prerequisite for the flexibility that will apparently be necessary in the future. The way in which research will be organised in the future has not yet been determined either. The question is essentially: What sort of cooperation can we expect to see?

Finally, questions about the future could perhaps be broken down into *what, who* and *how*. What areas should future R&D cover, who should conduct it, and how should it be organised and funded? The texts presented here describe how these questions have been answered in the past and what can be learned from this to provide answers when the same questions are asked today. The authors are responsible for the content of the texts and this introduction has been written by Dr. Henrik Blomgren, the Project Director and editor of the full report.

1.5 Effects of deregulation or not?

Is what we are seeing solely the result of deregulation? This is clearly not easy to prove, nor is this our intention. Furthermore, it is hardly plausible to see this in such a simplified way. New technologies, the capital market's yield requirements, globalisation (with or without deregulation) and market trends are just four examples of factors that are also of major significance to the changes we are seeing, and this is also discussed in the texts. It is suggested in the descriptions that the changes discussed were taking place for quite some time before deregulation was implemented, which, inci-

dentally, is hard to assign a specific date to or to define in precise terms. The changes we discuss are a combination of many factors where causal links would be hard to prove. Deregulation can obviously influence technical development in just the same way as it can itself be influenced by technical development.

This is perhaps most evident in the telecom sector. The birth and development of mobile telephony can, to some extent, be said to have driven deregulation at the same time as deregulation has had an impact on the way in which future technologies, e.g. 3G, have and will be developed. In addition to this, it is possible, in the telecom field in particular, to actually discuss what was regulated or not regulated and also what is really meant by deregulation.

One could also discuss how to draw the line between what is R – Research, and D – Development, in R&D in comparison to, for example, product adaptation, or how to place research conducted with public funds on an equal footing with research conducted with other funding, and even which accounting principles various players use. Even more difficult is how to compare research conducted by different sectors where different terminology is used. In the telecom field we refer to R&D, in the energy sector the term used is RD&D (the second D is for demonstration), while terms such as object-oriented research are used in the defence sector. The issue of how to relate research "input," e.g. funds invested, to research "output," e.g. skills development and export success, is an even more complicated one.

One could say that many of the changes have actually been accentuated by deregulation, and this begs the question whether it is even relevant to ask how R&D has changed since deregulation. Our intention is to try to understand what has happened. If, along the way, we are able to dispel a number of myths, add nuance to the discussion on the future of technical development in the sectors, and if we can learn things from the past that can be applied in future scenarios, then we should be satisfied.

2. The telecom sector

2.1 The significance of the unique process in Sweden

The development of the Swedish telecommunications system started much earlier than in most other countries. Another unique aspect was that this development actually originated from competition between local and international operators such as Bell Telephone. The Royal Telegraph Board (Kongl. Telegrafstyrelsen) of the day, later named Telia and now TeliaSonera, which originated from the military signal corps, was only one of several players in the Swedish market. The then LME company, now Ericsson, was also interested in the operator side at the same time as it was forced to compete in equipment production with the Telegraph Board's own factories founded back in 1881. What can perhaps today be perceived as a relatively clear-cut operator-supplier relationship involving only a few players, did not exist back in the early days of the development of the Swedish telecommunications system. Instead the situation was complex and characterised by competition, cooperation, various buyer/seller relationships and numerous players. It may be useful to consider whether or not this type of situation may reoccur in the future.

The complex competitive situation that existed was clearly a driving force for development. Back in the 1880s Stockholm already had more telephone subscribers than cities that were significantly larger, e.g. New York and London. There was, however, no coordinated traffic between different networks, instead networks were formed in a way that resembled a race between the various operators. Price levels were forced down and the number of telephone connections grew rapidly to far greater levels than the rest of Europe. The disadvantages included the fact that the customers had to obtain separate equipment for long-distance calls and local calls.

Another consequence, which later came to be seen as a fortunate one, was that Ericsson early on was forced to look for international markets. The company did not possess sole domestic rights for production, unlike its counterparts in, for example, Germany and France, which were actually protected by the monopolies in those countries in the development and operation of telephony networks. This so-called PTT structure, which included the postal services, was never introduced in Sweden.

2.2 Similarities and dissimilarities

In this sector there are thus certain historical similarities between the situation now and the early development of the Swedish electricity and railway networks, which, during their initial development phase involved a multitude of local initiatives. The last twenty years or so of the 1800s was in general a pioneering period with an atmosphere of dynamic competition in Sweden. Also, the guild system was abolished here earlier than in other countries. This liberalisation had a positive effect on growth in Sweden.

Another similarity between the telecom sector and the electricity and railway sectors is that the public utilities created in 1911 for telephony, electricity and railways gradually strengthened their positions. This was a political process in that the public utilities took over responsibility at the national level for development and operation, covering even the sparsely populated areas and smaller towns, and also a commercial process through the purchase of local companies. In the case of other sectors, this was established though formal monopolies.

No similar monopoly legislation was ever established in Sweden for the telephony sector. Parliaments in the 1920s reluctantly accepted the growing dominance of Televerket (Swedish Telecommunications Administration), since it was also involved in building networks and was responsible for the country's sparsely populated areas etc. However, the government saw no reason to create a formal network monopoly, unlike what subsequently happened in other sectors. Instead the telecommunications sector was regulated by the earlier established Utilities Easements Act, which is still in force today. This permits the building of public telecommunications networks with no oth-

er requirement than that the earth removed from the ground in the process must be replaced, which is entirely different from the legislation aimed at monopolies or concessions that applied in other countries. There were of course certain exceptions, for example, in the manufacture of telephones, but the formal monopoly introduced in other countries was never introduced in Sweden.

Since it was not only theoretically possible but also possible in practice, there was actually full network competition during those first decades. Swedish Televerket built up an independent operation early on with its own R&D department and production resources. Later Televerket kept its own balance sheet, which was separate from the State budget, and was able to borrow funds in its own name without having to comply with public procurement rules etc.

In a number of important ways the development of the Swedish telecom sector thus differs from this sector in the rest of Europe, including our Nordic neighbours; in Finland and Denmark on the whole the PTT structure was used with direct placement and control at the ministry level, in combination with concessions for private or municipal companies in certain areas. In Norway the situation was the same as in Sweden until 1905 when a national monopoly was established.

It could therefore be argued that development in the telecom sector in Sweden was unique right from the start and closer to what happened in the US and Canada than in any other country in the Nordic region or the rest of Europe. It would be fairly accurate to say that these three countries were the leaders for most of the 20th century, not only with respect to keeping price levels lower in general, but also in terms of coverage in sparsely populated areas and successful R&D. However, compared to the US and Canada, early internationalisation was crucial for companies based in a small country like Sweden. This is something that later on was a factor not only for Ericsson but also for Televerket (Swedish Telecommunications Administration) and its successor TeliaSonera. R&D financing is dependent on the ability to defray costs by operating in large markets.

In certain situations Ericsson's international presence provided important stimulus over and above that which a purely domestic operation would have access to. In other situations, Televerket's R&D contributed to Ericsson's development, e.g. in the areas of coordinate selector technology and digital switchboards, since Ericsson was excluded from other advanced markets for a long time. The well-known high point in this interplay was the creation of Ellemtel, which developed, among other things, the AXE switching system, and which was a joint development company staffed by development personnel from both Televerket and Ericsson.

It is hard to find an international equivalent to the partnership and the rivalry that existed between the two major players, Televerket and Ericsson. Outside Sweden there were, of course, such operator/developer/manufacturer combinations as AT&T/Bell Labs/Western Telecom (now Lucent) in the US, and Bell Canada/Bell Northern Research/Northern Telecom (now NORTEL), although these were examples of operations within privately-owned groups of companies with excellent opportunities for economies of scale. To get an idea of the size of these operations, AT&T at one time controlled 80 per cent of the US market and had almost one million (!) employees on its payroll.

In this climate, it is not surprising that Ericsson and Televerket saw an "enlightened vested interest" in the possibility of achieving much more within the framework of Ellemtel than if each of them continued working alone with what would become the AXE system, MD110 etc. In many respects it was a matter of sharing resources.

There were thus no industrial policy decisions behind the creation of Ellemtel, rather the situation that resulted in Ellemtel should perhaps be compared to what would happen if Volvo and Scania formed a joint development company to work on a new generation of engines.

2.3 The State (Parliament and the Government) focused on customer interests

In the telecom sector the Government's role has clearly followed a straight line for over a hundred years. The demand from consumers for low prices, compared to other countries, as well as good regional coverage, were the guiding principles. Exactly how this was accomplished, from the Government's perspective, was probably of secondary importance, as was the R&D being conducted by Televerket and Ericsson. Instead the end result was viewed from the consumer's perspective. This resulted in the Government largely accepting the fact that Televerket was gaining an increasingly dominant position.

The Government could therefore be said to have primarily, and consistently, regarded itself as

an advocate of consumer interests, including regional policy interests. The fact that Televerket was State-owned was of secondary importance. If other companies, Swedish or otherwise, or monopolies that still existed in their domestic markets, were able to offer better terms in Sweden, this was the determining factor for the State in its capacity as user and customer. British Telecom, for example, was awarded a contract for the Swedish Ministry for Foreign Affairs' traffic and France Telecom won a contract for the Swedish Police's traffic as a result of Sweden's open trade policy. This took place with no requirement for reciprocal open markets in other countries as was the case between the US and the UK, for example.

The focus on consumer interests explains to some extent the fact that back in 1980 the Swedish Government accepted international competition in the mobile sector; this happened in Sweden several years before both the US and the UK where there were no mobile operators at all at the time. It was not until later on that the governments of these countries started to pursue a more active course with respect to competition in the mobile sector with open international procurement processes for telephony services.

It should not just be considered unavoidable, but also productive and fortunate, especially in the longer term, that neither Ericsson nor Televerket were able to count on a guaranteed domestic market.

2.4 The effects of deregulation and reregulation on R&D

The Swedish telecom market was formally deregulated in 1992. This was an eventful year in which Sweden's first telecommunications act went into force and today's National Post and Telecom Agency (Post- och Telestyrelsen, PTS) was formed and assigned the role of regulator of such things as frequencies and competition. This was also the year that Televerket, the public telephone utility, became the company Telia AB. Although this transition came early compared to the rest of the EU and Sweden's Nordic neighbours, it was actually more a question of formalising something that was already in place. Back in the early 1980s, as mentioned earlier, Sweden was the only country in the world to have competing operators in the mobile sector, compared to the US and the UK where there were no mobile operators at all.

The political decisions were therefore hardly dramatic ones; they could be made without any party political contention since they were a natural consequence and a confirmation of the customer-oriented policy the Government had actually pursued since the infancy of telephony. Televerket and Ericsson had no objections either, because the increased freedom in Sweden opened up new opportunities to reach the otherwise closed markets in the US and the UK.

The benefits for Swedish consumers afforded by increased competition and the resulting lower prices were well in line with Ericsson's as well as Televerket's ambition to gain access to otherwise closed markets. This set Sweden apart from countries that persisted in defending their national monopolies and whose suppliers and operators therefore remained shut out of the larger (in terms of volume) markets in the US and the UK. Both Ericsson and Telia were therefore very early entrants into otherwise closed markets. The fact that the market in Sweden was actually open and provided reciprocal opportunities meant that Swedish companies, including Ericsson, were the first to gain access to the US market. This even happened before the UK, which, justifiably to a certain extent, was perceived as closed for international competition.

Even if 1992 can be considered an important formal milestone, the changes had in fact already begun in the preceding decade. It was quite natural for Ericsson to see it as a necessary step towards being able to sell technology, including AXE, to everyone, including Televerket's international competitors in Sweden. It was just as natural that Televerket no longer saw any reason to continue contributing to the financing of any joint development activity, the possible successful outcome of which would be of just as much value to Televerket's competitors. In this new situation, which emerged in Sweden long before the rest of Europe, the best alternative for both parties was an "amicable divorce" giving both parties greater freedom, thus Ellemtel was closed down.

The consequence of this "divorce" is that the supplier – in this case Ericsson – took over most of the financial responsibility for R&D, while the operator – in this case Telia – gradually reduced the extent of its R&D activity and later became a pure customer/purchaser. Similar splits became commonplace later on in other EU nations as competition increased.

The clear trend that can be identified involving a reduction of Telia's R&D in recent years is,

against the historic background described here, relatively natural and also in line with an international trend with respect to the commitment of other operators to R&D. The change that is taking place is following a similar pattern on a global level.

At the same time the R&D activities of various governments were for a long time clearly modest across the board in international telecommunications research. The lion's share of research was conducted by the suppliers, with Ericsson as a key player, while the engagement of governments in telecom development manifested itself in other areas, primarily through regulation and control.

2.5 Challenge from the new value chain

There are good arguments in favour of fragmentation of the established vertical value chain, because it had also begun to hide inefficiency in R&D processes. Now, instead, each individual link in the chain – inside or outside a company – is forced to prove that it is internationally competitive. The operators have thus reduced their R&D investment and instead, as customers, are relying on the suppliers' R&D, which more comprehensively covers the sector. It is no longer efficient for an operator to try to produce an entire value chain from the ground up, compared to a purchaser who, in each individual part of the chain, buys from the supplier that, at any particular time, can offer the best deal based on the seller's underlying R&D.

One problem with this new role distribution is, however, that it is still important to have an overall situation that works well for both users and customers. Supplier-driven technology like WAP was introduced prematurely before other technology necessary for packaged traffic had been introduced in European mobile networks, and was therefore more of a failure than it should have been. Likewise, GPRS with its promise of faster data transfer was introduced as a pure technology long before the operators had established infrastructure for content suppliers or even for their own co-ordinated traffic between or even within countries. The fact that this happened in these two examples cannot be entirely explained by the change in role distribution. It should, after all, be fairly reasonable to suggest that the prerequisites for one or more individual players to be able to see/monitor/control the overall situation are different today than during the period of regulation and control, and that this has had a major impact on the development of this type of technology in the market.

The launch of 3G ended up being another financial burden where the situation was unclear and many operators were left in limbo. It is even fair to say that at present, certain operators are not investing more than is required by law in the new 3G, nor are they investing in "old" technology, e.g. GRPS/WAP.

There are, of course, different ways of looking at this. Have, for example, the suppliers and their R&D departments been all too keen and focused too much on pushing the limits? Should the focus in the future therefore be more on R&D with a broader and more user-friendly emphasis? Were the operators too slow to make use of and actively market new technological advances? Or were the regulators simply too quick to hand out licences for 3G long before any equipment or services existed that could actually benefit from new infrastructure? Has regulation therefore actually increased the fluctuation and turbulence in the market instead of having a balancing effect, which was the case for Riksbanken (Bank of Sweden)?

The fact is, however, that R&D activity of both operators and suppliers has been subject to drastic cutbacks. New operators have been forced to compete with lower prices and consequently have even lower margins for financing their own R&D projects. Exceptions to this are resource-rich international corporations such as Vodafone and the operator 3, although these need a good reason for conducting any part of their R&D in Sweden.

The primary focus of future research, regardless of how one perceives the situation today, should not be how much money is invested in R&D, but rather what the outcome and results of the research are and what different players can do to help bring about a favourable outcome.

2.6 A few thoughts about the future

As mentioned before, it is hard to believe that it could be possible today to re-create the type of co-operation that existed in the past between Ericsson and Televerket – and perhaps this is not even desirable. As far as Sweden is concerned, however, the issue of whether it is possible to find successful initiatives in cutting edge technology for telecom-related infrastructure is an important one as we move forward.

An investment in R&D should, of course, never be an end in itself; it must be justified by its

ability to generate real added value for which users are prepared to pay. In this respect there is an obvious risk that the current tough cut-backs may go beyond what may be necessary as a result of a fall in sales and lower profitability. There is a growing suspicion about whether the R&D initiatives that resulted in WAP/GPRS/EDGE/UMTS etc. actually added, or could in the future add, value for which users are actually prepared to pay. These initiatives need not have been "mistakes" because similar technology has been successful in important parts of the markets in Asia and the US. What is lacking compared to these markets is an understanding of what users in any given situation are prepared to pay for, and coordinating this with the introduction of new technical possibilities. Outside Europe the reactions of players, including the regulators, have been more pragmatic and therefore they have been more successful in bridging the "gaps" between different segments in order to offer users more cohesive solutions.

There are important similarities here with a comparable trend a hundred years ago, at another time when there was a highly competitive environment. This time around, however, the number of players is even larger, as is the range of services, which includes a number of both complementary and competing services in addition to basic voice telephony. The telecom sector is not distinctly separate from other sectors. The players now include companies with backgrounds in such sectors as data, media, energy and finance. It is no longer a question of delivering a "One Size Fits All" service in telephony. The solutions for data, text and images must instead often be adapted to different end-user requirements with respect to performance, price, security etc. Traditional telecom companies have therefore become more isolated at both ends of the value chain. There is less and less direct contact with end users and their rapidly changing needs, and there are fewer opportunities to influence the suppliers' technical development work.

This "chink" in the industry structure has already had seriously negative consequences; for example, the introduction of WAP in Europe was considered a failure because it was premature, too isolated and lacked the support of technology like GPRS, which was necessary to provide a service that worked and was of practical interest to users. GPRS technology ended up instead in the shadows because of the expectations for UMTS and 3G network technology, which in turn were affected by credibility problems, among other things, in light of the fact that heavily marketed mobile data ventures in the past had very little success. UMTS and 3G also had their own problems due to an insufficient supply of cheap and battery-efficient equipment, which is yet another example of the "chinks" between different links in the chain.

Experiences from Japan and South Korea, among other places, point to the fact that many of today's problems have been and should still be able to be avoided with a more cohesive and seamless launch process. I-mode in Japan is considered a success in that the equivalent of WAP and GPRS were launched simultaneously and coincided with attractive service offering. With respect to 3G: KDDI in Japan achieved success by starting with a "light" version that can subsequently be upgraded for higher performance as interest from customers willing to pay for it increases and cheaper and less battery-thirsty equipment becomes available.

There is a historic parallel here with AXE technology. Its original modular development has made it possible over the years to implement upgrades and modernisation as more powerful processors etc. have become available. Also, AXE was initially created for analogue network technology, which was the dominating technology at the time. A decision was made, however, to be prepared for a possible transition later on to digital selector stages, which proved to be of great strategic significance and a successful example of seamless interplay between technical development and changing market conditions.

Today there are those who are prepared to disregard 3G, which shows a lack of a sense of history. It took more than eight years, several of which were spent sorting out unavoidable teething troubles so that 2G, i.e. GSM, could become the clear success that it is now considered to be. This time it may take even longer, not only because the technology is more complex, but also because it involves a time-consuming adjustment for the users and is no longer only about normal, simple telephony.

Now it appears at least as if an elimination and consolidation process, similar to the one that began during the early 1900s, can be expected. This is mainly an issue for the players in the market, but it is also to some extent a matter that should concern the Government. An important consideration is having a more practical regulatory framework similar to the one in Asia and the US, and in

Sweden in the past. The focus should be more on management by objectives rather than control by way of technology choices.

Another important point is to ensure, in a situation where cutbacks and elimination are unavoidable, that the baby is not thrown out with the bath water. This is important not only from a pure R&D perspective, but also to guarantee the future supply of qualified individuals, in a climate where Sweden has an unusually low level of government R&D funding compared to countries like Finland.

A third point to be made is the importance of acting as a powerful partner with the same enlightened vested interest that led to the Ellemtel collaboration. In other words, not to act as a consumer of a certain technology, but rather as a co-developer of services that can actually raise the quality of healthcare, schools and the care sector. Perhaps "SAMTEL" could be the name of a jointly owned and staffed development operation?

3. The energy sector

The following section describes development in the energy sector, primarily from the perspective of energy companies, but also with an emphasis on the vital role that the Swedish manufacturing industry, and in particular ASEA and ABB, have played.

3.1 Establishment period stimulated development

The establishment of the electricity system in Sweden spans the whole of the 20th century. It involved considerable technical development and numerous Swedish pioneering initiatives that were jointly implemented by the electricity companies, the manufacturing industry and the Government. Well-known examples include hydropower, nuclear power technology and long-distance transmission. Sweden has also made important advances in electricity-based industrial processes, heat pumps, environmental technology etc.

The development of the electricity system contributed to growth in two ways:

- In comparison to other countries, Sweden has an efficient electricity system and low electricity prices. An efficient electricity system is a fundamental prerequisite for the growth and welfare of the entire society. The low prices have given Sweden an important comparative advantage, which has contributed to growth and increased export revenue for industry in general. Access to cheap electricity has also significantly increased the quality of life of the Swedish people.
- Sweden's manufacturing industry, in particular ASEA (now ABB), has implemented successful, pioneering initiatives within many areas of electric power technology. This has enabled the company to grow to become a global corporation with huge export revenue, and has also contributed to the country's economic growth.

Much of the growth and establishment period in Sweden took place up to the time the final nuclear power plant was put into operation in 1986. During this time the energy companies, Vattenfall and ASEA, worked together to form one of the classic Swedish "development pairs." Now, however, in the beginning of the 21st century, the demand for electric power is not growing as fast as in the past with the result that the pace of development of new plants is slow. The electricity system has matured and the need for new plants is not as great as in the past. The current situation could be described as a hiatus.

At the same time, major challenges are looming and uncertainty about the future is great. The electricity system's margins are decreasing and new and/or alternative plants for the production, transmission and distribution of electricity need to be constructed. The peak load is approaching available power and the need for imported electricity has increased.

During much of the growth and establishment period development and the associated Research-Development-Demonstration (RD&D) activity was characterised by close cooperation and common interests and attitudes to goals among the Government, the power companies, manufacturing industry and the research community. The period involved major development programmes in power generation, transmission and nuclear power technology.

Energy production and long-distance networks were built by a number of power companies and the State-owned Vattenfall was the main player. Other companies, such as Sydkraft, Stockholm Energi, Skellefteå Kraft, Stora, Graninge Holmen etc. had municipal or industrial owners, and the latter were often energy-intensive companies within the forestry and wood pulp industries. The distribution networks were largely built by companies owned by local government.

The interplay took various forms and had various purposes. In 1910 the municipal and private power companies formed a trade association called Svenska Vattenkraftföreningen, which later became Svenska Kraftverksföreningen. The local distribution companies formed Svenska Elverksföreningen (the Swedish electricity board association) back in 1903. In 2000 these two were combined to form Svensk Energi (Swedenergy). The combination "Swedish ownership model" in-

volved both competition and collaboration in the industry for planning, forecasts, power system operation and, not least, R&D. Separate agencies were formed early on for these purposes and these have since undergone successive changes. Joint industry research is conducted today by Elforsk AB, which was formed in 1993, owned by Svensk Energi and Svenska Kraftnät (Swedish National Power Grid).

The oil crises in the 1970s, which essentially coincided with the major nuclear power development programme and the debate it provoked, had a number of consequences. Oil was replaced to a great extent by electricity in electric heating and new electricity-based industrial processes, e.g. thermomechanical wood pulp production. Environmental awareness, which first emerged during the hydropower debate in the 1960s, increased at the same time, focusing in the beginning on the issue of acidifying emissions from coal and oil combustion and later on the greenhouse effect and climatic issues. Recently the climatic issues and the concept of sustainable development have become important concerns and are providing a powerful impetus to development of the energy system as a whole.

Another consequence of the oil crisis was the creation of a major Government energy research programme which was launched in 1976 as an instrument for achieving energy policy goals. The focus of the programme starting in 2005 is currently the subject of a Government review the findings of which will be presented in autumn 2003. From the beginning the purpose of the programme was to find a replacement for oil, but early on the focus shifted to what is known today as sustainable development, in other words, an emphasis on efficient energy consumption and renewable energy. The programme gave Government agencies a more active and driving role in energy research than before. Increased investment in energy research was often part of the many energy policy agreements that were reached during the protracted nuclear power debate, and cooperation between the energy research programme and the power supply industry has developed over time.

The creation of the Government programme led to an increase in international cooperation within energy research. In the area of nuclear power, this cooperation was already well developed many years earlier. Since the mid-1970s, Sweden has been participating in a number of projects within the International Energy Agency's research programme and has also participated as an associate nation in the EU's thermonuclear fusion research programme. Since our entry into the EU in 1995 we have also been participating in the EU's full energy research programme.

There have also been examples of energy companies conducting their own projects that were more driven by energy and environmental policy considerations than by obvious commercial benefits. From the companies' perspective one could talk about "obligation motivated" versus "need motivated" research. Energy policy considerations have also been an important factor when building different forms of cooperation and creating special organisations in the RD&D area.

3.2 Research, Development & Demonstration (RD&D) following deregulation

The electricity market was deregulated in 1996. The power supply companies subsequently went through major restructuring processes, which led to fundamental changes in corporate cultures, and we have probably not seen the end of this yet. Essentially, these changes mean that the industry's large production companies have been transformed from national public utilities into internationally active energy corporations. These and other companies in the electricity industry are now being run under effectively the same conditions and with the same requirements as other industrial operations. Similar changes have also taken place on the production side, e.g. ABB has developed into a global corporation working more on a global perspective than a national one.

The amounts invested by energy companies in RD&D fell following deregulation albeit to a lesser extent than in such countries as the UK and the US. The focus has shifted from new technology for generation/transmission/distribution to effective system utilisation through improvement and renewal of these core activities; customer-oriented development projects; a certain, albeit decreasing number of projects that are essentially motivated by energy policy; and RD&D within broader fields than the traditional ones. New areas for research have emerged, e.g. research into separation and storage of carbon dioxide from fossil fuel combustion. IT is increasing in significance in systems and plants. Research as an element in ensuring the supply of competent individuals is still an important and common theme. It is interesting to note that the level of joint industry RD&D being

conducted by Elforsk has remained essentially at the same level since deregulation.

The electricity system represents a large quantity of capital stock requiring maintenance and replenishment, which, among other things, means that new and advanced technology needs to be integrated with existing technology e.g. through IT-based measurement and monitoring equipment in key components and control systems at different levels. Within such areas there is still a great need for RD&D.

These trends within the industry's RD&D can be expected to continue because the incentives are essentially still there. If it should prove necessary to expand new electricity production at short notice, the obstacle to this is not a lack of technology nor the fact that major research requirements have not been met, instead the obstacle is insufficient infrastructure, e.g. in the form of a natural gas grid or coal management on a large scale. Another obstacle could be gaining political acceptance for technology based on fossil fuels. If the ongoing research into carbon dioxide storage is successful, a new situation may arise, but not in a short-term perspective.

Vattenfall has conducted a study of RD&D at a number of European power and energy companies and the findings show a number of similarities:

- RD&D levels remain the same or are falling despite increased turnover.
- The focus is on efficient operation of production facilities, research into ways to reduce the effects of greenhouse gases and renewable energy for electricity production especially wind, solar cells and, in the Nordic countries, bioenergy.
- Oil companies, in particular Shell and BP, are focusing their RD&D resources on solar cells and hydrogen.
- Only limited RD&D resources are being used for transmission/distribution and efficient energy consumption.

3.3 New conditions apply

The situation today and in the foreseeable future is different in important ways from the growth period that is behind us. Deregulation came at a time when the increase in demand for electricity was beginning to slow down. The need for new power plants is therefore not as great as in the past. The electricity system has matured or is at least in hiatus. Although in the short term this reduces the need for RD&D in what were previously core areas, new needs are arising.

Changed industry structure

Deregulation of the electricity market has had a number of structural effects:

- The three largest companies, Vattenfall, Sydkraft and Finnish Fortum, have grown in size. Together these three companies currently account for 90 per cent of electricity production in Sweden.
- Companies have become globalised; Vattenfall has made considerable acquisitions in Northern Europe, Birka Energi has been purchased by the Finnish Fortum Group, Sydkraft has strong German part-ownership, Graninge is partly owned by EdF in France and Sydkraft.
- The transmission grid is administered and operated by the public utility Svenska Kraftnät (Swedish National Power Grid).
- The number of companies within the grid and in the electricity trading business fell during the second half of the 20th century as a result of mergers and acquisitions. Since the beginning of deregulation in the 1950s the number of distribution companies of various sizes has fallen from 5,000 to 270. At the end of 2002/beginning of 2003 there were 204 grid companies. Most of the acquisitions were implemented by the large corporations in the industry.

Internationalisation breakthrough

Power companies and the distribution industry have been internationalised and regard their continued development mainly in a European context as well as in a global one. The distribution industry benefited greatly during the establishment period from Swedish reference facilities in their export efforts. This is still important, but not to the same extent today as during the growth and establishment period.

New corporate cultures

The fact that the major establishment period is over, the electricity market is growing at a slow pace (as in most industrialised nations) and that internationalisation is increasing, is naturally leading to the emergence of new corporate cultures in both energy and distribution companies. Among other things, this is affecting the conditions under which RD&D is conducted. During the establishment period, the management teams of both elec-

tricity companies and distributors were made up of engineers.

Today, expertise in economics, financing, marketing and new business is of equal importance to electricity companies. The heads of these companies are judged more and more by the size of the profits. New technology in the companies' core activities is not as important as it used to be and RD&D issues do not, therefore, have the same significance as before. RD&D is often seen as a cost like any other cost, and when RD&D is considered an investment, it is expected to quickly pay for itself.

Today the energy companies operate in a national and international competitive market, where the risks are more complex than in the past. Margins and profitability in core business – electricity production – can be expected to go down as competition increases. The electricity companies are diversifying their business and their RD&D activity to increase their margins, which is necessary in order to be able to conduct RD&D. They are focusing on RD&D in new areas for products and services, in particular those which border on the traditional core business. At present this diversification seems to be heading in the direction of other heavy infrastructure, such as energy operations other than electricity (heating, refrigeration, gas), water & drainage and waste management. Although diversification actually started before deregulation, it became more apparent afterwards.

On the distribution side, the merger in 1988 of ASEA and Brown Boveri to form ABB led to major changes in several phases in the group's strategy, organisation, operation and product range. The major growth markets for electricity systems are no longer in the old industrial world but in the Third World where countries are at different stages in their development. ABB has divested a number of segments in traditional power engineering and has put more development resources into such areas as industrial automation.

3.4 Great uncertainty about the future

Developments over the past few years have resulted in shrinking margins in the electricity balance in Sweden as well as among our immediate neighbours. Peak load is drawing closer and closer to available power, electricity prices for consumers increased significantly during the winter months of 2002/2003, and the need for imported electricity has increased.

Uncertainty about the future is great. There is considerable political uncertainty with respect to the future role of nuclear power in Sweden. The large-scale alternatives to electricity production used in other countries, i.e. coal and natural gas, are limited for energy and environmental policy reasons, especially relating to climatic concerns. Major Government and private RD&D projects focusing on renewable electricity production from wind power and biofuel have not yet resulted in these being seen as viable alternatives – not even within a timeframe of 10–20 years. Climatic issues, by their nature, require international agreements, and there is great uncertainty about finding measures that different countries can agree on and about which schedules may apply.

The slow move towards a European electricity market is under way and this will require more transmission cables between countries. The risk involved for power companies when they expand electricity production on a large scale may be reduced if production is distributed between larger markets. At the other end of the spectrum, interest is increasing in so-called distributed electricity production at smaller units based on a variety of technologies. Political decisions, e.g. the EU directive on the proportion of electricity produced from renewable energy sources, may have an impact.

New players may enter the system. There are already a number of electricity brokerage and sales companies with no production operation of their own or other fixed assets. Distributed electricity production owned by consumers may emerge as a new phenomenon; for some time people have been putting forth the idea of a large fleet of fuel cell driven vehicles becoming a peak power resource when they are "off the road," and this could even involve each vehicle being a miniature power and heating plant etc.

3.5 RD&D continues but the methods and content may need to be changed

Sweden's electricity supply is still provided by a large number of companies of various sizes, even though they are now bigger and fewer in number. Their ability to run *proprietary* RD&D projects and to assimilate RD&D results still varies considerably depending on the size of the company. The outcome of this trend could be described as follows:

- A long tradition of RD&D cooperation with

good results among electricity companies and at the sectoral level as well as between electricity companies and suppliers.
- The large electricity companies have clearly also benefited from cooperation, e.g. through cost distribution. The benefits have probably been the greatest where cooperation has been focused on facing common "threats" enabling the industry to show a substantiated and joint reaction.
- The tradition of cooperation within the industry appears to have been maintained after deregulation, although there exists a moveable boundary between the RD&D that the electricity companies choose to conduct themselves and joint industry RD&D.
- The electricity companies' RD&D requirements are extended to new areas when they diversify their operations. This creates the need for cooperation in both new and old constellations.

International energy companies may also see the need for national industry cooperation in RD&D, e.g. to ensure the local supply of highly educated personnel. But at the same time as the larger companies in the industry are turning into international corporations, the industry concept itself and with it RD&D may become more international in nature. Work on such areas as the separation and storage of carbon dioxide is being done jointly by parties in different countries. It is also likely that companies will conduct their commissioned research work where it can be done best, paying less attention to national borders than in the past.

Cooperation between distributors is likely to continue and several types of distributors may enter the field as a result of the diversification of operations. The distributors of heavy energy technology equipment today are global corporations. Development of energy technology is costly and these costs need to be defrayed by the sale of products and services in large markets. Aside from the major distribution companies, new specialised development companies of the SME type may form partnerships.

Many current problems within the energy sector require more systematic and multidisciplinary solutions in the implementation of RD&D than before, e.g. in the form of increased collaboration between technical, scientific, financial and behavioural science research, both inside and outside Sweden. Examples could include research into the efficiency of instruments of control in the areas of energy and climate, the workings of the electricity market, social acceptance of new energy technology or how to create successful innovation systems within the energy sector and reduce the number of obstacles blocking the use of new technology.

The EU's Sixth Framework Programme which emphasises "Integrated Projects and Networks of Excellence" is an attempt to meet these needs. Successful multidisciplinary research is, however, not easy to actualise. It not only requires new forms of organisation that depart from traditional models within academia (and this may be a problem in itself), but also a new approach to such things as the system of academic qualifications.

We have witnessed changes in the way academic research was organised in the past. Around 25 years of Government funded energy research resulted in the emergence of a number of research groups, mainly at the major institutes of technology and initially based mainly along disciplinary lines. Energy research is sometimes conducted as a small part of a research institution's core research activity. To make it more effective, various forms of cooperation were developed, particularly during the 1990s. So-called centres of competence have been set up so that a certain energy research activity at an institute of technology or university is linked to one particular department. Responsibility for funding this research is shared by the Government and industry. Having a system of research departments and consortiums means that similar research activity at several universities is brought together in one organisation. Examples of these are the Competence Centres for Electric Power Engineering at the Royal Institute of Technology in Stockholm, for High Temperature Corrosion at Chalmers University of Technology in Gothenburg and for combustion processes at Lund Institute of Technology, as well as the Energy System programme which started as a research department for energy systems research, and research consortiums such as the Gas Turbine Centre of Sweden and the Material Technology Consortium for Thermal Energy Processes.

Research activity is becoming increasingly exposed to international competition for reasons that we have already discussed. This is one reason why graduate research must be focused and concentrated on larger and more competitive departments that are better able to work with an overall perspective.

3.6 The future

One crucial issue for the future is whether the successful forms of cooperation that characterised the growth and establishment period in this sector can be used or developed to suit the challenges that will be faced in the future. A more general question for the future is whether the sector's own technical development will generate as much growth as it did during the growth and establishment period.

The fundamental prerequisites for cooperation within RD&D have apparently remained the same, although the methods and content may need to be re-assessed in the future. We have referred to the fact that international driving forces are augmenting and that it is becoming increasingly important to adopt an international perspective. Although this may seem to conflict with national considerations, it does not need to be the case. An international approach is the deciding factor in successfully achieving the project's goals and to what extent Swedish innovative systems and RD&D structures, consisting of customers, executors and financiers, can sustain and increase their competitiveness in an international arena. If this is successful, former Swedish and now international energy corporations and their competitors will still come to Sweden to conduct their RD&D projects and the distribution industry will conduct parts of its development work in Sweden etc.

There is a very solid foundation in the energy sector in Sweden based on industrial traditions, the tradition of various forms of cooperation, a number of excellent research environments, and last but not least, the fact that our economy for a long period has been dependent on major exports. Operating in an international environment is nothing new in Sweden, and there are other clear advantages, such as shorter decision paths than in many other places. One important aspect for the future is the fact that collaboration between the Government, the energy companies, industry and academia has taken place under a variety of very different circumstances and the parties' roles have varied in different epochs. The parties have been able to adapt their forms of cooperation reasonably well to the changing circumstances. There is every indication that this should be possible in the future as well. Other sectors may be able to learn about various forms of cooperation from the energy sector.

One important success factor is, however, the ability to create competitive research organisations in Sweden. Organisations of the type being set up at the Royal Institute of Technology and Chalmers University of Technology i.e. competence centres and consortiums may be one path to follow. Rationalisation and greater cohesion in research are factors that are becoming increasingly important as well.

Another important factor is perhaps adapting the content of research from new technology for generation/transmission/distribution and energy policy projects to other areas. A few examples of such areas might be research related to equipment and renewal of core activities, customer-oriented development projects and research aimed at finding ways of guaranteeing the supply of expertise.

The joint Swedish initiatives in industry-oriented research carried out within academia and the business community have been dominated for some time by a small number of large corporations within the fields of telecommunications, energy supply, pharmaceuticals, IT etc. Over the past few years we have witnessed major cut-backs in RD&D in Sweden, e.g. in the case of Ericsson and ABB. We have not yet witnessed many steps being taken to rectify this. In Finland it seems that there is a better understanding of this problem. Finnish R&D was expanded in the 1990s in areas like energy research and a national council for research and development was established of which the prime minister is chairman. These types of steps should be considered in the future in Sweden too. Conceivable measures to stimulate R&D include tax relief or the allocation of funds for research initiatives and structural changes in the organisation of research programmes. Another alternative worth considering is giving the Swedish National Energy Administration increased resources and opportunities to participate in commercialisation.

Industry-oriented research for or within electricity companies today makes up a smaller portion of the total Swedish research initiative than during the growth and establishment period, although it is not insignificant. In order to put this in perspective, it should be emphasised that energy companies were not part of the most research-intensive sector; not even during the most active period. In the 1980s when research initiatives were at their highest point, the major power companies' research investments were equivalent to 1.5–2.5 per cent of their turnover. Today the figure is 1 per cent, i.e. far lower than sectors such as pharmaceuticals and parts of the IT industry, where the figure is 20 per cent. This is not to say that a par-

ticular percentage is too small or too large for a certain industry, it is only a size comparison.

A strategy for cooperation for growth could consist of the following steps:

1. Identify areas where Sweden is currently strong and also the future needs in the area of energy supply as well as the needs of the electricity companies' overall commercial activity. Sweden's strengths must be considered against a background of the whole RD&D structure or even the innovation structure in the energy sector, i.e. consisting of research customers, executors and financiers within the Government, industry and academia. There are many such areas of strength, in both traditional and new areas, sometimes within surprising and almost random fields, e.g. solar cell development. Sweden's strength lies in a long tradition of being able to combine technical components for complex systems and facilities.

2. Look at the shortcomings in these structures and take steps to fix them. This requires mobilisation of the strong tradition of cooperation between the Government, energy companies and the rest of the industry.

3. Prioritise and condense. This may mean that companies in the energy supply sector will need to reassign their research projects to fewer universities than today.

4. The railway sector

4.1 Major restructuring process in the railway sector

Sweden started to deregulate – or more accurately, reregulate – its railway sector relatively early on. The splitting up of SJ (Swedish State Railways) and Banverket (Swedish National Rail Administration) in 1988 can be seen as the starting point, although a significant event took place in the 1960s when Stockholm County Council took over responsibility for train services in the area. Despite the fact that the Swedish Parliament took a decision on full deregulation in June 1994, the railway sector is, strictly speaking, still in the throws of deregulation (Parliament actually altered this decision after a change of government in 1994). SJ still monopolises long-distance traffic on the profitable lines, while other lines have been acquired by Rikstrafiken (the National Public Transport Agency). The county transport authorities have purchased regional traffic and goods traffic was deregulated in 1996, although priority was given to established traffic.

The railway sector players today are companies and government agencies, manufacturers of trains and signal systems, suppliers of maintenance and various support systems, train service operators, transport authorities, i.e. county transport authorities who commission transport services and the national authorities such as the Swedish National Rail Administration, the Railway Inspectorate and the National Public Transport Agency. The operators include SJ (Swedish State Railways), Green Cargo, BK Tåg, Tågkompaniet, Connex and other companies running train services. Following deregulation a number of train operators emerged in Sweden, both on the passenger and the goods side. Tågoperatörerna (the Association of Swedish Train Operators) currently has 21 members. Suppliers include the companies that manufacture trains or that deliver services in the form of IT operations, maintenance, restaurants, cleaning etc. It is fair to say that the entire sector has gone through a restructuring process.

The companies manufacturing trains and carriages have, over the past 10–20 years, also gone through a process of restructuring. The focus has shifted sharply to core activities and peripheral operations have been sold off. ASEA merged with Brown Boveri in 1988 to form ABB and the train division was named ABB Transportation. This joined forces with Daimler-Benz's train division in 1996 and the jointly-owned company Adtranz was formed. In 1999 ABB sold its share of Adtranz to Daimler-Benz, which in turn sold the entire operation in 2001 to the Canadian company Bombardier. Bombardier is currently one of the leading global developers and suppliers of trains. Restructuring has thus brought about a strong concentration of manufacturers of rolling stock, i.e. locomotives and carriages, and from the beginning of the 1980s up to the present day the number of train manufacturers in Europe has fallen from more than 50 to about five.

Another consequence of deregulation in the sector is that the once cohesive production system has been gradually divided up. The result is a differentiated offering that includes new overall solutions and ticketing systems, and where the operators are focusing on running train services. This change is well illustrated by SJ's history. SJ (Swedish State Railways) was split back in 1988 into Banverket (National Rail Administration) and the transport company SJ. In the 1990s SJ took ASG public. The Swedish Railway Inspectorate was separated in 1992. In 1995 Malmbanan (the Ore Line) became MTAB and LKAB (ore processing company) became its sole owner in 1999. Another split took place in 2001 when a number of state-owned companies were formed: the passenger traffic company SJ; the cargo operator Green Cargo; the maintenance company Euromaint; the property company Jernhusen; and the computer company EDB Unigrid (now owned by Norwegian EDB). What we now call SJ is a company that only operates passenger traffic. It is no exaggeration to say that the sector that historically consisted of two central and cooperating players, SJ and ASEA, has changed dramatically.

During this process the operators largely abandoned development activities, going from active

development and detail specifications for trains to focus on functional requirements in the form of such things as capacity, comfort and travelling time. In other words, the operators released their responsibilities backwards in the production chain, allowing suppliers to integrate forwards, with activities such as maintenance, leasing of rolling stock etc. The suppliers have thus assumed a greater share of the responsibility for development than in the past, which is a trend mentioned by SJ in its annual report in 1996. This is also clearly illustrated by Adtranz's decision to develop the so-called Regina Trains (Reginatågen) without being commissioned to do so; something that was unusual in the past.

This is turn has meant that not only new skills and players have entered the sector, but also new types of players. One example of a new type of player is Transitio, which was formed initially by Adtranz to own trains and lease them to county authorities. Adtranz sold its shares in 1999 to the local transport authority in Stockholm.

This restructuring has, of course, also had an impact on the sector's R&D.

4.2 Deregulation – a threat and an opportunity

Not all of the changes that have taken place in this sector are the result of deregulation. Deregulation came at the same time as several other changes in society, e.g. the general restructuring of industry, globalisation, and EU membership. The current restructuring in the railway sector has also been affected by the EU decision from 1985 to focus on the railways. Today there are therefore plans at the EU level for future European railway initiatives. The Öresund Bridge was one of a small number of such initiatives in the Nordic region.

The European Commission is important to development in the railway sector in a number of ways. Directive 91/440/EEC contains a stipulation regarding conversion of the state-run railway operations into independent companies and the separation of infrastructure and traffic. The European railway companies have reached different stages in their deregulation of this sector and Sweden is one of the countries that has come the furthest. Foreign competitors have the right to compete in Sweden, while Swedish operators currently have few opportunities to compete in other markets because many countries have still not opened up their domestic markets. Also, SJ's owner, the Swedish Government, will not permit SJ to go beyond Sweden's borders and compete. This means that foreign operators as well as suppliers, which are protected in their domestic markets, actually have a strong competitive advantage in the current situation. Swedish companies therefore need to be big enough and financially strong enough to survive in an open domestic market while they wait for an opportunity to compete on their competitors' home turf. Companies that dominated in the past need to develop new strategies in order to be competitive.

Bombardier is one example of a company that seems to have succeeded under the new market conditions by integrating its Swedish operations into the group's international engineering and production network, and by expanding its business concept to include maintenance etc. In this context it may also be worth noting that Bombardier in Sweden increased its research budget by 600 per cent from 1989 to 2002, and that the Kalmar division in July 2003 became the development centre for carriage technology for the entire group.

Bombardier's success is explained by the fact that more trains are being produced; the Swedish operation is currently bigger than ABB's was at the end of the 1980s; R&D is more customer-oriented; and the level of technical expertise within the Swedish operations has been raised. Other companies have apparently been less successful in their restructuring processes.

4.3 Investment – historically and currently the driving force

Investment in the railway system falls into two categories: investment in infrastructure, e.g. tracks and signal systems, which are part of the social infrastructure; and investment in rolling stock, i.e. locomotives, carriages and train concepts, which are part of the responsibility of transport authorities and operators. However, it is apparent that these two areas interact. The most obvious Swedish example is perhaps the investment in X2000, which spawned a need for additional investment in infrastructure so the full potential of X2000 could be realised.

This interplay is also evident in the field of research, where it is fair to say that infrastructure investment should be supplemented by increased R&D investment. It may be worth noting that while the Government radically increased its investment in the railway sector following the creation of the National Rail Administration in 1988, government research funding (through SJ, the Re-

search Council and the National Rail Administration) was reduced in nominal terms. There may be many explanations for this; one is that the laying of tracks perhaps has less research attached to it than, for example, train manufacturing.

Infrastructure investments

From the 1950s to the 1980s several railways were closed down and faith in rail as a mode of transport was at a low ebb. When X2, commonly referred to by customers as X2000, was put into service at the beginning of the 1990s, people's faith in railways increased and this has in turn had a major impact on infrastructure improvement today. It is perhaps not entirely surprising that it was not until the 1990s that, for the first time in the post-war era, major investments started to be made in the railways. A few of these large projects include the Arlandabanan, Grödingebanan, Öresund Bridge, Svealandsbanan, Mälarbanan, Hallandsås Tunnel and Bottniabanan lines.

SEK 100 billion is to be invested in railway infrastructure in Sweden up to 2015. In order for this investment to provide the maximum possible benefit for society, increased technical expertise will also be needed. Such expertise/knowledge may in turn provide businesses in Sweden with new growth and export opportunities.

The Arlanda Line (Arlandabanan) is one example of a railway investment, but it is also an example of a new way of financing infrastructure; the Government commissioned the entire project from the privately-owned company/consortium A-Train AB. The commission comprised financing, track construction, delivery of trains and operation of the Arlanda Express for just over 40 years. The Swedish State owns the tracks and leases them and the traffic to A-Train which operates the Arlanda Express.

Investment in the railways should also be seen as investment in the social infrastructure, regardless of whether projects are publicly or privately funded. It is difficult to calculate the economic return on investment since the effects of such things as regional expansion or improved communications are difficult to measure. Successful infrastructure investments may also involve combinations of different forms of transport, e.g. road and railway. An example to illustrate this is the question of whether or not it would have been possible to construct the Öresund Bridge purely as a road project. All in all this points to the problem of using pure commercial calculations for this type of project and that modern financing solutions are not always easy to create. This is also the case for projects that are justified from a public finances point of view.

Investments in trains

In the past there had been close cooperation between customers and manufacturers at the national level. In Sweden this was mainly reflected in the relationship between SJ and ASEA, which resulted among other things in Rc-loken and X2000, as well as the partnership between SJ and Ericsson, which in turn led to the so-called ATC system of signal supervision. Although the relationships were close and long-lasting, few individual R&D projects were sustained for a long period.

One of the plainest examples of a long-term approach, but also an example of how projects often took different paths, was the project that ultimately resulted in X2000. The preliminary studies began back in 1968. In the 1970s the project was close to being abandoned, but then new studies were initiated. In 1980 the Swedish Parliament decide that SJ would invest in the new express trains. In 1986 ASEA received the first order, but the first train was not put into service until 1990.

Neither ASEA nor Ericsson was a sole supplier to SJ. At the end of the 1970s, SJ purchased locomotives built by FIAT, and the procurement procedure for X2000, the trains for the Öresund link and the trains for the Mälardalen service took place in a competitive environment. SJ ordered trains for Mälardalen from Alstom. The ATC system, developed in the beginning of the 1970s by SJ and Ericsson Signal, consisted of parts from both Ericsson and Ansaldo when it was put into operation. There were thus two types of technical solutions, while the interface for reading the information along the tracks was the same.

Today the train industry resembles the aircraft industry, with only a few large manufacturers who use a platform approach to try to sell different concepts in different markets. After the restructuring and creation of independent companies, the train operators are behaving more and more like airlines, i.e. they are ordering trains with functionality specifications in terms of capacity, travelling time, comfort etc. instead of specifying technical solutions in detail as they did in the past. This in turn has created new types of business models, e.g. owning trains and leasing them to various operators.

The parties responsible for regional traffic serv-

ices have started to order more of their own trains. The train manufacturing industry's customer base has therefore increased since deregulation, at the same time as there is more competition from foreign manufacturers.

4.4 More players; broader playing field

The "player map" that gradually emerged following deregulation is far more multifaceted than before, in terms of the number of players and the number of different conceivable perspectives that may shape the future development of the sector. We have no ambition here to illustrate the entire spectrum; however, a few players and perspectives should be spotlighted and described as we discuss the future. One question that immediately comes to mind in this context is how the ability of various players to conduct modern forms of networking is crucial to success in the future.

The Government's role

In the past the Government was able to control of the entire sector through SJ, to the extent that both large investments and changes in price levels needed to be approved by Parliament. SJ thus had fairly limited autonomy, even when it was a public service company. The role of the State has now changed in the railway section; today the Government has more means of control than before, by controlling the activities of various public agencies and companies in the sector and with more sweeping forms of control.

In this context it may be of interest to note that deregulation of the railway sector and the privatisation of the public service company SJ have resulted in SJ today consisting of a number of companies, all of which report to the Ministry of Industry, Employment and Communication. Thus it could be said that part of the role of co-ordinator for the sector, which was formally the responsibility of Swedish State Railways has now been transferred to the Government Offices.

The fact that the Government has multiple roles in this sector does of course beg the question of how the Government today is harmonising its activity, i.e. co-ordinating its instructions to companies in its ownership capacity, with Government directives to the authorities and, of course, co-ordinating this with overall transportation policy. Experiences gained over a number of years underscore the need for a cohesive strategy for the development of the railway sector.

Public transport authorities

The role of transport authorities, i.e. the parties purchasing rail services, is related to a political mandate of creating an efficient transport system. The transport authorities are the county transport companies and Rikstrafiken (National Public Transport Agency). In a sense SJ also has a transport authority role because it runs its own train services. Apart from the Government, the only party to have a nationally defined mandate is the National Public Transport Agency. Other transport authorities have a comparatively limited political mandate.

The role of the operators

It is fair to say that the operators have shifted their focus from technical development to business development with a shorter timeframe than before. The operators are now focusing on operating train services according to assignments or independently (SJ). International companies have started to compete in Sweden at the same time as the Swedish operators have continued to enter markets in other countries. An increased focus on customers, improved efficiency and profitability are key success factors.

The role of the manufacturers

These days when the customers of this industry, i.e. the transport authorities and operators purchase trains they have specific functional requirements. Development in the past was largely financed by the customers, i.e. the parties placing the orders, whereas today, the suppliers themselves finance much of the development work, and are thereby taking a greater risk. The manufacturers have greater freedom to find optimal solutions and put their experiences from other markets to good use.

The role of research

Before deregulation almost no rail research was being conducted at Swedish universities. ASEA and Statens Järnvägar (Swedish State Railways), on the other hand, carried out a significant amount of research and development themselves. When the National Rail Administration was formed, research centres were set up at Chalmers University of Technology (CHARMEC), the Royal Institute of Technology (Railway Group KTH) and at Luleå University of Technology. This led to an increase in the number of dissertations on the subject of the railways in Sweden. These research

centres are jointly funded by the railway sector. Other areas are relevant as well; the freight companies provided some funding for logistics research, for example, at Chalmers and the School of Economics and Commercial Law at Gothenburg University.

One effect of deregulation is thus an increase in fundamental R&D at the universities. These can be seen today as arenas for R&D, and there is close cooperation between companies, universities and authorities. These R&D centres together with the knowledge companies that have emerged in the industry, and can be collectively regarded as the "lubricant" for the sector's development in that they bring parties in the industry together to focus on development issues. In certain cases they can even act as catalysts for development.

4.5 R&D since deregulation

The system of collaborating on development has changed considerably since the days of monopolies. Before deregulation the monopolist (SJ) worked closely with the major manufacturers, ASEA and Ericsson. These companies accounted essentially for all development of technology and knowledge within the sector. During the monopoly era it is also fair to say that SJ had a self-imposed responsibility to the sector for rail research, i.e. by funding a number of doctorates relating to the sector.

In connection with deregulation, however, responsibility for long-term R&D has to some extent fallen between the cracks. The first change took place back in 1988 when the National Rail Administration was created and the partnerships between SJ and ASEA and between SJ and Ericsson were discontinued. Collaboration in research, development and investment for the past fifteen years has taken place in temporary arenas where many players can participate. With the exception of research groups affiliated to universities and institutes of technology, these development arenas exist for a limited period and have specific goals. Calculating expenditure on R&D is difficult, but it would appear that the Government reduced its funding for transportation R&D in connection with the transfer of the activities of the Swedish Transport and Communications Research Board (KFB) to VINNOVA and by Statens Järnväger ending its own development programmes. It seems that over the past few years the Government's attitude is that R&D is the responsibility of the market, while, at the same time, the industry has become far more specialised and is focusing on the short term.

R&D seems to be of greater importance to the sector. The two competence centres, CHARMEC and Railway Group KTH, are co-funded today by State research financiers, rail manufacturers and operators, and compared to the situation 20 years ago, today's programmes probably involve more research than development. At the same time there are examples of successful products being developed recently, e.g. the Regina train (extra wide to hold more passengers) from research initiated at a university, and MTAB's Ore Train (30 tonnes of axle load) where university research played an important role in the development of the new system, including the new train.

The combination of internationalisation and deregulation makes it more difficult, however, to take national considerations into account in development work. In a small country like Sweden it may be difficult to keep competence within the borders to conduct R&D programmes. We therefore need to find new types of financing for long-term R&D work, which is often a necessary resource when international companies are choosing where to establish manufacturing and development operations.

4.6 Future challenges

It would seem that a major change in the Swedish railway system requires active participation on the part of the Government. Today it appears that this role has not been sufficiently clearly defined. Major technological/system development is unlikely to be possible without the participation of the Government as a major source of funding. The key question for the long-term perspective is perhaps who can and should be the driving force in the Swedish railway sector's long-term development.

A number of other questions that are also without definitive answers in this context are:

- How can a holistic view of railway development allow scope for enterprise? Sweden is perhaps not always the first to develop new ideas, but, on the other hand, Sweden is able to quickly catch on to ideas and introduce them. This question also touches on the increased market development necessary for today's operators.
- Who today has the competence to initiate and

implement procurement of future train systems and who should own this equipment? This is linked to the question of how purchasers can maintain and develop their evaluation abilities and the issue of how public finance calculations relating to railways should be made. Another question within the framework of this issue is how to efficiently conduct technology procurement procedures under the current Swedish Public Procurement Act.

- What is the Government's strategy for retaining SJ and Green Cargo as State-owned companies? This question highlights the overall issue of the Government's attitude to long-term development.

These questions are linked in different ways and some are the effect of others. Altogether they could be condensed into this one question: Who can and should be the driving force behind the long-term development of the Swedish railway sector?

5. The defence sector

The innovative structures and conditions for research and development in the defence sector went through very significant changes in the 1980s. In many respects, these changes resemble the deregulation of other industries, even though the Swedish defences have not been deregulated in the same sense as other sectors and there are significant differences compared to other areas such as the telecom, energy and railway sectors.

5.1 Differences and similarities between this and other sectors

One key difference between defence and the energy, telecom and railway sectors is that governments are still "monopoly operators" when it comes to legitimate "defence services" and are thereby the only real customers. For this reason it is important from the beginning to try to define how these differences have affected the role the defence sector has played in Sweden's technical-industrial innovation system. The differences also affect the role defence can play in the future.

The standard for material procurement that was established after WWII was such that development and manufacture of defence material was to take place within the country and the material would be given a Swedish profile for the needs of the Swedish national defences. Another important factor was the attitude that access to advanced technology was crucial for our ability to obtain a relative advantage on the battlefield.

In order to avoid dependence on other countries and guarantee acquisitions and maintenance of defence material, even in times of unrest, Sweden accumulated a pool of broad and comprehensive competence to ensure that development and production could take place within Sweden's borders. Experience from WWII and Sweden's difficulty in accessing a supply of advanced material was a major contributing factor behind this philosophy. Another clear ambition was to develop and produce defence material with a Swedish profile, which would guarantee that the material was adapted to the country's requirements and circumstances and would give us exactly the performance required for the country's particular needs and circumstances. This included our national service system and special geographical conditions, e.g. the hydrography of the Baltic Sea. Sweden's policy of non-alignment and the desire from a security policy point of view to emphasize Sweden's need to defend its own territory were also contributing factors. The aim was to achieve Swedish autonomy, not to mention an isolated profile, which would make it difficult for potential contractors to exploit and force their way into the system.

The powerful political element in the defence material market makes it an unrealistic notion that a country of Sweden's limited significance from a global politics point of view would have been able to reach anything like the world-leading position we have attained in the areas of telecom and power transmission, in particular with respect to the most advanced systems such as in electronics and air defence.

Despite this, Sweden still managed to gain a prominent position in certain niche areas in the export markets; the frequently mentioned examples of this include anti-aircraft guns, sea target missiles, recoilless antitank rifles, supreme command systems, training simulators and certain types of counter measures dispensing systems (CMDS). The major gains for Sweden's economy, ascribed by many analysts to the defence industry, are not related to this relatively limited export activity. Rather, they are related to the high-tech defence industry as a part of Swedish development activity in complex systems. According to this point of view, the defence industry has contributed to the Swedish technological environment through the transfer of specific technologies in areas such as mobile communication, and by making the environment for work on advanced systems broader in scope and more sophisticated.

As a branch of Swedish industry, the defence sector has not enjoyed a presence in the global arena and an international position of strength as several other sectors have; however, it should be remembered that Sweden's achievement in terms of domestically developed defence products and systems was entirely on a par with what others succeeded in producing. Also, as already men-

tioned, Sweden created several exportable products despite an expressed desire for a Swedish profile. The explanation for this apparent paradox is probably related to the fact that the Swedish demand was, after all, relatively generic for the needs of different branches of the military, and that Swedish systems have been characterised by a flexible system architecture open to adaptations for new requirements.

What distinguishes the "Swedish model," which was originally established with self-sufficiency in mind, was close cooperation, especially in development programmes, between the Swedish Defence Material Administration (FMV) and the domestic suppliers. The country's relative limitation, in terms of the number of players involved in both decision-making and implementation of projects, was the most important factor in these close relationships.

The dependence on strategic technology imports, especially from the US, is also something that – at least hypothetically – distinguishes the defence sector from the other sectors in this study. There may be a paradoxical – and little examined – aspect to the defence industry's role in technology transfer to Swedish high-tech industry in general. When Sweden, being a country with such limited resources, tried to develop its own solutions within the "great power arena," it subsequently became necessary to make certain compromises with respect to self-sufficiency. In many cases support was needed primarily from the US in the form of critical system components. This brought Swedish engineers in close contact with world-leading development environments. One could also speculate that the short distances in our limited cultural environment meant a shorter path for this expertise to travel to reach other application areas than was the case in, for example, the US.

In Sweden there have always been several important defence material suppliers and no single company has dominated. Sometimes there were even two potential Swedish suppliers in one particular transaction. In this respect the defence sector differs from other sectors where the model of having dominant development pairings is fairly standard.

Another important factor that distinguishes the defence sector is related to the differences between armed conflict and operational activity within "normal" service industries, such as the transport sector. Armed conflict is in reality a very rare occurrence. Development of military capacity must therefore be largely based on hypotheses, which can seldom, if ever, be tested. The value of having the advantage on a single occasion is also incomparably greater than in a competitive environment where the customer base creates an element of inertia, which means that it takes time to achieve success. Thus, competitors in commercial markets where a technological advantage is important are afforded a "grace period." These circumstances have created great interest in innovative solutions within the defence sector.

One example of successful technology procurement during the Cold War is Stril-60. Based upon an understanding of the opportunities afforded by new technology, a specification of requirements was defined and formulated for a system that would come to drive industry and change behaviour in Sweden. The choice of technology proved to be an important aspect and a major factor in a sweeping shift from analogue to digital technology. There is a flip side to this in that new solutions are sometimes not subjected to sufficiency stringent scrutiny. An often cited example of this is the Stridsvagn S tank.

The Swedish model in this case led to a fortunate solution, thanks, among other things, to relatively open system architecture, which was flexible and enabled adaptation. This is typical of many Swedish defence systems. The Gripen system, for example, has an open and flexible system architecture which proved to have generic applicability, both for the needs of other defensive forces and from a system of systems perspective, e.g. future network-based systems.

5.2 Restructuring and internationalisation of the sector

On the supply side of the defence industry, several development trends are heading in the same direction as in other sectors, i.e. a gradual internationalisation and restructuring processes, the focus on core competencies and the concentration of activity; however, there are differences as well. Globalisation has, for example, not yet had its full impact, in that there are only a few companies within a certain area, even though development in the dominant defence industry nation – the US – has arrived at this point. The driving forces behind this development are also different to some extent within the defence sector; governments have, in several cases, initiated and driven the restructuring of industry, if by no other means than by way of clearly dictated conditions and stipulations. There

are also similarities in terms of the consequences of changed technical development models, like the significance of generic technologies and access to competent sub-contractors etc.

Elements of transborder cooperation, alliances and action within the defence industry accelerated in the 1990s and is still continuing. The incentive is primarily the possibility of sharing development costs, gaining access to other qualified players' technology and especially of entering new markets. The Gripen system and its sub-contractors is one example, another is the IRIS-T and Meteor missile projects.

Internationalisation increased significantly as well on the demand side after the end of the Cold War. In Europe in particular, cooperation between nations in development work and procurement of defence materials is increasing. One important reason for this is certainly a desire to develop a European crisis management capability and all that making existing and future systems interoperable entails. It is important here to underscore the fact that successful defence material cooperation between governments must after all meet expectations with respect to reducing material procurement costs.

Phases in the internationalisation of the defence industry

The structure of the national and international defence industries has gone through different stages of consolidation. A few years after the considerable national restructuring and consolidation of the US defence industry in the 1990s, a similar process took place in Europe. The restructuring of the European defence industry can be roughly divided into three phases. The first phase involved national consolidation and privatisation of formerly state-owned companies. In the second phase loose forms of cooperation were established to handle an increasing number of bilateral and multilateral defence material partnerships, which gradually intensified and led to a number of transborder joint ventures being formed. In the third phase the restructuring process involved the foundation of transnational corporations. The creation of EADS though the merger of French, German and Spanish defence material companies is the foremost example to date. In Europe the missile industry is the most consolidated industry, followed in descending order by aviation, electronics, submarines, seafaring vessels, land vehicles, artillery, and other less sophisticated, more traditional defence material. The companies then gradually (some simultaneously) worked towards being participants in an international market structure. They were incorporated in transborder collaboration projects, transborder mergers or corporate acquisitions. In this phase the national production structures and resources were, however, largely maintained. Today there are also examples of an ongoing transatlantic consolidation, albeit from a low level. Some indications exist of the beginnings of globalisation within the defence sector, but it is likely that national interests, especially with respect to where certain production will take place, now and in the future, will affect the defence market for a long period. One consequence of the increasing number of partnerships is an emerging complex network of associations between companies that are competitors in certain areas and partners in others. The two leading and competing European defence companies in the aviation sector, BAE Systems and EADS, are, for example, simultaneously integrated in various collaborative projects and joint ventures.

Internationalisation of the Swedish defence industry

Since the mid 1990s the Swedish defence industry policy has encouraged integration of the domestic defence industry with the defence industries in other countries, and major changes have taken place, both in terms of national consolidation and in the form of a sharp increase in internationalisation. Foreign ownership of defence material companies that operate in Sweden is considerable. 35 per cent of Saab – the dominant company focusing on defence – is owned by the UK company BAE Systems. The wholly foreign-owned companies include Hägglunds Vehicle, acquired by the UK company Alvis in 1997, and Bofors Defence, acquired by the US United Defence in 2000. Kockums is part of the German HDW, which was acquired in spring 2002 by a US investment fund. Exceptions from the wholly or partly foreign-owned companies are Ericsson Microwave Systems AB and Volvo Aero. Both of these, however, belong to highly internationalised groups. Despite the fact that the defence industry in Sweden, has largely been integrated, from an ownership perspective, with defence material companies based in other countries, it is not integrated to the same extent in terms of actual operations. The reasons for this include the fact that there is generally not a big demand for new products and systems and therefore the opportunities for new collaborative projects is limited. It is also considered difficult to

become part of an international project unless a customer at home guarantees an order of a certain size. Recently, however, there have been some examples where industry has, on its own initiative, applied pressure to create international industrial partnerships, e.g. Bofors Defence's development of intelligent ammunition with the US company Raytheon.

New structure in the defence industry

Swedish defence industrial capacity a few decades ago could justifiably be described as remarkably large in an international comparison. Today, however, it is more limited, although not insignificant from a development point of view. From a defence industry perspective, Sweden could be described today as medium sized on an international scale.

The defence industry in Sweden and its present-day changes cannot be comprehended without putting it in an international context, even though, as far as Sweden is concerned, the structure of international corporations and their transformation has not yet reached a firm conclusion. There are many reasons for this: the political goal of securing national interests is a slowing factor, while the shrinking Swedish defence products industry over the past decade, similar to the situation in many other countries in Europe, has not permitted any degree of domestic growth in the defence sector. The proportion of material and development acquired from other countries for the Swedish defences has gradually increased and is currently at more than a third.

5.3 Defence industry research and development in Sweden

As part of the country's defence and security policy during the post-war period, a significant portion of the Government's defence budget has been used for development and purchasing of defence materials within the country. Defence related research and development in Sweden has thus been financed primarily by public funds from the Ministry of Defence. A considerable portion of R&D conducted for defence purposes has also been conducted by Swedish industry for the purpose of developing and supplying defence material, i.e. targeted R&D. More than a quarter of defence R&D funding has gone to research conducted by businesses, industry and consultants. The intensity of R&D carried out by industrial enterprises was also very high; there are examples where R&D spending is equivalent to 15–30 per cent of a company's turnover, which is on a par with R&D intensity levels in, for example, the pharmaceutical industry. A fair-sized portion of R&D resources has gone to core defence research activities, but the development and acquisition of defence material and systems has taken the lion's share.

During the post-WWII period up until the fall of the Soviet Union and the end of the Cold War around 1990, Sweden was conducting relatively comprehensive defence industry research and development by international standards. Defence-related R&D accounted for around a tenth of Sweden's total R&D costs or about a quarter of public spending on R&D. This level could be compared to the development programmes of the major powers and other countries in highly vulnerable positions. Similar to what happened in many other countries, the resources for Swedish national defence research, were reduced around 1990 after the fall of the Wall and the collapse of the Soviet Union; although this trend subsequently slowed and was stabilised, albeit at a somewhat lower level. The more or less independent, core defence research has now been toned down and given less weight from an industrial innovation perspective. Although the issue of a broad, cohesive and financed defence research agency has actually been in the pipeline for more than fifty years, the actual decisions have tended to fall back on the structures that were established during WWII.

About half the cost of defence R&D around 1990, or SEK 2.5 billion (value of that time), was targeted, and an additional one fifth or SEK 1 billion was earmarked for the Swedish Defence Material Administration's technical expertise, which was assigned to support the supply of defence material. The joint research conducted with the Swedish Defence Research Agency (FOA) as the main agency accounted for approximately an additional one tenth of the total defence R&D costs. It should be noted that the FOA previously used a larger portion of the funding for defence R&D, in relative terms. In the final stages of WWII and for many years thereafter, the FOA was very important to the Swedish national defence and its technical development, particularly due to its emphasis on defence technology innovation, which early on and for many years characterised Swedish defence policy.

Due to the shortcomings in the statistical materials relating to defence-oriented R&D, it is not possible to provide a detailed picture of Sweden's R&D development in the defence sector over the

past few decades. Among other things, there were different opinions within the ministries and authorities on disbursements and execution, and on which categories to focus on. Nor is it easy to get a clear picture of the distribution over time of R&D between, for example, development focused on industry or tied to material production. The description is brief for this reason. To what extent R&D that was primarily defence motivated has benefited other sectors, parts of civil society and industry is still difficult to determine through statistics. Relatively little is known in detail about the extensive industrial diffusion effects from large defence products, such as JAS GRIPEN, which we know to have been considerable, and the figures that are quoted in certain contexts are fairly rough estimates.

5.4 Different conditions rather than different activity

We have already mentioned that the conditions, both in the defence and security service markets and on the supply side of the defence sector, have changed to the same degree as within the deregulated industries over the past few decades. For a variety of reasons, however, these changes have not had such a powerful impact on the national defences or the defence industry's actual activities – even if major changes have been discussed. This is important to remember when discussing future changes to the defence sector, not least when different activities perhaps require an understanding of the new conditions and circumstances.

Once could justifiably maintain that the transformation in the defence and security services market (conflict market could be an alternative term here) has been just as radical as in other sectors. It is not, however, a question of deregulation involving the replacement of organised forms of monopolies with competition, but rather of a situation where market segments have disappeared, been regenerated and fused together. The traditional military threat is no longer a realistic scenario; it is hard to imagine any traditional military conflicts in our immediate surroundings. Efforts to prevent, reduce or end conflict in other parts of the world have instead become the main focus for military defence, humanitarian aid initiatives and development assistance. The threat of international terrorism is far greater than in the past. New methods of exerting influence, e.g. intelligence operations made possible by IT advances and new media could conceivably expose the country to new types of threat.

From having to manage a distinctly limited and predictable market segment, Swedish defence policy has thus been changed to deal with a far more complex and hard-to-read market situation. Should we then, when aiming to participate in international initiatives, look for obvious geographical and functional niches? What will be the roles of the military authorities and other authorities with respect to defence against terrorism and intelligence operations? What forms of cooperation should be developed between public and private players in international initiatives, infrastructure protection and information security? And above all, which partners and alliances around the world should we aim to work with when old structures are dissolved and new ones created?

5.5 A glance into the future

Today there is considerable uncertainty about the future of the defence industry, not least with respect to political will. A common standpoint here could be summarized in the following question: Why not purchase the most cost-effective material, regardless of where it was produced? Even if this point of view is by no means a main one in the debate (the Government sees the defence industry as an important component in its capacity for adjustment and as contributing to a stable material supply) it is still a relevant point of departure when discussing the future. The reasoning in favour of maintaining and developing a defence industry base in Sweden, which is not necessarily a separate defence industry, is perhaps to be found in security and economic policy arguments. Without solid security policy incentives it is hard to understand why a country like Sweden would want to continue investing in a defence industry. Accordingly, economic policy interests must be in symbiosis with security policy interests in order to carry any weight.

During the Cold War, as mentioned earlier, the main point of the Swedish defence industry was to demonstrate Sweden's independence and the country's own, distinctive defence concept. This argument has lost its relevance due, among other things, to Sweden's EU membership and global technical development. Nonetheless, on a more practical level, there is a desire for a certain degree of independence so that we will be able, in the spirit of adaptability, to develop our defences as needed in response to changes in the world

around us. Another security policy aspect is that the relatively large defence industry, in certain situations during the post-war period, gave Sweden more weight with respect to security and defence policy than other countries of a similar size. A clear example is that Sweden is one of the founders of the Letter of Intent/Framework Agreement (LoI/FA) and can therefore be regarded as one of Europe's six most important defence industry countries. Furthermore, there is every indication that the US in many contexts has regarded Sweden to be an interesting nation, relative to its size, with respect to defence technology and advanced concepts.

Being in the forefront of development is also likely to provide Sweden with a chance to influence security policy development in the world, especially in a formative stage like the one we are ostensibly in at the moment. A historical comparison, which is at least partly relevant, is the development of nuclear weapons, where Sweden as an early threshold nation chose not to acquire nuclear warheads and therefore gained an important position as an independent technical expert in arms control contexts. The focus and direction of the Swedish defence industry (formerly determined by security policy considerations) as a mini-major power industry specialised in independent system cohesion on a large scale, seems, however, to be presenting certain problems today. Sweden's relatively limited participation in collaborative projects may be an indication of this problem; although the simple fact that Sweden entered the European common market late is of course also a factor. From an expertise perspective, Swedish companies would, in many cases, certainly be suited to taking on a system cohesion role, at least in the case of advanced and politically prestigious projects. The trend towards network-based defence (NBD), which supports a flexible and adaptable capacity could be seen as the most important challenge for the defence programmes today. This also brings to the fore the problems that exist in technical and industrial development. Developing network-based defence differs in several important respects from developing heavy weapon systems, such as fighter aircraft or missiles. While in the case of systems the process is essentially a linear one, NBD development is instead an ongoing process where new systems of systems are constantly being designed, tested and modified. We have to imagine that reasonably advanced nations want to be able to conduct such work themselves. From this perspective a partner, which, like Sweden, can combine considerable expertise with little power-political ambition, may be a very attractive option. The system of systems level, like the advanced system module level, may therefore be a more suitable arena for Swedish expertise than heavy system projects in the future. Network-based defence does not, however, mean that the national defence material supply apparatus has played out its economic policy role. It is, for example, interesting to note that the national defences are still "State-owned." It is also interesting that the EU's competition rules do not normally apply to this area. Thus there remains one main prerequisite for a technology procurement model unlike in sectors that have been deregulated, even though the major changes that have taken place in innovation systems mean that this prerequisite should be applied in new and carefully considered ways. From the perspective of generic technologies, it is important for the defence sector to develop its capacity to cost-effectively look after its interests in cooperation with other players, both in and outside Sweden. The basic consideration here is to follow, understand and evaluate global development in relevant generic technologies. There is a clear synergy effect here between, on the one hand, the security policy related need to deal with the emergence of new threats and the ability to handle the assignments of the armed forces, and on the other hand, the same needs from a business perspective, i.e. understanding the opportunities that new technologies create for oneself and one's competitors. It is not entirely clear whether or not a medium-sized military authority like the one in Sweden should be involved in the development of new generic technologies on the global development front, even if there may be cases where this is plausible. IT security is an example in which there exists a prominent Swedish niche industry at the same time as network-based defence requirements are very high. Another and even more important example involves the methods and tools needed to develop so-called functionality solutions based on flexible system architecture.

Network-based functionality solutions – a future industry for Sweden?

The synergy between security and economic policy can be described as follows: Sweden's defence doctrine emphasises today the ability of the national defence to reorganise – sometimes rapidly – its capacity to face new threats or in some other way

accomplish new tasks that are made necessary by changes taking place in the world. A network-based defence can be regarded as a means of enabling this kind of flexibility and adaptability. This cannot normally be done by bringing in comprehensive new systems, but instead by integrating existing ones – perhaps somewhat modified and with the addition of one or more new, smaller systems – to create a new system of systems or functionality systems to carry out the new tasks. With this approach, all system resources are essentially part of a network enabling integration of situation-adapted functionality systems. One example of such a solution is the use by the US of mounted forward observers for guided bombs in Afghanistan. While the focus in traditional system work is to try to establish definitive user requirements and then design the system based on these, the functionality solution approach involves working in a number of stages. If systems are expected to have a long life, they should be seen as a type of infrastructure which can be a platform for a wide range of future functionality solutions the details of which are not yet determined. The direct user-oriented approach is instead used for each functionality solution. In order to work efficiently it is also important not to start from the basic systems every time, but instead to be able to re-use existing functionality solutions, which requires special working methods and tools. From an economic policy point of view this approach to system and functionality work has clear similarities with development within commercial service industries, such as telecom, which means there should be plenty of synergy opportunities. At the same time this area is entirely in line with traditional Swedish areas of strength in system integration.

Network-based defence may thus be seen as an attempt to benefit from the opportunities created by technical development to accomplish new tasks using new functionality solutions based primarily on existing material systems, rather than with new material systems. It is also important to understand that even an opponent with limited resources can exploit an opportunity to use an element of surprise through new functionality solutions. This may test our own ability to respond quickly with new solutions, within parameters, of course, which are determined by the material systems that are available and preparations that have been made. Traditionally, Sweden has been particularly strong in transfunctional work and also in system integration. In simple terms, the Swedish approach is characterised by an informal culture of cooperation, whereas the big nations rely on bureaucracy and formalisation to achieve cohesion in large-scale system work. Historically, Sweden's approach has proved competitive in many other areas in addition to defence systems, e.g. in telecommunications, electric power and transport systems. When it comes to material systems for the armed forces, however, the approach that has been successful up to now, no longer stands out as a clear Swedish advantage. In international cooperation Sweden cannot count on having a system cohesion role very often, and even less on being able to leave its mark on entire projects. On the other hand, the functionality solutions level appears to be opening up interesting industrial possibilities for Sweden.

APPENDIX 1

Panel members

Energy
Chairman: Morgon Andersson, Managing Director Elforsk
Moderator: Aage Reerslev, Project Manager, IVA
Expert: Harald Haegermark, CHH Consulting

Andersson, Bo, Sollentuna Energi
Berggren, Christian, Linköping University
Cegress, Torsten, Royal Institute of Technology
Frank, Harry, ABB, Corporate Research
Groth, Magnus, Vattenfall AB
Gullbrand, Lars, Ministry of Industry, Employment and Communication
Heden, Håkan, Swedish National Energy Administration
Hedenstedt, Anders, Göteborg Energi
Hellner, Cecilia, Swedish National Power Grid
Klerdal, Lennart, Fortum
Sjunnesson, Lars, Sydkraft

Railway
Chairman: Staffan Håkanson, Managing Director, Bombardier Transportation
Moderator: Thomas Malmer, Project Manager, IVA
Expert: Staffan Hultén, Stockholm School of Economics

Andersson, Evert, Royal Institute of Technology
Beijbom, Christer, IKEA Rail AB
Dahlström, Kjell, National Public Transport Agency
Edström, Nils, National Rail Administration
Ericsson, Lena, National Rail Administration
Halvarsson, Eva, Ministry of Industry, Employment and Communication
Hellstadius, Ragnar, Consultant
Lundén, Roger, Chalmers University of Technology
Persson, Magnus, SJ AB
Prenler, Mikael, Tåg i Bergslagen AB
Sparring, Lennart, Green Cargo
Torwald, Rolf, BKTåg AB

Defence
Chairman: Major General Staffan Näsström, head of systems management at the Swedish Defence Material Administration
Moderator: Bengt A Mölleryd, Project Manager, IVA
Expert: E Anders Eriksson, Swedish Defence Research Agency

Bergh, Svante, Ericsson EMW
Bjurel, Gunnar, Swedish Institute of Computer Science
Brehmer, Berndt, Swedish National Defence College
Eliasson, Gunnar, Royal Institute of Technology
Fredriksson, Billy, Saab AB
Görtz, Hans-Ove, Swedish Armed Forces Headquarters/ Strategic Command
Johansson, Göran, formerly with Kockums
Rehnström, Folke, formerly with Swedish Armed Forces Headquarters/Strategic Command
Sandström, Madelene, VINNOVA (Swedish Agency for Innovative Systems)

Telecom
Chairman: Bernt Ericson, Ericsson Foresight
Moderator: Staffan Eriksson, Project Manager, IVA
Expert: Bertil Thorngren, Stockholm School of Economics

Björkman, Marie, Vodafone
Choi, Soki, BlueFactory
Dahlbom, Bo, SITI
Hammarkvist, Karl-Olof, Stockholm School of Economics
Madfors, Magnus, Ericsson
Marklund, Göran, VINNOVA
Nycander, Claes, Telia Research
Sandberg, Olof, Ministry of Industry, Employment and Communication
Zander, Jens, Royal Institute of Technology
Åsander, Indra, Telia Internet

APPENDIX 2

Cooperation for Growth – Project Plan

Summary

Sweden has reregulated[1] many if its government monopolies faster than other countries; examples include transportation, the post office, telecommunications and energy. The defence material sector could be said to have gone through a similar development even though this market was not formally regulated. The purpose of this project is to study how innovative intensity changed when these sectors were reregulated, and, based on this information, gain an understanding of how Sweden can maintain a strong engineering industry and sustain strong growth.

While highlighting, discussing and sharing experiences from the electricity, defence, telecom and rail sectors in Sweden over the past 20 years, the following three aspects will be the main focus for analysis:

- Technical development and R&D
- Strategic development of corporations
- Actions of the Government and the authorities.

The project will also aim to promote a dialogue that focuses on the future and forms a basis for a strategy for a sound innovative climate in reregulated markets. Dialogue will lead to the drafting of proposals for how the interplay between technology, industry and the Government can be further developed in a way that is effective from an innovation perspective contributing to strong growth in Sweden, and how different players can act to contribute to this development.

The project will consist of three parts:

- Study and analysis of the three categories: technical development, business development and governmental control. This analysis will be both quantitative and qualitative in nature.
- Dialogue enabling the sectors that traditionally seldom intersect – in this case telecom, electricity, transportation and defence material – to exchange information and experiences.
- Synthesis where proposals for greater interplay between government, industry and R&D will be prepared to continue to promote strong technical development and growth in Sweden.

The intended timeframe for the project is 2002–2004 and IVA will act as principal.

Background

At the national level, technical and industrial development can be explained in the form of different models of how innovation develops. The interplay between research & development, government and industry is an important factor in this development[2] and the terms "innovation systems" and "clusters" are frequently used.[3] Models aside, it is worth noting that there is consensus on one crucial factor for the future, namely, establishing how players like the Government/authorities, industry and academia can *cooperate* to promote development. Examples of past success include geographical collaboration, e.g. the development work that laid the foundation for the growth of a telecom/data cluster in Karlskrona/Ronneby; Uppsala as a biotech region; and Kista as an IT cluster. Another form of collaboration is sectoral partnerships, such as the partnership between Televerket and Ericsson to create the AXE system, or between Vattenfall and ABB in the field of energy technology. One of the most important collaboration models was technology procurement based on cooperation between a demanding (competent) customer and an advanced industry as the supplier. Today when we talk about technical and indus-

[1] Generally called deregulated. Here it is a more a question of a new market being created and new rules being established. Reregulation is therefore a more appropriate term.

[2] Sometimes called the Triple Helix, a model presented by Henry Etzkovitz and Loet Leydesdorff, most recently in an article entitled Research Policy 2000. The model as such is not unique; it has similarities with Gibbons' more philosophical description of research and development according to the "2nd mode."

[3] See, for example, www.vinnova.se

trial development, the starting point is finding ways to achieve effective cooperation between industry, the R&D system and the political system. The fundamental goal is to develop models that can in turn be applied to develop effective innovation systems and thereby create growth and renewal.

When considering technical development in reregulated markets, it is very important to analyse how cooperation between different players is affected. Since sectors that undergo reregulation are fundamentally changed, so too are the conditions, and the applicability of different models for technical and industrial development is also affected. Although the need for knowledge is great, this area has been the subject of relatively little analysis.[4] This is especially significant in Sweden where the progress of several Swedish corporations is to some extent the result of successful partnerships with academia and the Government.

Generally speaking, sectors that undergo reregulation go through three stages: the monopoly phase, the monopoly with competition phase and the competition phase. The monopoly phase is subject to a degree of control for the purpose of, for example, defining monopolies and preventing the abuse of power in the consumer market. In phase two when the monopoly is faced with competition, additional regulatory control is required, for example, to stipulate how publicly-owned companies should go about securing financing. If the number of players in the sector increases and a functioning market is needed, only a limited amount of control is required to ensure a healthy competitive climate and possibly also that public service goals are maintained.

It should also be noted that this development may be reversible. The government has the option of modelling markets to resemble public sector monopolies. The Swedish government did this with the railways in the beginning of the 1900s to co-ordinate the railway network, and the British government reverted to a state monopoly for Railtrack (the equivalent of the Swedish National Rail Administration).

Analysis of reregulation conducted over the past few years has primarily had economic considerations as the starting point focusing on the competitive situation, prices, efficiency etc. In line with the three phases described above, it could be maintained – perhaps with some amplification – that the analysis was indirectly based on three very clear situations and has not studied the "content" of the phases. Aspects that were not closely examined following reregulation, perhaps in part because we have not been able to draw conclusions about them until now and in part because of the national economy method, are:

- The consequences for R&D and technical development
- The commercial process and pattern recognition between different areas that are studied and discussed individually instead.
- Government control and roles, and developing the role of the authorities.

The questions relating to action to be taken that should be asked while we consider the above points are:

- How can innovative energy be increased in reregulated markets?
- What roles should the various players in the system (government/authorities, industry and academia) assume, what action should they take, and how should they work together to promote continued strong technical development?
- What skills need to be improved among the various players to promote a sound innovative climate in Sweden in the reregulated markets that are often exposed to international competition?

These are the issues this project intends to address.

Purpose and anticipated results

Sweden is an important research nation. We have a number of successful companies in technical industries as well as prominent technical research programmes. Today, however, we lack a full understanding of what is happening with R&D and technical development in markets that have been reregulated and how we should be acting in this new environment. Some experiences have been gained internationally, primarily in the US and the UK, partly associated with constitutional traditions. Since Sweden, from an international perspective, is very advanced in this area, there is not a lot in general that we can learn from other coun-

[4] There are exceptions, but overall the analysis that has been conducted into technical development appears to be fragmented or divided by sector.

tries. If anything it is the other way around; Sweden has experience to pass on internationally, particularly within the EU where Sweden is forcing the pace of reregulation. In order to ensure the continuation of strong technical and industrial development in Sweden, we need to analyse and discuss the conditions for technical and industrial development in Sweden.

One of the project's purposes is to describe and *analyse* what happens to R&D and technical development in markets that are reregulated, how businesses react to these new markets, and how governments act after reregulation (the roles of the authorities etc.).

The second purpose of the project is to support development by *disseminating information on results and experiences* from practical situations to the players that are affected, by, among other things, forming panels to work on this. At the moment we are not learning enough from each other. Sectors that have been reregulated have much in common, even though after initial scrutiny they may seem very different. This part of the project will give individuals and companies the opportunity to "get a different perspective on their activities" and thereby develop their ability to act effectively.

The project's third purpose will focus on development and aims to *draft proposals with respect to the roles different players can assume and what they should do* to ensure continued strong technical development. It is very important to gather resources and to take certain risks when investing in long-term development. In the future the project may also be able to provide public authorities and agencies with new information that they can use when dealing with already reregulated industries or to reregulate others in an efficient way. The experiences from the project may also form the basis for future industrial and technical policies with increased national innovative energy. The results of the project will also be aimed at industry and the research community and how they – perhaps through new forms of cooperation – can work more closely to promote technical development.

The project's overall purpose is to contribute to an *increased understanding in society* in general for what happens when markets are reregulated and how the authorities, academia and the business community act and should act in the future.

In addition to an increase in contacts and new networks between sectors through the exchange of experiences, the project will generate a number of *reports*. These are described later on in this project plan.

Limitations

The project will deal with the developments in technology, industry and government authorities in reregulated sectors. National economy related issues and specific legal questions will not be addressed other than in cases where they are important to the theme of the project.

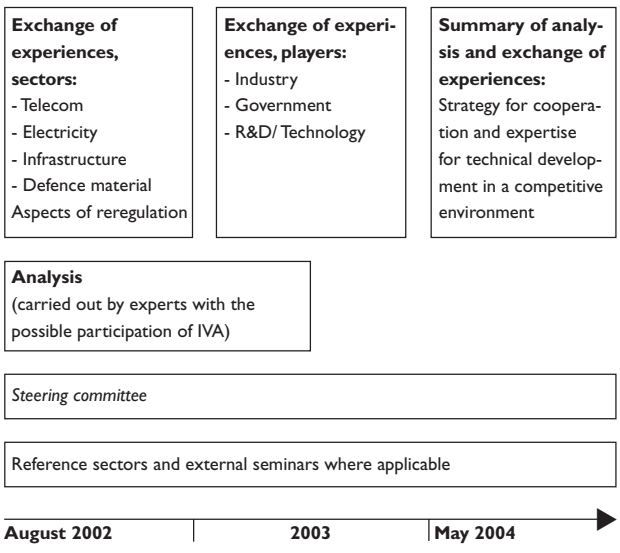
The project will obviously deal with most of the technology-intensive sectors, such as transportation, telecommunications, defence material and the energy markets, covering both publicly and privately financed research. Certain sectoral limits will be established, e.g. transportation is limited to the rail market and energy is limited to the electricity market. Although the project's core consists of four sectors, the results will be of interest to many different sectors, both those that are or may become reregulated and those that are interested in long-term investment in R&D and technical development.

The project's structure

The project will consist of three parts: *analysis*, *dialogue* and finally *strategy*, including a summary (see fig. 1). The analysis part will be conducted concurrently with the other two parts providing them with data and information throughout the course of the project. The dialogue part will provide substance for the strategy part.

The project is expected to run for 24 months starting in the summer of 2002 and ending in spring 2004.

Figure 1. Proposed structure



Analysis – description of development in reregulated markets

A number of sectors with very similar development have been chosen to form the core of the project, in this case transportation (railways), telecom/IT, defence and energy (electricity.)

The *analysis* part of the project will analyse the present and past actions of the players in these sectors in their various roles through the different stages of reregulation. The sectors that have been reregulated will be analysed based on how they reacted before and during reregulation. This analysis will form the basis for a dialogue where experiences will be shared.

This analysis will also be part of an international comparison. The US and the UK are of particular interest. Cooperation is possible with such agencies as Euro-CASE (European Council of Academies of Applied Sciences, Technologies and Engineering), NAE (the US National Academy of Engineering) and RaEng (the UK Royal Academy of Engineering) where energy development etc. is already being studied.

In order to study development in industry in general and form a picture of the restructuring that took place during the same period, sectors such as paper/pulp, pharmaceuticals and the motor vehicle industry will be used as reference objects in this project.

The chart below provides a rough illustration of the basic structure for analysis and also gives examples of issues. When comparing different sectors, patterns emerge that show similarities and differences in the reactions of various players to reregulation in the different sectors.

Cooperation according to a Triple Helix model aims to develop technology or products to be used for an end customer. The customer perspective, e.g. how future markets are assessed by players, also therefore needs to be considered.

During the analysis part of the project the following types of issues will be analysed:

Figure 2. Analysis of the roles of different players during reregulation and examples of issues

Players and examples of roles/ issues	**Phase 1 Monopoly**	**Phase 2 Monopoly & competition**	**Phase 3 Competition**
Industry - Owners/ management - Customers - Technology developers - Sellers - Users - Business logics	- Government strategy	- Market adjustment - Adjustment process	- Global strategy - Restructuring
Government - Influence - Influence through authorities/ agencies - Users - Regulatory frame-works	- Action - Legislation - Ordering - Supervision - Monitoring	- New authorities - Different reactions - Legislation	- Amended laws - New roles for the authorities
Academia - Knowledge developers - How much R&D funding is available? - Who provides funding? - Who conducts research? Utilisation of expertise	- Distribution - Key players	- Emergence of new players, including internationally - Qualitative shift	- International development - Market versus technology

The strategic development and reactions of industry

A description will be prepared and analysis conducted of the strategic development of a number of companies over the past ten years (e.g. Telia, Vattenfall, Swedish Railways and Saab). The focus will be on:

- Structural changes in, for example, purchasing, sales, outsourcing, management buy out.
- Strategic considerations and decisions that have laid the foundations for change
- Market development (international, partnerships, strategic alliances)
- What is behind the strategic decisions made by the companies?
- Internal changes, i.e. systems of governance, support processes, staffing
- Skills displacement and market analysis.

One of the main tasks of the studies is to find *patterns in the development processes* between companies, and how these have affected the companies' R&D activities and technical development.

Companies that are not considered to be under government control will be selected as reference objects, e.g. companies in the pharmaceutical and forestry industries. Examples may also be taken from the manufacturing industry, which has undergone major changes over the past ten years.

Government actions and control

A description will be prepared and analysis conducted of progress over the past ten years of organisations closely associated with government authorities, e.g. the Swedish National Post and Telecom Agency and its predecessors, the National Rail Administration, Swedish Board of Civil Aviation and the Swedish Power Grid. The emphasis will be on:

- What drives development? Technology, markets, industry or political review?
- Principles of government control (from direct action to?)
- Development of the role of the government agencies
- Background to the choice of interface: company–government agency–authority
- Dealing with transition regulations and stability in the new climate for the players.
- Incentives for reregulation
- How the market is defined
- Dealing with dominant forces in the market

Here too *patterns in the development processes* are of key importance.

Technical development in regulated markets

A quantitative and qualitative study of technical research and development within the chosen sectors focusing on the following:

- Shifting sources of funding.
- The distribution of publicly versus privately funded research and development.
- Have a few large, concentrated areas become a greater number of smaller initiatives?
- Application of technology procurement and other models for transactions involving significant technology content.
- Market analysis used as a basis for investment.
- The consequences of different initiatives for building up domestic expertise within different technical fields.
- Time perspective for technical development.

One way to conduct analysis is to compare how products are produced today and how they were produced during the period when these areas were regulated. A hypothetical chain of events for product development can act as a framework for analysis of this kind:

Idea <—> analysis (basic research) <—> applied research <—> finished product

The analysis will explain, among other things, who is participating and who is funding the various parts of the chain, as well as development issues, predictability etc.

A number of technological fields that are not perceived as traditional, government-run enterprises will be chosen as reference objects, e.g. pulp/paper, pharmaceuticals or motor vehicles. Since it is important to describe the *fundamental principles* of technical development in different sectors, the reference objects provide an insight into the other sectors. The analysis is conducted concurrently with other work, and data and information from it is used on an ongoing basis in dialogues to enable an exchange of experiences among the sectors.

Exchanging experiences to increase knowledge and cooperation

The dialogue section of the project will be based on panels consisting of three different groups from Industry, Government (ministries, authorities/agencies) and Academia (research/development). The panels will evaluate and exchange experiences and learn from this within their respective areas. The sectors being compared and studied have varying skills distribution and interfaces between customers/users and suppliers/producers.

Brief analyses of the sectors in question will be used as a basis for these discussions. These will summarise what has happened in the sectors and what roles various players have had. The brief studies to be discussed will prepared by researchers/experts in cooperation with some of the players from the sector.

Below are a few examples of issues for discussion in dialogues within the respective areas:

Issues for discussion by the Industry players

- Defining a company's new core business in the value chain
- Business development versus technical development
- How to establish an internal transformation process
- Working with vague directives from owners
- Experiences from outsourcing and restructuring
- Strategies for internationalisation
- Consequences of internationalisation
- Introduction of new calculation principles and internal systems of governance
- Input into and experiences from political proc-

esses (from industry/companies)
- Working with partners and in strategic alliances
- Cooperation with academia and government agencies
- Consequences of sector shifts
- Foundations for new business models
- Internal changes as the result of IPOs and new auditing principles
- Business logics and market analysis

Issues for discussion among the Government players
- The ownership role versus the governance role in partly or wholly owned companies
- Management by objectives and technology policy
- Creating laws that are flexible in following development in technology and industry
- Securing long-term infrastructural stability and growth
- Governance through regulation, supervision, subsidies or structures
- The Government's control capabilities in the future taking into account the EU's competition rules, e.g. if the Government in the future will have to cover the deficits of state-owned companies
- Role assignments for ministries, authorities, agencies, municipalities, county councils
- Input to and experiences from government driven transformation processes (from the authorities' side)
- The line between public utility – government agency – transformed government-run company
- Regulatory framework
- Supply of technical and financial expertise
- The competition aspect
- Relationships with small and large companies
- Cooperation with industry and academia
- How to handle dominant forces in the market during reregulation
- How to assess the potential of different technological initiatives (the technology as well as the market)
- How to create stable rules in reregulated markets.

Issues for discussion among the players in Academia
- Technology driven versus market driven technical development. Who is steering and who is pushing?
- Technical development in unstable conditions
- Flexibility in development work
- Changes financial conditions for R&D
- Spreading risk in technical development (portfolio mentality)
- Input to and experiences from business strategy driven transformation (from a development perspective)
- Cultural "remodelling" of a development culture
- Cooperation with industry and government.

The work of the groups will be documented on an ongoing basis and this will be used for three of the project's reports.

Strategy: Cooperation for technical development in a reregulated world

When the groups have completed their work, the strategy section of the project will include a summary of the role distribution, competence and cooperation needed among the different players so that companies in Sweden will be able to retain a leading position in R&D and technical development. The information gained here should form a platform where the sectors can learn from each other and the government can develop its various roles, e.g. supervision and other government agency duties. Forms of cooperation between the various groups of players to stimulate an increase in innovative activity through industrial and technical development will be analysed. This may relate to how the fundamental conditions have changed and what is required from an active economic policy.

Participants

The intention is for the project to involve many different players, such as business leaders, researchers/experts and persons in authority. It is vital to include several boundary breaching competencies, partly to initiate a broad discussion and partly so that the actual structure of the project is broad in nature, e.g. the choice of multiple sectors. A broad participation is also important because the mobilisation that the project process is meant to bring about is a key aspect of this particular project method.

A number of sectors in different stages in market development should form the core of the project; a number of other sectors will then be given the opportunity to follow the progress via reference groups and seminars. The core sectors are the electricity, telecommunications, train services

and defence material sectors. The table below shows examples of participants from R&D/technology, industry and government agencies. Proposed reference sector players are indicated in brackets.

R&D/Technology	Industry	The Government through authorities/ agencies
Heads of technology at companies such as Telia, Vattenfall, Sydkraft and SJ as well as *researchers* from universities and institutes.	*Strategic management/ marketing* from Vattenfall, Birka, Sydkraft, Telia, Europolitan, SJ, Green Cargo, Bombardier, Saab, ABB, Ericsson, (Astra, SCA, Volvo)	*Management and heads of technology* from the Swedish National Rail Administration and Energy Agency, VINNOVA; PTS, Swedish Defence Material Administration and Defence Research Agency, Ministry of Industry, Employment and Communication Ministry of Defence, Swedish Competition Authority, the Armed Forces, Swedish Civil Aviation Authority (Apoteket pharmacy chain, National Road Administration)

A steering committee for the project will ideally consist of individuals with boundary breaching experience from business/industry, government or academia as well as insight into a number of sectors. The steering committee members are:

Jan-Åke Kark, Chairman
Birgitta, Böhlin, Swedish Defence Material Administration
Per Eriksson, VINNOVA
Stig Larsson
Carl-Erik Nyquist
Lars Rekke, LFV (Swedish CAA)
Ulf J Johansson
Henrik Blomgren, IVA
Subject to additions

A reference group will also be linked to the project for the government agencies, business/industry and trade associations from other sectors that may be interested in following the project, such as the National Road Administration, Apoteket, Elforsk (energy research organisation), the Swedish IT Commission, Swedish National Board of Trade, Swedish Bankers' Association, IT-Företagen (trade organisation for the IT industry), Confederation of Swedish Enterprise etc.

Communication

Since one of the project's aims is to build networks between different sectors and help the players involved to learn from other sectors, communication is crucial. Much of the project activity should therefore be directed outwards and be in the form of think tanks, seminars etc. Information about project components and results will be presented on IVA's website (www.iva.se). The results of the project as a whole will be presented in four reports to coincide with seminars and newspaper article publication etc:

Reports:
1. Technical development in reregulated markets
2. Enterprise in a reregulated world
3. The role of the Government in a reregulated world
4. Synthesis report entitled "Cooperation and technical development in a reregulated and changed world" or "Important mechanisms for the innovative processes in reregulated markets."

APPENDIX 3

Influences and literature

Individuals

Individuals who to date have actively participated in discussions regarding this project include: Jan-Åke Karl (Telia), Thomas Korsfeldt (DG) and Egil Öfverholm (Swedish Energy Agency), Thomas Falk (formerly of the Confederation of Swedish Enterprise), Billy Fredriksson (Director of Technology at Saab), Staffan Håkansson (CEO of Bombardier), Göran A. Persson (IVA Energy Foresight), Dag Holmberg (Head of R&D at SVK, Swedish Power Grid), Daniel Johannesson (Deputy MD Skanska, formerly CEO of SJ and Kinnevik), Nils Nygren (Vice President Birka Energi), Lennart Klerdal (Head of R&D at Birka), Lennart Sparring (Green Cargo), Sune Carlsson (CEO SJ) and Bengt Anderberg (DG FOI Swedish Defence Research Agency).

Literature and theoretical influences

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This paper is a report from the *Cooperation for Growth* project which is being run by the Royal Swedish Academy of Engineering Sciences, IVA, for the purpose of investigating whether it is possible to find new forms of cooperation.

In many respects, Sweden is an unusual industrial nation. One specifically Swedish phenomenon often referred to is the cooperation that has historically existed between government, industry and academia. We sometimes refer to this as the *Triple Helix*. Examples such as the AXE system (exchange technology in the telecom field), HVDC (direct current transmission), X2000 (express train) and JAS (military aircraft) are frequently cited in debates about the positive effects of past cooperation between, among others, Televerket (Swedish Telecom) and Ericsson; ABB and SJ (Sweden's National Railway); Vattenfall (public energy utility) and ABB; and Saab and the Swedish Armed Forces. Sweden has held an unusually strong position internationally in the telecommunications, energy, railway and defence sectors. Thus, cooperation has led to growth.
The climate today for continued cooperation of this kind has, however, changed fundamentally. One main reason for this is deregulation and the subsequent restructuring that these sectors are currently undergoing. Alternatively, one could say that it is due to the restructuring and subsequent deregulation in these sectors. Regardless of how we view the issue, the question is whether in this new business landscape it is possible to find new forms of cooperation to promote a positive trend in technical and industrial development.

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