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Corporate Governance and Innovation in Mobile Telecommunications:

How did the Nordic Area Become a World Leader?

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PREFACE

This research has been funded by the Key Action on Socio-Economic Research under the IMPROVING Programme of the European Commission under the Fifth Framework Programme. Corporate Governance and European Performance CGEP was coordinated by William Lazonick and Mary O'Sullivan at the European Institute of Business Administration (INSEAD). In addition the authors gratefully acknowledge counterpart funding for this study from the 'Næring Finans Marked' Programme of the Research Council of Norway. We would also like to thank Morten Fraas, Finn Orstavik, and Mona Domas Wibe for invaluable assistance in the preparation of this paper.

ABSTRACT

This paper studies the links between corporate governance and one of the major technological innovations of the modern era, mobile telephony. We focus on three countries of the Nordic area – Sweden, Norway and Finland – asking why this relatively small and indeed peripheral region has become a world leader in this complex and dynamic technology. Our argument is that the governance systems of the major telecommunciations service companies of the region underlies the evolution of the technology.

The approach taken to corporate governance in this paper differs from that which is common in the literature. Rather than looking at governance as a problem of how corporate managements comply with the value maximisation objectives of shareholders we follow Lazonick and O'Sullivan (2000) in seeing it in terms of resource allocation. Specifically, we are concerned with the processes through which firms allocate resources to tangible and intangible investments in innovation. A key question is how different modes of corporate governance contribute to innovation performance and economic growth over the long run.

The Nordic region is a world leader in the diffusion of ICT products and services, and has a sustained record of innovation and enterprise development in telecommunications. In recent years, most of the attention in this field has gone to such firms as Ericsson and Nokia. In 2000 Ericsson supplanted Lucent as the leading producer of telecom equipment, mainly because of its position in mobile networks. Ericsson now has a 40% global market share in GSM infrastructure systems, a strong position in other major mobile standards (such as TDMA), and was by the end of May 2001 involved in 31 of 50 3G infrastructure agreements announced, in many cases as sole supplier. Nokia has continued to increase its lead on global terminal (that is, handset) markets. In 2000 Nokia's market share was more than 30%, over double the share of second placed Motorola. Its market share had increased to more than 35% by the end of the first quarter of 2001, approaching the goal set by Nokia of a 40% global market share.

In seeking to understand the evolution of the technology, and the growth of the firms themselves, we emphasize the need to look behind the firms, at the long run commitment of resources into telecommunications in the Nordic area. The development trajectory in this field has now lasted more than a century, and has shaped the overall capabilities of the region, as well as the dynamics of such firms as Ericsson and Nokia. The long-term role of telecommunications service providers – firms such as Telia, Telenor and Sonera – is central to the development of capabilities, and the development of the technlogies and standards that culminated in satellite communications, in the NMT technology, and then in GSM. These telecoms enterprises played central formative roles in all of the major innovation decisions, and in the evolution of the technology as a whole. Telia, Telenor and Sonera are former publicly-owned monopolists, whose governance was shaped by complex social, regional and industrial objectives; the governance systems permitted the emergence of far-sighted technological cultures. So we argue that it was precisely the governance structure of these enterprises that permitted and shaped the long-term technological, engineering and skill commitments, in the face of sustained uncertainty, that made the radical innovation of mobile telephony possible. These enterprises made bold, long-term bets on a range of radical technologies in communications. It was their decisions that shaped the technologies brought to fruition by Ericsson and Nokia, and indeed they who decided which firms would win and lose, for some key equipment suppliers disappeared along the way. Now, of course, telia, Telenor and Sonera are deregulated and largely privatised, and so major governance shifts have occurred simultaeously with the evolution of the core technologies. We conclude by discussing whether and how these governance shifts affect the ability of these enterprises to sustain technological advance in the years ahead.

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Wherever two or three Swedes, or Norwegians, or Danes, or Finns of Scandinavian descent, are gathered together, they almost infallibly proceed to immediately establish a church, a school, and a telephone exchange,

A. R. Bennet: *The Telephone Systems of the Continent of Europe*, Longmans, Green and Co., London 1895

1. Introduction

It is often suggested that innovation is shaped by institutional factors, but innovation theory is not particularly strong in identifying the relevant institutions, let alone how they operate, or how they influence specific technological trajectories. This paper studies the impact of a central institution of capitalism, the system of corporate governance, on one of the major technological innovations of the modern era, mobile telecommunications. We focus on three countries of the Nordic area – Sweden, Norway and Finland – asking why is it that this relatively small and indeed peripheral region has become a world leader in this complex and dynamic technology.

Modern mobile telecommunications is by any standards a radical technological shift, incorporating a range of technological developments in a complex and large-scale technological system. However it is by no means a recent innovation, and has involved prolonged and comprehensive programmes of search, based on the commitment of substantial financial and technological resources over long periods, in the face of considerable uncertainty. In analysing how this was possible, we emphasize the importance of a long-run perspective focusing on the structure and operations of corporate governance in this sector in the Nordic countries.

How should corporate governance be understood in this context? Most users of the term ‘corporate governance’ are concerned with arrangements that are intended to align the behaviour of professional managers with the financial interests of shareholders – that is, arrangements that cause managers to maximise ‘shareholder value’ (an ambiguous term that usually means achieving a high stock market valuation of the enterprise). But corporate governance can be thought of differently, in the manner pioneered by Lazonick and

O'Sullivan, as the process through which resources are allocated within the enterprise (Lazonick and O'Sullivan, 2000). Their approach, followed here, focuses on the enterprise strategies and processes of control that encourage or inhibit the commitment of resources to the development of the enterprise: such resources include training and capability-building, R&D, engineering development, and capital investment. Here, the institutional mechanisms are likely to be far more complex than those relating simply to the financial performance of enterprises.

In Nordic mobile telecommunications most of the attention of financial analyists and innovation theorists has been on the spectacular performance of such companies as Nokia and Ericsson – hardware producers which have generated a constant stream of product innovations. However we emphasize the long-term role of telecommunications service providers – firms such as Telia, Telenor and Sonera. These enterprises played central formative roles in the innovation decisions, and in the evolution of the technology. We argue that it was precisely the governance structure of these enterprises that permitted and shaped the long-term commitments that made this radical innovation possible. These enterprises are former publicly-owned monopolists, now deregulated and largely privatised, and so major governance shifts have occurred simultaeously with the evolution of the core technologies. We shall argue that these governance shifts raise interesting questions about the continued ability of these enterprises to sutain technological advance.

This paper has three sections. The following section briefly outliens the dimensions of ICT diffusion in the Nordic area, and some of the issues raised by it. This is followed by an extended overview of the development of the major telecoms suppliers in the Nordic area, focusing on three companies - Telia, Telenor and Sonera. We then turn to an analysis of the development of wireless communications in the Nordic area, exploring the links between the governance of these enterprises, the evolution of the technology, and innovation in the supplier enterprises.

2. Telecommunications services and diffusion in the Nordic area

In terms of most indicators of ICT use, the Nordic countries are among the global leaders. On the ITU composite telecom indicator (based on penetration rates of mobile phones, internet hosts, internet users, PC ownership and ISDN subscribers) Norway, Finland, Denmark and Sweden rank respectively numbers 1, 2, 3 and 6 in the world. Along a series of indicators of telecom use, there is at least one Nordic country among the three global leaders in each area. In four of six indicators from the ITU *World Telecommunications Database* shown below, a Nordic country tops the list. Just as they were global leaders in the implementation of fixed telephony during the first decades of the telephone's history, they are global leaders in the implementation and utilisation of advanced telecom systems, mobile telephony and wireless applications today.[1]

[1] A similar picture is painted at the EU level in the recent ESIS report, DG Information Society, *Information Society Indicators in the Member States of the European Union*, European Commission October 2000.

Figure 1
Selected telecom penetration rates 2000. Global leaders and Nordic countries.

		Global leadership			*Nordic countries*			
		1	*2*	*3*	*FIN*	*NOR*	*SWE*	*DNK*
Main lines per 100 inhabitants	*Country rank*	DNK	NOR	CHE	13	2	5	1
	Value 2000 or latest avail. year	75.3	72.9	72.0	55.2	72.9	68.2	75.3
Digital main lines of total	*Country rank*	ISL	FIN	JPN	2	5	7	10
	Year achieved 100%	1995	1996	1997	1996	1997	1998	1998
Cellular subscribers per 100 inhabitants	*Country rank*	AUT	ITA	FIN	3	5	4	12
	Value 2000 or latest avail. year	78.6	73.7	72.6	72.6	70.3	71.4	61.0
ISDN subscribers pr 100 inhabitants	*Country rank*	NOR	CHE	DNK	11	1	14	3
	Value 2000 or latest avail. year	11.9	10.3	7.0	3.0	11.9	1.3	7.0
Personal computers pr 100 inhabitants	*Country rank*	USA	SWE	CHE	8	4	2	7
	Value 2000 or latest avail. year	58.5	50.7	50.2	39.6	49.1	50.7	43.2
Internet hosts pr 100 inhabitants	*Country rank*	USA	ISL	FIN	3	5	9	11
	Value 2000 or latest avail. year	29.3	14.2	10.2	10.2	10.1	6.7	6.3
Internet users pr 100 inhabitants	*Country rank*	ISL	POR	NOR	7	3	4	9
	Value 2000 or latest avail. year	59.8	59.5	49.1	37.2	49.1	45.6	36.6

Source: ITU World Telecommunications Database, 2001

These countries are among the global leaders in the development and use of new telecom services (such as text messaging), as well as being host countries of major global producers of telecom equipment and systems. With wireless systems and applications being regarded as one of the major dynamic areas of ICT growth at the present time, we have a unique situation in which very small countries are playing a leading role in an important technological revolution. Because of this rapid diffusion, the Nordic area functions as a global test laboratory of new and prospective wireless technology and related consumer dynamics.

In analysing this achievement, most analysts have focussed attention on the two major producers of telecom equipment, Ericsson and Nokia, and their transformation over the last 20 years into global leaders in the area of mobile technology. During the late 1990s these firms were discovered by international capital markets, despite the fact that each company has a business history of more than a century, and they became stars of the international stock markets. This was primarily a result of their entry into and success in wireless telecommunications. The interesting question of *how* these two companies succeeded in this technological and business transformation is often addressed purely at the company level, focussing on innovative strategic initiatives by company management. Nokia CEO Jorma Ollila, for example, is frequently portrayed as a maverick manager who saw something in 1992 that nobody else saw, and acted on it to make Nokia a global leader.

This perspective is misleading. Certainly, these companies have had a remarkable development, and their managements have made a range of wise choices and bets. However, focussing just on these companies and their global activities cannot provide a full understanding of how they attained their present positions. They are part of wider techno-industrial complexes, or development blocks to use Erik Dahmén's famous concept, that have been a significant focus of national industrial policies in their respective countries for many decades. The long-standing relation between Televerket (the Swedish PTO) and Ericsson is a classic case of an integrated 'development pair' (Fridlund 1997). We argue that these contextual aspects ultimately provide the link between the two empirical facts of rapid deployment and social acceptance of telecom services in these countries, and the global position attained by these companies, as well as being important factors in the shaping of the strategic choices and priorities made by companies such as Ericsson and Nokia.

The Nordic PTOs, the national telecom service providers, have played a major, indeed often a decisive, role in the development and diffusion of ICT in the Nordic area. Much of the hardware development has occurred in tandem with long-term innovations in types and levels of telecommunications services, and the service providers have played a major role in shaping the evolution of the technology, the standards it embodies, and therefore the whole process of equipment supply. We claim here that the former public PTOs[2] were decisive for the later global success of the Nordic telecoms industry, and especially for Nokia and Ericsson. As we shall show, this was part of an evolutionary process: other lines of technological advance emerged, and other companies developed and died along the way. But we look beyond the growth of these companies to the development of mobile cellular telephony as a whole. Our argument places great emphasis on the design and procurement role of the PTOs, as organizations with a strongly forward-looking and technology-oriented role. It was the governance structures of the PTOs, not just the entrepreneurial capabiliteis of specific hardware suppliers, that laid the foundations of wireless telephony success in the Nordic area. The governance structures associated with the PTOs were crucial in establishing a framework for technological system development and commercial exploitation of telecom developments. Over the past decade these governance regimes have changed considerably. In the finals ection of this paper we raise questions about the capability of the present governance regime in these enterprises to launch development projects of similar technological and economic scope in the future.

3. Changing roles of the Nordic PTOs – an overview

In this paper we keep our focus mainly on the former PTOs in Finland, Norway and Sweden, since they were key organisations within the telecommunications systems of individual countries, and in the Nordic area as a whole. In fact their influence, via the establishment of standards (notably GSM) has been global.

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[2] We use the generic PTO acronym for the public telephone and telegraph organisations and authorities, instead of the more common concept of PTTs, Post, Telegraph and Telephone organisations. In the three countries considered here, the PTOs of Sweden and Norway were organised outside the public organisation of postal services from the beginnings in the 1850s. The Finnish history differs from the Norwegian and Swedish ones; there, the early public organisation of telecom activities is intimately linked to the political history of Finland up to the mid-20th century. A separate PTO was organised from the integrated PTT, established in 1927, in Finland as part of a reorganisation following the new Telecommunication Act introduced in 1987. A large number of private telecom suppliers, today organised in the Finnet Group, have played a significant part in the Finnish telecom system since its origins more than a century ago.

There was nothing accidental about this. The national PTOs built substantial technological and telecom-related competences especially during the post war period, using their position to shape national telecom systems and industrial development. However, during the last 25 years these organisations have been through a major transformation process involving de-regulation and privatisation. The de-regulation process implied a radical change in the governance structure of these organisations, as well as in their development strategies of technological systems and telecom services. The immediate task of this section is to sketch the differences in the governance systems and innovation strategies of these companies before, during and following the de-regulation period. We will do this by outlining the structure and governance system of PTOs at three points in time, together with describing their contemporary innovation strategies and how these were set;

- *during the late 1970s*. This was the high point of the original integrated PTO structures, at a time when automation of the telecom systems and program controlled switching systems was promising the completion of the tasks of providing voice-based analog telephony to all citizens. The emerging agenda of digitalisation and promises of wider telecommunications provided promising scenarios for future telecom systems and the role of the PTOs. The PTOs had a strictly national focus and were increasingly seen as a vital element of national technological infrastructures, supporting national development of new industrial activities. In governance terms, PTOs were closely connected to relevant ministries, and strongly oriented towards technology objectives.

- *in the mid-1980s*. At this time the process of de-regulation was in full sway. As monopolies were de-regulated the PTOs, their supervising agencies and policy were hard at work trying to find ways to reorganise the PTOs to meet competition in several segments of their activities. While the functional aspect of contemporary PTOs still were mostly national, the regard for internationalisation of technology and system development had increased.

- *at the end of the 1990s*. In 1998 all countries were required to comply with the EU directive on telecom regulation and to have a deregulated telecom system in place. The chain of market regulation, certification and supply of telecom services had by this time been fully reorganised, while the national telecom operating companies had been reorganised on the basis of stock-based ownership and limited liability. By 2000 the telecom industry was generally regarded as a globalised industry, with expectations of the future industry to be dominated by trans-national, even global, oligopolies in service provision, in system deliveries and technology development. Government holdings in these companies remained, but governance had largely been transformed. [3]

Today the most visible heritage of these PTOs, the Swedish company Telia and Sonera in Finland, from 1 January 2003 forming the TeliaSonera Group, and the Norwegian Telenor, are organised as joint stock companies, with a rapidly diminishing public ownership. As these companies emerged during the 1980's and 1990's the organisation of PTO activities was fundamentally altered. Firstly, the reorganisation of the former PTO agencies as publicly owned companies was accompanied with a devolution of a wide range of the *de facto* monopoly rights of these agencies, on terminal equipment, on service provision etc. Secondly, their responsibilities for national standardisation were transferred to new and separate telecom authorities. Lastly, responsibility for regulation and competition surveillance was placed with new authorities outside the reorganised PTOs.

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[3] In May 2001 the Swedish and Norwegian Parliaments acknowledged a goal of reducing puiblic ownership to 30-35% from today's 70-75%.

We will argue that the performance of these companies raises important issues related to innovation and corporate governance, since each has emerged from public ownership (and in fact are only partly privatised today), yet all have been responsible for ambitious investment and innovation strategies. It is often suggested that much of the dynamism of modern telecoms results from deregulation and more market-oriented strategies and modes of governance. But the governance issues are far more complex than just a public-private transition accompanied by rapid growth. There has in fact been a complex four-way interaction between publicly owned telecommunications companies (and their research arms); government ministries responsible for transport, posts and telecommunications; government agencies responsible for industrial strategy; and major supplier companies. The present dynamism of telecom development is closely linked to features of the former PTO-based telecom system. To some extent it may be argued that the present dynamism is a direct effect of choices and priorities made by the 'old' system. For example, Ericsson's later success may be traced to one single project, the PTO-Ericsson joint venture that developed the digital AXE switching system, a venture initiated in 1970 at the prime minister level (a case that will be discussed in more detail below).

So the current highly competitive telecommunications markets in the Nordic area should not obscure the far more regulated background within which key telecom technologies were developed. In analysing these developments, we argue that Nordic telecommunications development should be seen not only in terms of institutional interactions and collective development, but also as a cumulative process occurring over a very long time period. This is not just a matter of looking back over a decade or two. In fact the relevant time periods are long – it could be argued that a good understanding of Nordic developments in this field requires a horizon of a century or more. Even with respect to the current technology, key decisions go back thirty years or more. In any event, in what follows, we adopt a historical approach, stressing the importance of cumulative innovation and investment decisions over long time periods. This is important not only in understanding the course of developments, but also in understanding what did not happen – why, for example, did producers in Norway and Denmark, with leading technological capabilities in radio transmission systems, fail to develop?

4. Corporate Governance in Swedish Telecom – Structures and Strategies

Organizationally, Televerket had for a long time been dominated by civil servants and engineers, generating a genuine engineering culture with a strong technological focus. A factor, contributing to this technologically oriented organisation culture, was the tradition of educating own staff through the "school of telecom" (Teleskolan). Educational facilities included both general introductory courses for non-skilled workers as well as higher degree engineering studies. Consequently, not too many university graduates were employed in Televerket in the period in question, a situation that did not change until the 1980s and 90s. In ths respect it is worth noting that Televerket's practice was similar to that of large Japanese corporations. In Televerket, this practice was maintained for many years and had a great impact on the character of the organisation.

During the 1960s and 1970s, Televerket went through a series of comprehensive restructuring campaigns, aiming at rationalising the organisation. Following a parliament decision in 1965, Televerket established its first subsidiary company, Telefabrikation AB (TEFAB), in January 1966, with a share capital of 10 MSEK. In the following years, the Parliament decided that three additional companies should be created within Televerket. The first was the wholly

owned subsidiary Swedish Telecommunication Consulting AB (Swedtel) in 1968[4], then ELLEMTEL[5] was established together with LM Ericsson in 1970. Finally, in 1972 the 50% owned SOS Alarmerings AB (SOSAB)[6] was created to promote the establishment of local emergency centres. Wthin the organisation of Televerket, the levels of authority were reduced from seven to four and the telephone operations were divided into 20 "teleregions". Thus, a matrix organisation was created, where vital functions were coordinated in centralised agencies common to all the teleregions. One of these functions was marketing, which never had been an issue in Televerket until the marketing division was opened in 1971. In addition some nationwide divisions were kept, like the industrial division (Teli), the radio division, the material division and the buildings division. The overall objective of these measures was to gather similar activities in individual agencies, clarify functions, support delegation and generally increase the economic efficiency of the organisation (Lernevall and Åkesson 1997). Another important incidence coincided with this organisational transformation of Televerket in the 1970s, namely the appointment of Tony Hagström as Director General in 1977. Hagström was a high-profile economist, who had enjoyed a rapid political career as parliamentary secretary in the socialist government's Ministry of Industry, before the conservatives took over in 1976 (Andersson 1999). The choice of Hagström as DG reinforced the shift in Televerket's strategic focus towards a market orientation, that was indicated the early organisational changes around 1970.

The move to liberalization

In the 1980s, Televerket was subject to very much the same legislative governance structures as in the 1970s, implying that there were no real changes in the appointment and composition of Telestyrelsen. In 1986, all previous instructions and statutory instruments were replaced by a new legislative decree, Teleförordningen, which was in force to 1993 when it was substituted by the first Swedish law of telecommunication. Predominantly, the content of Teleförordningen resembled the decrees it replaced, except for some new elements following the 1980s liberalisation process of the telecommunications sector, which will be the main theme here.

Altogether, the 1980s represented a decade of major change for Televerket, in terms of both technology and altered market conditions. In this period, the telecommunications sector in Sweden, as well as in most other countries, was subject to a liberalisation process, which implied that the previous monopoly gradually ceased to prevail. In addition, Televerket was facing the challenge of technological convergence, and the technological diversification resulting from it. In many ways, the process of convergence represented a technological discontinuity, to which Televerket had to adapt, although it allegedly imposed far-reaching consequences on its operating environment. In this respect, major political and organisational changes seemed appropriate as means to adapt to the challenges posed by this development. This seemed to be the general opinion of both Televerket and the political authorities at the time, and major efforts were made towards market orientation of Televerket.

The initial steps towards market orientation

According to Karlsson (1998), the first signal of the forthcoming liberalisation of the telecommunication sector occurred as early as 1965, when the Parliament decided that Televerket should establish TEFAB. Allegedly, TEFAB represented a means to strengthen the

[4] Swedtel later became the largest telecommunication consulting company in Europe.
[5] See below
[6] The other 50% of the shares was owned by Kommunförbundet (Swedish Association of Local Authorities) and Landstingsförbundet (Federation of Swedish County Councils) (Karlsson 1998).

manufacture capacity of Televerket, in the face predicted growth flowing from new developments in telecommunication technology. Thus, the establishment of TEFAB seemed both to imply a clearer technlogical orientation, as well as to clearing the way for the process of market orientation, which characterised Televerket's strategic behaviour in the 1980s.

In October 1980, the non-socialist coalition government then in power presented an additional bill, P 80/81:66, where the issue of telecommunications was addressed. Here, the overall political objectives of Televerket were formulated for the first time, stating that Televerket was to be responsible for satisfying the requirements of Telecommunications for both individuals as well as society in general. Additionally, the government made it clear that they regarded information technology an area of priority, as a means to improve Swedish industry and to increase Sweden's competitiveness internationally. By presenting this telecommunications bill, the government had placed telecommunication issues on the political agenda and thus facilitated the forthcoming self-government of Televerket. The proposals of the bill, which was based on a previous initiative from Tony Hagström and Televerket, fell into two main categories - the first concerned the demarcation of the monopoly sector, and the second affected the organisation of Televerket (P 80/81:66, Karlsson 1998, Lernevall and Åkesson 1997).

The telecommunications bill proposed that only equipment for voice communication over the public telephone network and modems for data transmission should be included in the monopoly sector (P 80/81:66). However, the proposal to cease the annual assessments of Televerket's investments was not endorsed in this document. The socialist government headed by Olof Palme, which succeeded the coalition government in 1982, pursued the policy established in the 1980 government bill. During the 1980s, it sought to open up competition in telecommunication equipment and services, by gradually diminishing the monopoly sector of Televerket. Telex-equipment was omitted from the monopoly sector in 1984, telephones in 1985 and private branch exchanges in 1988/89. In 1988, the government made the decision that Televerket's monopoly in equipment and services was to be removed completely, which was put into effect in 1989 (Lernevall and Åkesson 1997, Karlsson 1998).

As to the liberalisation of telecommunication infrastructures, the course of events progressed somewhat differently. According to Andersson (1999), the first private mobile network in Sweden was set up in 1964. In the subsequent years, a few other local networks were established as well. The only constraints to new entrants in this sector were 1) the limited availability of radio frequencies, and 2) the necessity for a permit to connect a mobile network automatically to the public telephone network (Karlsson 1998). Televerket was in charge of the implementation of these issues, which it enforced restrictively, and Televerket was therefore virtually a monopolist in this sector as well. However, in 1981, after a series of petitions, refusals and complaints, a company called Comvik AB was granted permission, through a government decision, to become the second national mobile operator in Sweden in competition with Televerket. Televerket opposed this decision, and during the 1980s, several confrontations took place between the two operators. These conflicts involved amongst others the "competition authority", as Televerket in this period played the role both of an instance of authority and a business organisation (Karlsson 1998). In 1985, the parliament allowed further liberalisation of infrastructures when it decided to opt for competition in the cable television market.

The Kinnevik Industrial Group, which owned, amongst others, Comvik AB, came to play an active part in the liberalisation process, by advocating the pre-eminence of free competition over the earlier regime in telecommunication infrastructures. On behalf of the group's many companies, they repeatedly challenged the prevailing regulations of Televerket's monopoly

sector during the 1980s. Gradually, as the monopoly sector was reduced, Kinnevik claimed the right to offer additional services in the field of telecommunications. In 1988, another Kinnevik company, Comvik Skyport (later Tele2, now a major operator) received permission to establish an international business telephone service between Sweden and USA, based on satellite communication. In the following years, two other companies, Comviq GSM (1988) and Europolitan[7] (1990), were given licences to operate digital mobile systems in competition with Televerket (Andersson 1999).

Separation of authority and control in Televerket

The organisation of Televerket as a public enterprise was made an object of analysis several times prior to the 1980s, but no changes were carried out at that time. However, following the successive reduction of the monopoly sector, it became clear that the integration of business and control in Televerket was a problem for development of the telecommunications market in Sweden. The Kinnevik Industrial Group called attention to this instance several times, with reference to the question of fair competition. Hence, the amalgamation of authority and business in Televerket became an issue in the political debate on telecoms, and the structural separation of these functions was carried out progressively during the 1980s and 1990s, starting with the establishment of Avdelning P. According to Ingelstam (1991), being organised as a public enterprise conferred many advantages on Televerket, in particular regarding control of priorities regarding the running expenses of the organisation.

Since most of the Swedish expertise in telecommunications technology was assembled in Televerket, the public enterprise form allowed Televerket substantial control in most areas of telecommunication, particularly with respect to technological issues. This never seemed to be a problem as long as Televerket held the status of a public monopolist. In 1989, following many complaints regarding Televerket's bias in favour of own interests, both in connection with equipment and infrastructure competition, the government decided to establish a national telecommunications council (Statens Telenämnd, STN). STN took over the responsibilities of the two above-mentioned agencies in 1990, and it assumed the function of frequency administration in 1992 as it was converted into the National Telecommunications Agency (Telestyrelsen) (Karlsson 1998).

Finally, in 1993, when Televerket changed its organisational status to a state-owned limited liability company, the separation of business and authority was completed. Telestyrelsen was then placed in charge of the previous activities of STN, licensing activities previously administered by Televerket as well as standardisation activities and general regulation of the competition in the sector. Altogether, the changes made in the authorities relations to Televerket made the Swedish telecom sector the most liberalised in Europe at the time. Below is a comparison between Sweden and the EU in 1993 with respect to the state of the liberalisation process in the Telecommunication sector.

[7] Europolitan was originally named NordicTel

Products and services	*EU (exl. UK)*	*Sweden*
Terminals	**Free market**	**Free market**
Telephony services	**Monopoly**	**Free market**
Third-party traffic (telephony)	**Restrictions/ ban**	**Free market**
Data communication services	**Free market, latest - 96**	**Free market**
Third-party traffic (data com.)	**Free market, latest - 96**	**Free market**
Value added services	**Free market**	**Free market**
Satellite communication	**Limited freedom**	**Free market**
Mobile telephony	**Monopoly/duopoly**	**Free market**
Setting up physical networks	**Monopoly**	**Free market**
Cable TV	**Geographical monopolies**	**Free market**
Separation of business and authority	**Completed**	**Completed**

Fig: Telecom policy in the EU compared with Sweden – 1993 Source: Telia Annual report 1993

Corporatisation of Televerket and the first Swedish law of telecommunications

The decision to create Teleinvest signalled that the government had accepted Televerket's vision of the new challenges for the telecommunications sector, and represented the first serious step in the process of corporatisation of Televerket. This finally culminated in 1993, by the transformation of Televerket into a wholly state-owned limited liability company, named Telia AB.

In 1988, the government had initiated another inquiry regarding the organisational status and responsibilities of Televerket, in which Televerket was well represented. Unfortunately, many participants in the working group died in an air crash in 1989, and the work was temporarily impeded (SOU 1990:27). In 1990, the work was completed and it concluded that Televerket had both a regional and social responsibility, regarding the fundamental objective of providing telecommunications, primarily telephony, to all citizens. It was furthermore stated that Televerket would be better equipped to face the challenges posed by developments in telecommunications technology and markets if the organised as a limited liability company (SOU 1990:27, Lernevall and Åkesson 1997). Based on this inquiry, the government decided in 1992, to convert Televerket into a wholly state-owned limited liability company, Telia AB, on the 1st of July 1993. During 1992, Televerket was obligated by the Swedish government to pay a one-time sum of SEK 5 billion to the state treasury, as well as to buy out a state loan of SEK 2.2 billion.

In a 1991 government decision, regarding interconnection to the public network, the new non-socialist coalition government stated that Televerket must allow third party traffic on this network. Following this decision, the Kinnevik industrial group decided to establish Sweden's second national operator on fixed telephone services, and Comvik Skyport was renamed Tele2 for this mission. Finally, in 1993, conditions for the regulation of the various telecom

operators' activities were assembled in Sweden's first law of telecommunication. According to Lernevall and Åkesson (1997), the law specifically highlighted its neutrality in competition matters and stated that telephone tariffs were to be decided by the respective telecom operators according to own costs, and that these must be open to public examination. However, telephone services via the public network were prescribed not to exceed a certain cost.

4.1 Technological strategies

Televerket had a long history in R&D and technology development. In 1918, telecommunications technology involved telegraphy and telephony, but during the years to come, the field telecommunications evolved to comprise increasingly more complex and diverse technology. As described above, the establishment of the industrial division in 1891 allowed Televerket to be active in telecom technology research, and over the years, the administration was involved in various R&D projects. Between 1918 and 1980, the research agenda constituted, amongst others: automatic, and later, electronic telephone switches, private branch exchanges, mobile telephone systems, television, radio links, telefax, computer networks and data transmission, the potential of satellite technology, cable TV and alarm systems, as well as the contingency of computer-monitored telephone exchanges (Karlsson 1998, Lernevall and Åkesson 1997). Additionally, new technologies including telex, computers, transistors, trans-Atlantic telephone cables, colour television, satellites, mobile telephone systems, data transmission via modem (Datel) and a paging system (MBS) (Karlsson 1998, Tahvanainen 1993). Moreover, both L M Ericsson and Televerket introduced several innovations in this period. Many of these inventions came into being because of the on-going automation of the fixed telephone network, either directly as a response to demands arising in the automation process, or indirectly, as the automation process represented a starting point for further research, for instance in relation to the upcoming digital technology.

In the 1970s, R&D activities in Televerket were generally carried out in the individual divisions according to their fields of specialisation. In particular, the technical division and the radio division represented major contributors of R&D to the organisation. Additionally, Televerket performed considerable R&D in co-operation with L.M Ericsson in the joint development enterprise ELLEMTEL. In 1981, Televerket initiated an operation named Teldok, which was intended for documentation and publication of information regarding telecommunication technologies in working life. According to Lernevall and Åkesson (1997), research work produced by Teldok was available to the public free of charge and much of it constituted the basis for Televerket's strategic decisions. After the corporatisation in 1993, Telia took over the Teldok activities, which are still major sources of information on telecom technology and market issues.

The 1983 establishment of Avdelning [Department] P represented the first effort to centralise R&D activities in Televerket and was constituted by merging existing research units in Televerket, mainly sections from the technical division. Avdeling P had three main objectives. Firstly, it coordinated the research operations of Televerket. During the 1980s, Televerket had increasingly come to participate in international research and development projects. Hence, one of the chief assignments of Avdelning P was to act as a central coordinating unit for Televerket's research activities. Secondly, Avdelning P was responsible for testing, documentation and approval of telecommunications equipment produced at Televerket's own manufacturing plants, and after 1985, the testing of equipment from other suppliers. Avdelning P was also in charge of the standardisation and patenting activities of Televerket. Thirdly, Avdelning P was carrying out its own research within various fields of telecommunication as well, although it was not the only R&D unit at the time. Research in

for instance mobile technology was not included in the operations of Avdelning P, but was carried out in a separate branch placed under the radio division. In 1991, Televerket established a separate research company, Telia research, which comprised Avdelning P and all other research departments of the organisation.

International and Nordic co-operation

Nordic co-operation in the field of telecoms has existed for a very long time, a fact which became extremely important in the development of mobile telephony. In fact, as early as 1855 the DGs of the Swedish, Norwegian and Danish telegraph administrations met and discussed common business matters, and from 1916, Nordic telecom conferences were arranged (almost) annually (Heimbürger 1968). In the 1960s and 70s, the Nordic countries undertook several co-operative telecom projects, headed by the national telecom operators. In the introduction to Lernevall and Åkesson (1997), Bertil Bjurel[8] highlights three instances in which the joint Nordic effort was decisive. Firstly, the collaborative work which resulted in the establishment of a Nordic satellite station in Tanum (Sweden) in 1971. Secondly, the Nordic co-operation in the development of a common Nordic computer network, the datex-network, which was put into commercial use in 1981. And finally, the joint effort in mobile telephone technology development, leading to the launch of the Nordic Mobile Telephone standard, NMT, in 1981.

ELLEMTEL

From the 1930s, Televerket also participated in co-operative R&D with LM Ericsson on mathematical optimisation of telecom systems, which was intensified during the 1950s and 1960s (Lernevall and Åkesson 1997). However, the major breakthrough of Televerket, and indeed Ericsson, regarding the development of digital technology, followed the establishment of ELLEMTEL Utveckling AB in 1970. ELLEMTEL was a joint venturefor R&D and production between Televerket and LM Ericsson and represented a contractual continuation of the long tradition of research collaboration between the two. Early in the 1950s, subsequent to the advances in microelectronics and the invention of semiconductors and integrated circuits, Ericsson had started a new research project utilising this technology to develop an electronic telephone switch. Televerket commenced a similar project a few years later, in 1963 (Tahvanainen 1993). Allegedly, these projects were more complex and resource consuming than expected, and a joint effort between the two seemed plausible (Karlsson 1998). Consequently, ELLEMTEL was established with the main objective to use and improve existing electronic switching technology to develop computer-controlled telephone exchanges, which later became known as the AXE technology. In 1976, the first AXE 10 exchange was ready for trial, and in 1980 the first AXE stations was put into regular service (Tahvanainen 1993). So by the 1980s, Sweden had the highest telephone density in the world (Tahvanainen 1993), but was also was at the vanguard technologically both in mobile radio communication and in research of data transmission and electronic switching systems.

Technological integration and diversification

Major changes occurred in telecommunications technology all over the world in the 1980s. The advances in microelectronics rendered possible a large-scale usage of digital technology to improve and replace existing systems. The economic potential of microelectronics in this respect contributed to the increased research and development regarding its areas of application, which turned out to be fundamental to innovation in telecommunications. Hence, in the 1980s, integration of the previously independent segments of the computer and telecommunications technologies emerged in a very rapid pace. This again fuelled

[8] CEO of Televerket from 1966 to 1977.

technological diversification, in terms of numerous new technologies and services in the intersection of telecommunication and computing, and thus, the general competition in these areas (McKelvey, Texier and Alm 1998).

Televerket became aware of the importance of having a competitive strategy resting on the convergence of telecom and computer technology, at an early stage. They acted to promote liberalisation, through several proposals to the public authorities, as a means of facing the novel challenges of the Swedish telecommunication industry. Thus, widespread technological development, hand in hand with liberalisation of telecom regulations, characterised the period between 1980 and 1993 in Sweden, which began with a conservative government coalition in command. In the 1980s Televerket's main strategies seemed to be constituted by researching the potential of data transmission, mobile communication and satellites and it was involved in international standardisation activities in all these matters.

Mobile telecommunication

The 1980s was the era of the pan-Nordic NMT standard, which was launched in the Nordic countries in October 1981, as NMT 450. In 1986, at the same time as NMT 900 was released, Televerket introduced the mobile text communication service, Mobitex. Mobitex was a mobile messages service based on the mobile radio network (MRT) developed in the 1970s. Mobitex expanded very modestly in the beginning and the service did not gain a surplus in Televerket until 1993. Furthermore, Mobitex may be seen as a precursor to the Short Messages Service (SMS). In 1993, the two NMT systems had more than 770 000 (263 100 and 511400 respectively) subscribers (Karlsson 1998), and Sweden had the highest mobile phone penetration rate in Europe with about 7% (Hommen and Manninen 2001). The relative success of mobile telephony in the early years after the introduction may be one reason why Televerket in Sweden apparently had more confidence in the potential of this new technology than the PTTs in the other Nordic countries seemed to have. Hence, before the development of the first NMT system was completed, Televerket was already considering the development of the digital mobile telephone standard, which later became known as GSM[9]. GSM was introduced in Sweden in 1992. In relation to the standardisation work on GSM, Televerket was involved both in the work of CEPT (Conférence Européenne des Administrations des Postes et Télécommunications), later ETSI (European Telecommunications Standards Institute).

Data communication

Even though the oldest means of telecommunication, namely the telegraph, was decreasing in the 1980s, Televerket was still involved in the development of text communication technology (Tahvanainen 1993). During the end of the 1970s, the magnitude of data communication (Datel) had increased, and Televerket responded to this by developing a public data transmission network and then introduced an array of new public services. In 1980, Televerket introduced Telefax. In 1981 they were featuring Datex, which was a data transmission service based on circuit-switching technology. In 1983, Teletex, an improved version of the telex, was in commercial use (Tahvanainen 1993). In 1981, Televerket also offered a nation-wide packet-switched service of data transmission called Telepak. Televerket expanded and renamed this service Datapak in 1984, apparently with the intention of building a public packet-switched network (Karlsson 1998).

ELLEMTEL was heavily involved in most of the research activities behind all these new inventions in data and mobile communication. Finally, in this period, other services such as

[9] Global System for Mobile communication, previously Group Spécial Mobile

"heta linjen"[10], "conference-TV" for business meetings, Text-telephone for hearing-impaired persons and a wide range of telecommunication consultancy services.

Satellites

In relation to both data transmission and mobile communication, satellite technology was a separate research area in Televerket; it began in earnest the early 1980s. In the 1970s, there had been discussions on the political level regarding Nordic co-operation in space and, in particular, of a Nordic satellite test-project, TELE-X. Subsequent to a political decision 1982, the Swedish private limited company, NOTELSAT, was founded. NOTELSAT was jointly owned by the telecom administrations in Sweden and Norway and had conducted the TELE-X project. Even if the enthusiasm on behalf of the potential of satellites was very high in 1982, TELE-X ran into problems after a while and it was never realised on a commercial level as intended (Lernevall and Åkesson 1997).

Telia commands a leading position in all telecommunication divisions in Sweden, at the same time as the company is expanding in neighbouring markets. In particular, the Baltic regions have been an area of priority and today, Telia is active in all Nordic countries and all Baltic States. In addition, Telia has operations in numerous countries outside Europe. From early on, the main strategy in the neighbouring Nordic countries was to establish undertakings under its own management. The first foreign operation set up was in Denmark, in 1994. In the Baltic States, the main strategy has been to invest in existing operators in office and to get them ready for market competition in advance of the anticipated deregulation. The first investment in this area was in Estonia, in 1991. Telia also established itself in Poland as a secondary operator in fixed telephony in competition with the nationwide, state-controlled telecom operator. In the St. Petersburg region, Telia is a partner in one of Russia 's most successful GSM operators. Today, Telia is involved in the development of 3G mobile UMTS network in all the Nordic countries.

5 Telenor

Telenor is the leading telecommunications company in Norway, which hosts one of the most advanced telecommunications markets in the world: it has the world's highest penetration rates for mobile phone, fixed line digital telephony, personal computer and Internet usage. Telenor also has substantial international operations and investments, particularly in the areas of mobile phone, fixed line digital telephony, personal computer and Internet and Internet protocol-based communications services, satellite services and pay television services.

5.1 History in brief

Telegraphic service was established in Norway in 1855 under the name Telegrafverket, and the first telegraph line was opened soon after.[11] In 1968, the organisation of Telegrafverket was changed, when the central administration was moved from the Ministry Posts and Transport and converted into an independent state enterprise with its own board. This change implied that the agency was formally more independent than before, and in the process Telegrafverket changed its name to Televerket. The research institute of Televerket,

[10] A telephone service where several people can talk together at on a line the same time.

[11] The Norwegian Telegrafverket has had several names throughout the time of existence. In the period from 1855-1919 the agency had several names: Telegrafvæsenet. Statstelegrafen, Rikstelegrafen and Telegraphværket. 1919- 1933: Telegrafvesenet, 1933-1969: Televerket, 1969-1994: Telegrafverket, 1994-: Telenor AS. In this paper Telegrafverket will be used when we describe the period before 1933, Televerket will be used in the period 1933-1994 and Telenor from 1994.

Televerkets Forskningsinstitutt (TF), was also established at that time. Previously, Televerket did not conduct any in-house research and development. In 1971-1977, the regional division of Televerket was reorganised. Before it consisted of 12 districts and 150 local administrative units, which were shifted into a new structure of 7 tele-regions and 27 tele-areas.

On the 6th of May 1985, Parliament decided to alter the organisation of Televerket again, a reform that was formally implemented from the 1st of January 1988. The decision implied that the organisation and operations of Televerket was divided into three parts: Firstly, there was an administrative unit, Statens Teleforvaltning (STF), which was concerned with control and licensing activities, reporting directly to the Ministry of Communications (Samferdselsdepartementet). Secondly, a competitive organisation was established, Televerkets Bedriftsinterne Kommunikasjon (TBK AS), which was supposed to be relatively autonomous and direct its operations towards a limited part of the telecommunications market. Finally, the rest of the monopoly sector was to continue to have the status of a public enterprise like the former Televerket.

In practice, this meant that part of Televerket's monopoly sector was eradicated in January 1988, by the opening for competition in, amongst others, user equipment and cable TV. From 1989, Televerket was also allowed to compete in the market for value added services. In 1994 Parliament decided to convert Televerket into a state-owned public limited liability company, which took place in November the same year. In early 1995, Televerket AS changed its name to Telenor AS, with a new and business oriented organization structure. Telenor established seven main business areas: Telenor Bedrift AS (business market), Telenor Privat (private market), Telenor Nett (networks and network products), Telenor International AS, Telenor Plus AS (holding company for value-added services (VAS) companies), Telenor Mobil AS and Telenor RNT **(**Regulated Network Services) for ONP (Open Network Provision) products.

In 1993, the EU decided that the telecommunications market was to be opened for full competition by January 1st 1998. Via European Economic agreement, this decision became valid also for Norway and from that date, the telecommunication market in Norway was completely deregulated. On the 4.December 2000, Telenor went public and was listed for the first time on the Oslo Stock Exchange and on the NASDAQ in New York, USA. The Initial Public Offering (IPO) recorded the largest number of private shareholders in Norwegian history. The stock debuted at NOK 42 per share, giving Telenor NOK 15.6 billion, or USD 1.7 billion, in fresh capital.

5.2 Structures of corporate governance

Central problems and actors related to the development of Televerket's organisation form.

Televerket was established in 1855, subsequent to a parliament decision in 1854. From the start, the organisational form of Televerket has been subject to public debates. Following several revisions of the public enterprise model, Televerket was converted into a state owned limited liability company, Telenor, in 1994 and in 2000, Telenor was partly privatised with the state as the largest shareholder.

According to Vatne (1998), three main areas of problems have been central to the development of Televerket's organisation form. Thjese are firstly Televerket's independence with respect to R&D issues vs. detailed governance via the ministries; secondly, a more loose connection to the state budget as a means to increase its freedom in economic and budget issues; and finally, the question of a more independent role of Televerket outside the government administration. The development of the organisation has proceeded through

conflicts between four players in particular: The board and management of Televerket, the labour movement, the Ministry of communication and the Parliament.

Televerket's board and management have since its establishment in 1855 been fighting for their independence in investment and R&D issues, independence both with respect to ministries and to policy instructions issued from the Parliament and Government. Problems with financial support was a problem for Televerket and the demand for freedom from the state budget soon became stronger, as this was understood to imply a more business oriented direction for Televerket. The unions appeared as adversaries in this issue since they feared rationalisation and potential unemployment of their members as a consequence. This view had support from government, since communication enterprises were always of importance in welfare policy, and had a major symbolic role in public ownership.

The Ministry of Transport and Communication, with a micro-managing orientation that survived until the 1980s, seemed to be one of the main opponents to giving Televerket more freedom in economic and budget issues. It was not until the autumn 1993 that the Ministry of communication acknowledged that the organisation form of a state owned limited liability company was the only solution of Televerket in the future. Both the Norwegian Parliament and Government had a tradition of strict governance and regulation of the industrial sphere, and Televerket was from the start used as an instrument to achieve social and regional policy objectives. This built on a fundamental agreement in these issues, which crossed the borders of political parties and lasted until the mid-1970s. Then came the "Thatcherism"[12] of the 1980s. Along with major changes in the telecommunications market, the tension between political governance and freedom of business became increasingly pervasive, which produced very different opinions among the political parties regarding the optimal proportion of these two considerations.

5.3 The development of the organisation

From the beginning, Televerket was organised as a detached directorate, where decisions were made independently of the Ministry. In 1926, the central agencies of both the post and the telegraph were incorporated into the new communication department in the Ministry of Transport. This implied that the influence of the technical board (fagstyret) and the director general of Televerket was increased.

The years following World War II represented a difficult period for Televerket. The war had left the telephone network in poor condition since no maintenance or investments had been carried out in more than five years. Although the need for capital in Televerket was critical, it had to fight for funding on a level with other public tasks. In the 1950s, Televerket was organised as a directorate in the Ministry of communication. The labour union in Televerket claimed that this was an obstacle to business development and compared the public enterprise with the state owned limited liability companies. More freedom and independence would make Televerket capable of solving its financial problems and meeting new challenges. In 1955, the Post and Telegraph commission (Tvedt-kommisjonen) was set up with a mandate to examine the most rational and efficient way of organising Televerket.

The majority of this commission concluded with suggesting a new organisational form for Televerket. However, the recommendation of a more liberal solution for Televerket's organisation was not sustained and Televerket continued to be a part of the Norwegian central

[12] In Norway this is called "høyrebølgen" and refers to the change in politics from socialist values to conservative/liberal values of privatisation and liberalisation.

administration, but with the board and management now organised as a detached directorate[13]. This directorate was named Teledirektoratet. Even if the reorganisation did not imply any immediate reforms, it was nonetheless a step in the direction of more independence in business matters.

In the 1970s Televerket remained a public enterprise under supervision of the Ministry of Transport and the management consisted of the telecommunication board, the communicational council, the Director General, and the telecommunication administration.

At the beginning of 1980s Televerket's organisation was the same as in the 1970s, but Televerket's organisation form was again on the political agenda during the state budget negotiations the spring 1979. Yet another committee was instituted to evaluate Televerket's organisation and financing, Stette-utvalget. The committee proposed that Televerket should be organised as a state owned limited liability company, but the public authorities would not go so far as to liberate Televerket. Instead they proposed that the basic organisation of Televerket (the monopoly sector) was to remain a public enterprise, but with some extended authority. Still, a parliament decision of 1985 entailed a shift in the development of Televerket, when parts of the administrative tasks - such as licencing and type approval - were transferred from Televerket to an independent public institution, Statens Teleforvaltning (STF) [State Telecommunications Administration] under the ministry of communication. Furthermore, the parliament agreed to the establishment of the competitive enterprise, Televerkets Bedrifts Kommunikasjon, TBK A/S [Televerkets Company Communications]. Hence, Televerket was no longer in charge of approval and regulation commissions and TBK, the wholly owned affiliate company, was responsible for sale of terminals and additional telecom equipment in competition with other suppliers. Televerket still had the sole responsibility for the telecommunication network and installation of telephone subscriptions. However, the establishment of TBK January 1st 1988 represented the beginning of the dissolution of the telecommunications monopoly in Norway. The subsequent year, further steps towards liberalisations were carried through, when competition was introduced on value added services.

Over time, several wholly owned subsidiaries were established to meet the competition that followed in the wake of deregulation. The dismantling of the national telecommunications monopolies cleared the way for establishment of private network operators and service providers. These companies were usually subsidiaries of large foreign firms, and were at the outset active in areas such as long distance telephone and mobile short distance communications. Gradually activities expanded also to local telephone services, access services (including cable television) and several types of value adding services (information, trade, email).

During the winter of 1991, work commenced on devising a new basic organisation structure for Televerket. Even though the institution's surroundings had changed considerably, the internal organisation had been nearly unchanged since the since the early 1970s. The new reorganisation, during 1991 and 1992, proved to have very significant impact on the whole institution. On January 1, 1993 *Teledirektoratet* ceased to be operative. The administrative core of this organisation, however, continued a new existence under that name *Televerkets Sentraladminstrasjon*. At the same time, a new venture organisation was established under the name *Televerkets Nye Muligheter* [Televerket's New Possibilities]. The mission of this organisation was to help people from the old organisation build competence and find new employment opportunities, in existing or new enterprises in the telecommunications field.

[13] Borten-government 1968.

The split in a commercial part and a public service part was not a very thorough one at first. In May 1993 *Norwegian Telecom AS* was established as a holding company for the various commercial businesses, and while the board of Televerket would be the board also for the holding company, the CEO of Televerket would be the CEO also for Norwegian Telecom. In effect, the two main parts of the new organisation could be run as one corporation. Thus, in spite of the fact that Televerket formally was barred from integrating commercial businesses in the form of joint stock firms into its basic organisation, a solution was constructed whereby the management of Televerket could control all the activities that had originated inside the original telecommunications organisation.

The establishment of Norwegian Telecom can be seen as a tactical move in the progress for a more independent Televerket. The implementation of the organisation created a tension between political governance and freedom of business. With the same CEO and board represented in both organisations made the whole organisation appear diffuse and disorderly, which could not last over time. The new name of the organisation, Norwegian Telecom also sent out strong signals referring to freedom of business and a final spurt to a definite organisation of the company.

The European Community decided in 1993 to open for competition also in various areas of network operation, the infrastructure part of telecommunications. Deregulation was to be effective by January 1, 1998. After a long debate in the Norwegian parliament in November 1994, such a change was decided, and Televerket became the wholly state owned joint stock company, Telenor in 1995.

Telenor wanted to profile itself as a new company, with a stronger commercial orientation. New organisational changes were implemented, and organisational units serving a total of seven main business areas was established: Telenor Bedrift AS (for the business market), Telenor Privat (private consumers), Telenor Nett (networks and network product), Telenor International AS, Telenor Plus AS (a holding company for value-adding services companies), Telenor Mobil AS (cellular phones) and Telenor RNT for ONT (Regulated network services for open network provision) products.

As regulatory changes became effective on January 1, 1998, Telenor still consisted of the holding company Telenor AS with subsidiaries serving these main business areas, each subsidiaries encompassing several divisions and daughter companies: the overall scope of Telenor expanded dramatically.

5.4 Telenor goes public

On 4 December 2000 Telenor went public. Telenor was listed for the first time on the Oslo Stock Exchange and simultaneously on the NASDAQ in New York, USA. The IPO recorded the largest number of private shareholders in Norwegian history. The stock debuted at NOK 42 per share, giving Telenor NOK 15.6 billion, or USD 1.7 billion, in fresh capital and was valued at NOK 74 billion.

What happened prior to the IPO?

In 1994 the former government corporation Norwegian Telecom was transformed into the limited company Telenor AS, wholly owned by the Norwegian state through the Ministry of Transport and Communications. In 1998 and 1999 there were efforts toward a possible merger between the Norwegian Telenor AS and Swedish Telia AB. The aim was to partially privatise the merged company through a stock exchange listing in Oslo and Stockholm - and perhaps other stock exchanges. In mid-December 1999 the two owners - the Norwegian and Swedish

states respectively - decided to cancel the merger process, for reasons that will be discussed further below.. After that the Norwegian government proposed to partially privatise Telenor AS through a stock exchange listing - during 2001 at the latest - preferably in autumn 2000.

In June 2000 the Storting passed a resolution to partially privatise Telenor AS. This resolution involved the state initially reducing its stake by 15-25%. At the same time the Government was authorized to undertake further sales of shares, provided that the state's stake was at least 51%. The partial privatisation took place through a combination of an increase in capital (share issue) and sale of the state's shares (dispersion sale). The Government evaluated several models, before the final one was proposed and then adopted by the Storting.

In connection with the stock exchange listing, the Storting expressed its desire for broad ownership in the listed Telenor. For that reason private individuals were offered a discount arrangement through bonus shares following special rules. At the same time a separate arrangement was adopted for Telenor employees. For institutional investors there were special allotment rules, among which were related to any over subscription.

As a consequence of the authorities' desire for broad ownership, Telenor shares were to be marketed actively in Norway. A comprehensive sales campaign vis-à-vis the private market was launched in November 2000. At the same time the management of Telenor held a series of open meetings in Norway - and made presentations to the professional market in several countries. In advance of the actual stock exchange introduction on 4 December approx. 53,000 private individuals subscribed, of whom about 5500 were Telenor employees. Telenor thereby became the company on the Oslo Stock Exchange with the most private individual shareholders. Approx. 7.5% of shares, totalling NOK 100 million, was allocated to private individuals.

At last Telenor and the Norwegian state had identical interests concerning the organisational structure, based on the partial privatisation of the company. From Telenor's side there was an intense desire to strengthen the company's financial foundation, to meet both long and short-term market challenges - in the domestic market as well as internationally. The authorities pointed out, among other things, that continued 100% state ownership would mean disadvantages for Telenor in the competitive market taking shape in the telecom sector, with restructurings, alliances, and joint ownership. By 2000 almost all formerly state-owned companies were completely or partially privatised. The authorities also by now shared the view of Telenor management that in order to keep and develop the strength necessary to maintain a leading position in Norway, the company has to grow abroad. The view was that this required access to the capital amrkets that could only be assured by privatization.

5.5 Research and development in the long run

In 1967 Televerkets Forskningsinstitutt (TF) [Televerket Research Institute] was established, as a research unit for civilian telecommunication. There is a long debate on what caused the establishment of TF in 1967, but Oland (1992) argues that "…in the final resort it was the recognition of an increasingly stronger need for competence within the telecommunications sector in the 1960s, which was decisive for the establishment …." (s.183)[14]. TF has since its establishment become a central player in the development of the telecom sector in Norway.

[14] Translation is done by authors. For a more comprehensive discussion see (1992) or Collet and Lossius (1993)

The first technology areas

From the outset, TF selected three areas and technology platforms for research. Tehse were data communication, pulse-code modulation (PCM), and switching. In each areas it was faced with an expected technological revolution. As to the transmission of data, there was probably no tangible need for it at the time, but the experience of the USA showed that transmission via public networks might become a major service opportunity in the future. PCM and the field of data communication were together crucial for the digitalisation of the telecommunications. Through the PCM technique voice signals would be available in digital form, which primarily would benefit the transmission technique (Collet and Lossius 1993, s.59).

Regarding switching technology, automatic stations were already in use. In other countries the work on digital switches was already about to develop from the stage of experiment to practical application (Collet and Lossius 1993, s.61). In this field it was important to draw on competence from outside and TF entered into collaboration with Institute for telephone technique at the Norwegian Technical University and ELAB, to build up a competence environment within computer-controlled switches.

In order to plan and develop the telecommunications network of the future it was vital that Televerket had competence in all core knowledge fields. So in 1969, a research group in "tele-traffic" was established as a means to achieve a better foundation for decisions regarding the optimal structure and dimension of the network. In 1971, a new group was added to TF, to work with operation analysis. This was a direct response to the challenges of developing methods and instruments for planning and management of Televerket. Satellite communication also became an area of research at TF at a very early stage and was soon to become an important part of the institute. The field became the point of departure for an ambitious attempt to gather Norwegian industry and research into a joint development project, which must be regarded among the most advanced projects in telecommunications at the time.

In the early 1970s Telenor began work on what would become the world's first satellite-based telecommunications system for the oil industry. It was driven by the need for reliable communications between the Ecofisk offshore oil platform in the North Sea and the mainland. Despite scepticism from many in the industry, Televerket's scientists managed to develop a satellite-based telecommunications system that opened for business in May 1976. Using the NORSAT system, Telenor linked the oil industry with Norway's main telecommunications network.

Ship-to-shore

Another example of Televerket's resourceful approach to problem solving can be found in the marine industry. In the 1970s, Norway's merchant fleet was the third largest in the world. Communication was only available via short-wave radio, which meant that ships were often out of range for hours, if not days, at a time. Telenor's solution was to develop the world's first automatic shore station that could be used to communicate directly with ships at sea. Countries throughout the world copied the low-maintenance, highly effective, shore stations and until recently the original station was the busiest in the world.

Mobile Telephony

Televerket was also researching mobile telephony at an early stage. It had been involved in, wireless communication for a long time: as early as 1966, Televerket was offering the services of a manual mobile system (Collet and Lossius 1993, 72). In 1969, the Telecommunications Administrations in the Nordic countries initiated a collaborative project, which aimed to

develop an automatic system by common specifications – NMT. In 1975, TF was involved in this, due to its expertise in computer technology. Roughly, the division of labour among the Nordic countries implied that the Swedish group was in charge of the physical equipment, the hardware, while the Norwegian group took care of the software. The NMT-project incorporated a distinct industrial policy: the telecommunications operators wanted to contribute to the creation of a competitive subcontractor industry. The project succeeded in obtaining equipment from Norwegian suppliers, amongst other through a development agreement with Simonsen Elektro A/S, which resulted in the manufacture of advanced mobile telephones in Norway. This matter will be discussed in detail in the final section of this paper.

TF was occupied with goal oriented research and development with three main objectives. Firstly, it aimed to support Televerket's capabilities in future multifaceted telecommunication needs. Secondly, it sought to strengthen the Norwegian telecommunications environment. Finally, TF sought to ensure production of adequate equipment by Norwegian firms. UL was to provide for the quality of the services that was offered to the subscribers, and the operations thus included all kinds of type control of both the equipment and the telecommunications network. In addition, UL participated, along with other divisions in Televerket, in international collaboration of development and determination of system principles within telecommunication (Annual report 1980).

At the beginning of the 1980s, the main priority areas of TF were business communication and the public ISDN network. In 1975, UNINETT was established as a packet-switched data network of Norwegian universities, but it was not until 1984 that Televerket was able to offer packet-switched data transmission over the regular network (Datapak). Satellite communication was one of the core areas of TF during the 1970s and continued to be so in the 1980s. The chief interest of the 1970s research activities was satellite communication for telephone connection with the Norwegian merchant fleet, the oil installations in the North Sea and Spitzbergen. In the 1980s, the interest seemed to be inclined towards use of satellites for television transmission and broadband business communication (Collet og Lossius 1993, s.140).

Since the 1980s, the most important area has been the development of GSM. Televerket's engineers and scientists played a leading role in the original design behind GSM, as well as building the final specification. Other leading technologies that Telenor has been heavily involved in include integrated services digital network (ISDN) and the compression software within the MPEG2 standard that makes it possible to distribute moving pictures at lower bandwidths.

Due to its geographical and climatic barriers, Norway had always been deemed to be a poor country for fixed-line telecommunications. Rising to this challenge, Televerket saw the potential of using digital telecommunications technology to address those issues. Working with Alcatel, it developed the world's first low-cost, automated network service centres. Tasks such as maintenance and repair, which would previously have been managed by teams of as many as 10 to 15 people, could now be managed automatically from a central location.

5.6 Research and development contracts

Behind the establishment of TF laid the expectation that TF would serve as a catalyst for the establishment of a Norwegian "IQ industry" (Collet and Lossius (1993, s. 90). There was a desire that Norway should develop an independent high-tech industry. The intention was that the state, by funding R&D investments in Televerket, particularly in TF, should compensate for the shortcomings of competence and capital which were present in Norwegian industry at

the time. In addition, this was meant to secure markets for Norwegian industrial products. Hence, the use of R&D contracts within telecommunications represented an important industrial policy instrument. Nevertheless, there were several problems attached to the employment of such contracts. Companies that were selected as contract partners for an R&D contract would have an advantage in preference to their competitors. There was also a question of whether contrcts could be implemented with foreign-owned firms since there was a somewhat nationalistic debate on whether such contracts might be considered as subsidies, generating increased competitive advantages in the foreign-owned firms in preference to Norwegian firms. Televerket kept in close contact with STK and EB, which were some of Televerket's most important contractors, in spite of the fact that these were foreign affiliates relying on foreign technology..

What emerged was a triangular co-operative network between TF, the industry and the Norwegian research institutes. The Norwegian institute sector was to continue basic research activities in the fields of its expertise, industry was to develop prototypes and equipment, while TF's role was to prepare the systems analysis based on their insight into both technology and future market potentials (Collet and Lossius 1993, s96). On the one hand, Televerket was to function as the engineer, and later the administrator of the telecommunications network as it was constructed. On the other hand, the industry and the research institutes were participating as "joint developers and contractors" (TF's Annual report 1979, p. 6-7.). The most important institute for TF was ELAB and their research, particularly within the field of telecommunications.

Today Telenor R&D is Norway's largest research establishment within ICT (Information and communication Technology). Telenor supports and collaborates with a number of Norwegian colleges and universities, among them the Norwegian University of Science and Technology (NTNU), the university of Oslo (UiO), the University of Tromsø (UiTø), the Center for Technology at Kjeller (UNIK), Agder College (HiA), Stavanger College (HiS), the Foundation for Research in Economics and Business Administration at the Norwegian School of Economics and Business Administration in Bergen (SNF) and the Norwegian School Of Management (BI). Telenor has also collaboration with the Research Council of Norway. Through the ICT-Forum they are together working for a stronger national research environment in the field of ICT. This collaboration has resulted in several collaborative projects right through Norwegian industry.

5.7 The continuing Nordic telecom battle

After the abortive merger between Telia and Telenor at the end of 1999, a major competitive struggle emerged in the Nordic telecom market. In July 2000 Telia purchased Norway's second largest mobile operator NetCom with 750,000 mobile subscribers, after strong competition with TeleDanmark. A few weeks earlier Telenor had acquired Sonofon, the second largest mobile operator in Denmark with over 900,000 mobile subscribers. Telia became the largest mobile operator with over 3,7 million mobile subscribers, compared to Telenor's 2,9 million and TeleDanmark which had lost the battle and had only 1,4 million subscribers. This means that Telia are the second largest mobile operator in Norway and Telenor the second largest in Denmark. A further strengthening of the battle came with the merger of Telia and Finnish Sonera by 1 January 2003.

6. The Finnish Case

We start the analysis here with a brief sketch of the current situation in the telecommunications industry in Finland. We then provide a brief sketch of the history of

telecommunications technology and the development of the institutional structure of the industry in the country. Then we analyse the organization of telecommunications service provision in Finland from 1980 until today. We conclude by looking more in detail at some of the more specific aspects of the mobile phones development in the country.

6.1 Finish telecommunications until 1980 - Institutional structure and legislation[15]

Finland has long had a complex mix of public and private operations in telephony. At the time of the construction of the first telegraph line in 1855, Finland was an autonomous Grand Duchy of Tsarist Russia. The Crimean War was in progress. Russian military authorities were responsible for construction, and in Russia as in other European countries, telegraph operations were an exclusive right of the state. Telegraph districts operated under the Imperial Telegraph Office, and in 1864 the Russian Imperial Telegraph Office was completely restructured as a civilian authority. The Telephone Statute issued by the Finnish senate in 1886 meant a division in telecommunications activities: telegraph traffic carried by the Russian Empire's Telegraph Office and on the other hand telephone operations operated by private companies and co-operatives subject to Finnish administrative control.

Because the Telegraph Office had functioned as a department of the Russian Imperial Telegraph Office between 1855-1917, there were no statutes in Finnish law governing telegraph equipment and its use. The deficiency was rectified in 1919 with telegraph legislation that gave the government the sole right to build and use telegraph equipment and lines. Following independence, the Telegraph Office began to supervise Finland's interests in the telegraph field in international co-operation. Finland joined the International Telegraph Union in 1920 and the International Radiotelegraph Convention in 1927.

From the start, certain parliamentary factions demanded that the Telegraph Office and Post Office be combined. The Telegraph Office had to operate under provisional statues until Parliament voted to finally combine the administrations. The combined Post and Telegraph Office began its operations in 1927; at the same time the Post and Telegraph Office's activities expanded significantly, particularly in the telephone sector. Besides the Helsinki - Vyborg - St. Petersburg telephone line opened in 1914, telephone lines that the Finnish telegraph district had built for the use of Russian naval forces during the First World War also came under the jurisdiction of the Post and Telegraph Office.

In densely populated areas, telephone networks had been built by private companies or co-operatives. The building of the Post and Telegraph Office's first large-scale telephone network was carried out during the early 1920s in Lapland, where private enterprise in the telephone sector was underdeveloped. During the 1930s, the transfer of all telephone operations to management by a government telephone company, as had been done in several European countries, was considered. This would have merged the Post and Telegraph Office's telephone operations with Finland's approximately 850 private telephone companies. The plans were however never realised.

On the other hand, telephone operations were consolidated through the purchases of smaller telephone companies. Between the years 1920-1949 the Post and Telegraph Office acquired the equipment of approximately 170 telephone companies, primarily in eastern and northern Finland. In 1935 the government purchased the Southern Finland Long-Distance Telephone

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[15] Sources: http://www.sonera.fi/telegalleria/english/index.html and http://www.thk.fi/englanti/index.htm.

Company's network. In practice, all long-distance telephone operations in Finland came under the Post and Telegraph Office's jurisdiction.

The standardisation of the telephone network was however still tied to the question as to whether all of Finland's telephone operations would be concentrated under the control of a state-owned company. But nationalisation never received sufficient political support, although the technical standardisation of telephone networks emerged as an increasingly urgent issue. In 1954 the larger telephone companies were ordered to immediately adopt a new set of structural regulations for telephone networks. It was however clear that many smaller telephone companies lacked the economic and technical resources required for the switch to modern telephone technology. This led to the field's consolidation during the 1950s and 1960s. The Post and Telegraph Office, as well as other large telephone companies, purchased the networks of smaller telephone companies. In 1950 there were 687 telephone companies in Finland; by 1980 the figure had dropped to 61. During this period the Post and Telegraph Office acquired the equipment of 315 telephone companies.

At that time, the Post and Telegraph Office's dualistic role as an operator and a supervisory authority hindered relations between the Post and Telegraph Office and other telephone companies. Besides disputes arising in connection with purchases, disagreements also arose in such areas as the regulation of data transmission. As a public authority, the Post and Telegraph Office demanded that data transmission be carried out within the framework of telegraph legislation because data transmission was viewed as the exploitation of a more advanced version of the telegraph. On the other hand, private telephone companies considered data transmission to be telephone traffic because it was transmitted over telephone networks. In a compromise solution reached in 1970, both telecommunications camps were granted the opportunity to practice data transmission.

6.2 Technology and services

In thinking about Finnish adaptation to modern telecommmunications, it is probaly significant that Finland has historically been an early adopter of major telecommunications innovations. The first telephone connection was built during December 1877 in Helsinki. Finland's first telephone exchange began operating in Turku in October of 1881. During the following year, telephone companies were founded in Finland's larger cities. Telephone tests over fairly long distances were carried out in the 1880s, with the first long distance connections between Finnish cities becoming operational in 1884. Advances in wireless communications were made at the turn of the century, and as early as 1900 a radio telegraph connection was built in Finland.

The invention of the vacuum tube in 1906 made possible the multi-channel use of telephone lines and audio frequency amplifiers improved audibility over longer distances. Using carrier wave technology, a single line could handle several calls simultaneously, which also lowered construction costs for telephone networks. In 1922, the first carrier wave systems in Finland were used in the Southern Finland Long-Distance Telephone Company's network. The Post and Telegraph Office acquired its first carrier wave system in 1929.

The automation of telephone exchanges began in Helsinki in 1922. Several cities had already switched to subscriber trunk dialling traffic during the 1920s and 1930s. The Post and Telegraph Office's first automatic exchange came in 1932 with the purchase of Tammisaari telephone company. Beginning in 1925, telegraph connections were arranged over telephone lines. In the 1930s teleprinters began to be used in telegraph traffic. In Germany and England they were connected with exchanges, and the form of business began to go by the name of

telex (teleprinter exchange). In 1945, the Post and Telegraph Office began the transmission of private telex traffic in Finland.

In Finland long-distance network cabling was just beginning when the Second World War interrupted development. Until the 1950s, Finland's long-distance telephone network was almost completely dependent on physical connections and open line carrier wave systems. The most important trunk lines were heavily overloaded. Solving this problem began with the building of a long-distance cable network in 1953. The decision was taken to use coaxial cable systems, and coaxial cables were run through large population centres. This accomplished the main goal of cabling, which was to connect a significant number of the country's telephone subscribers to a subscriber trunk dialling network. Radar technology developed during the Second World War also made possible the construction of radio links for voice transmission. In the Post and Telegraph Office's network, the first radio link was implemented in 1958.

The application of digital technology to voice transmission began in the early 1970s. During the duration of the call, analogue voice signals were converted into digital form using pulse code modulation (PCM) technology. In 1973, the Post and Telegraph Office began using a 30-channel PCM cable system whose transmission rate was 2 Mbit/s. Subscriber trunk dialling began between Helsinki and Vihti in 1955. With the completion of coaxial cables and their carrier wave equipment, Helsinki and Tampere, the country's largest cities, could be connected by automatic long-distance traffic. The automation of the Post and Telegraph Office's local exchanges took place for the most part during the 1970s. The last manual switchboard was consigned to history at Pello in Lapland on January 1, 1980.

Finland's first stored program control exchange was the Post and Telegraph Office's international exchange in Helsinki that became operational in 1974. Automatic international telephone traffic from Finland began during the same year. The first “modern” data transmission in Finland occurred earlier, however, in 1964, when Kesko used the Post and Telegraph Office's telex network to transfer perforated tape data between Joensuu and Helsinki. The telex network proved to be too slow, however, and data transmission was switched to the general telephone network.

Innovation also extended to early car telephone systems. A nationwide vehicle-mounted radio telephone network was being planned from the late sixties, and the Post and Telegraph Office's ARP network was opened to traffic in 1971. In 1978 the network covered the entire country. At that time there were 16,000 subscribers. Until the early 1990s, the ARP network, operating at a bandwidth 150 MHz, was fully manual.

6.3 Finnish telecommunications after 1980

During the 1980s, Finnish economic policy was characterised by efforts to foster competition and dismantle monopolies. There were of course foreign precedents for this in telecommunications, and a process aimed at establishing a corporate structure was set in motion in the Post and Telegraph Office's telecommunications segment.

The Post and Telegraph Office's opportunities to compete were limited during the 1980s by the administration's commitment to the state budget. Income was transferred directly to the state treasury and funds for operation and investment activities were only allocated at the beginning of each fiscal year. In 1981 the Post and Telegraph Office became Posts and Telecommunications. In 1983 commercial competition began for terminal devices. Posts and Telecommunications allowed customers to acquire their own telephones, auxiliary devices

and switchboards provided that the device's connection to the general telephone network had been approved.

The Telecommunications Act of 1987 finally consigned the 100-year old Telephone Statute of 1886 to history. Commercial telecommunications operations and regulatory functions were disassociated by law. Supervisory functions were transferred from Posts and Telecommunications to a telecommunications administration centre established under the jurisdiction of the Ministry of Transport and Communications. Competition in network services began during the 1980s. In 1988 corporate telecommunications and data transmission were partially deregulated. In 1990 Posts and Telecommunications became a state business enterprise and its operations were detached from the state budget. In 1994 the limited company Suomen PT Oy (PT Finland Ltd) was formed. The corporation's company in telecommunications was named Telecom Finland.

In December of 1997 the Parliament approved the partial privatisation of Telecom Finland. As part of the privatisation programme PT Finland Ltd was split in two and Telecom Finland's name was changed to Sonera. The Sonera's parent company Sonera Group plc was listed on the Helsinki Stock Exchange in November of 1998 when the Finnish government sold 22.2 per cent of the company's shares to domestic and international investors.

During the 1990s, the major thrusts of Sonera's activities have related to the expansion of business activities outside Finland, and the increased significance of mobile communications, a development that began already during the 1980s.

To summarise, Finnish telecommunications legislation encouraged competition by:

- Opening data networks and GSM networks to competition in 1990.
- Granting competitive licences to long-distance and local telecommunications in 1992.
- Obliging telecommunications operators to lease connections to each other in 1996.

With the recent acquisition by Telia, Sonera is now part of the TeliaSonera Group.

6.4 Technology and services

The organizational changes that created Sonera were accompanied by significant technological shifts and concomitant changes in services. Following automation, the network digitalisation accelerated. Digitalisation had begun in the early 1970s with PCM transmission systems. Converting telephone exchanges to fully digital operation began in the early 1980s and by 1996, all telephone exchanges in Finland were digitalised. In transmission systems, analogue carrier wave systems gave way to digital PCM systems. Field-tests for optical fibre cables began in Finland in the late 1970s. In the 1980s optical fibre cables were taken into extensive use for connections between exchanges.

In 1981, as corporate data transmission increased, the Post and Telegraph Office opened a public data transmission network (YDV) as a part of a general Scandinavian data network. YDV initially offered circuit switched Datex services; this was followed also by Datapak packet switching services that began in 1983. Datapak gave Finnish users opportunities to access large international information systems and data banks. Its users were primarily information retrieval professionals employed by large corporations. In the Videotex service, the customer used a terminal to scan information recorded in a database. Travel agencies, for example, could use it when ordering and booking services. Unlike the Minitel service in France, however, the videotex never achieved a significant foothold in Finland during its initial stages.

The possibilities offered by the combination of computer processing with the data transmission capacity of telecommunications networks were readily apparent, however, and these formed an important area of service innovation in Finland. Post and Telecommunications' Videotex service's second generation was given the brand name TeleSampo in 1988. The number of users grew as the range of services expanded: between the years 1987 - 1990 the number of users of Videotex services in Finland rose from 4,500 to 64,000. Post and Telecommunications also initiated the Telebox electronic message handling system within the TeleSampo service network.

Numerous innovations in telephone sets came to market when the liberalisation of terminal equipment was implemented in 1983. No longer was it necessary to accept the model offered with the connection provided by the local telephone company. At the same time, the transformation from impulse-based selecting disk telephones to voice-frequency-based touch-tone telephones was rapid. The enlargement of tariff areas, calculation of call times based on shorter metering pulse intervals, as well as the discontinuation of calling categories used in manual traffic, meant a reduction in telephone charges. In particular, prices for long-distance traffic fell dramatically. Between the years 1980-1990 the number of telephone connections increased in Finland by 60%, from 1.7 million to 2.7 million.

In mobile communications, the saturation of the manual ARP network's capacity was foreseeable. A new solution was sought through Scandinavian co-operation. The result was the NMT 450 automatic cellular network opened in 1982. In Finland as in the other Nordic countries, this network was an immediate and major success. As a result of the network's immense popularity, a second NMT network operating in the 900 MHz area was opened in 1986. A larger bandwidth ensured a multiple channel capacity for NMT 900. Both NMT systems are analogue. The NMT mobile telephone network adopted in 1982 extended Finland's mobile telephone services to all Scandinavian regions. Automatic telephone call transmission was also an improvement over the ARP network. There was also an arrary of mobile service innovations: chargeable value added services in the NMT network such as call transfer, limited calling and itemised calls in billing. By 1990, the number of NMT subscriptions had already reached 226,000. On the basis of this, during the 1990s, telecommunications in Finland were characterised by two major developments: the switching of mobile communications to the digital GSM network and the breakthrough of the Internet.

In mobile communications the pan-European GSM network was opened in 1992. NMT had provided Scandinavians with experience in international mobile telephone co-operation, but in GSM, roaming had to be possible within a clearly larger group. The harmonisation of networks and terminal devices was not a simple matter. GSM's digital properties made it more than just a telephone. New text message services and even Internet connections further integrated mobile communications with other telecommunications modes.

So the 1990s were the decade of very rapid growth in digital telecommunications services. A digitised telephone network, the GSM digital mobile telephone network and the Internet have made Finns heavy consumers of telecommunications. With digitalisation and intelligent networks, call transmissions have speeded up, the quality of calls has improved and it has been possible to diversify the range of telephone service. Services built on intelligent networks include virtual networks that connect different branches of a company. In 1996, a major number renewal replaced 74 numbering areas with 12 telecom operating areas. Competition has significantly lowered the prices of long-distance and international calls during the 1990s. Customers are now able to select their operators either by agreement or by selecting an operator prefix in connection with each call.

7 The evolution of Mobile Telephony – the NMT system

This section of the paper discusses the role of the telecoms companies in the development of mobile telephony in the Nordic area. We emphasize the cumulativeness of this process, and the long-term commitment of resources in the face of very significant uncertainty. The development of Nordic mobile telephony is an interesting case from a wide range of vantage points. First of all the NMT system when it was launched in 1981 was the first major success of an analogue cell-based system of telephony with mobile terminals. Secondly it laid the ground for later world leading mobile phone penetration and use rates in the Nordic countries – thus reliving the century old story about the diffusion of the incipient fixed telephone system. Thirdly this development process in the period 1970-90 was the decisive period for giving Ericsson and Nokia the basis for their present global positions as suppliers of mobile telephone systems and equipment. Lastly, and as we will see, this was attained due to the leading and decisive role played by the then generally public telecom utilities. This came about not because of Nokia's and Ericsson's strategic capabilities – to put it bluntly it almost happened *in spite of* these companies strategic choices and capabilities.

The history is important in quite concrete ways. The rapid spread of mobile – or cellular – phones from the 1990s was based on a century-long historical development, and in particular on a very early vision of being able to speak to a specific individual independent of his or her geographical location. This section outlines some features of this history, providing a broad-brush historical background before turning to the main topic – the role of the three state-owned telecom operators, the Swedish Televerket (from 1994, Telia), the Finnish Posti- ja telelaitos (Posts and Telecommunications Office, from 1998 Sonera) and the Norwegian Televerket (from 1995, Telenor)[16]. At the time when this history starts these organisations were state monopolies, with variously-defined national interests as their prime objective and task.

Over a period extending of about four decades these national telecom agencies have changed dramatically from essentially public agencies providing and closely regulating a national service, to general telecom service providing companies. From a status as public agencies they are in the course of being transformed to more or less fully privatised companies. During this process these organisations have, partly separately and partly jointly, seen the extensive development of telecoms technology in a wide range of areas. During the most of the 20th century a central issue for these companies, as with all other telecom operators, was the transformation of the fixed line telephone system from the original manual system to fully automated systems, later into fully digitalised systems. On the basis of radio transmission technologies developed during and after WWII, development of cellularly organised mobile phone systems became a major concern for these organisations during the 1960s and 1970s. The joint development of a Nordic automatic mobile telephony system was initiated three decades ago, 1969 and led ultimately to the launching of the analogue Nordic Mobile Telephony (NMT) system about ten years later. The 450 MHz NMT system, later supplemented with the enhanced NMT 900 MHz system, and the experiences gained with these systems, were essential for the development of the European digital GSM (originally named for the CEPT group Groupe Speciale Mobile, today Global System for Mobile Communications) standard, which in turn leads on to current standards.

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16 The Danish telecom operator, today the fully privatised TeleDanmark/TDK could also be included in this list.

7.1 Mobile communications in the Nordic area

7.1.1 World leading use of mobile telephony

Today the Nordic countries are well established as the world's leading users of mobile telephony. By the end of 2000 there were about 17 million mobile subscribers in the Nordic countries. The growth rate of numbers of terminals and subscribers has been around 25-30% p.a. over the last 3 years, in spite of already high penetration rates. By 2000 the density of mobile terminals was more than 650 per 1000 persons in the Nordic area, and nearly 750 per 1000 in Norway and Finland. By 1999 there were more GSM subscribers than PSTN (including ISDN) subscriber connections in some of these countries. Population penetration, measured as lines as a proportion of the total population, of mobile telephony is now larger than the penetration of fixed lines in Finland and Norway. Thus, the Nordic area is, if not saturated, at least thoroughly permeated with mobile phones.

New user groups, and new use patterns, account for a major share of the growth of mobile telephone use. According to one of the GSM operators most of its growth was subscription sales to teenagers. However even though the explosion of mobile phones among young people has attracted substantial interest, less than 25% of mobile phones in Norway were in fact used by consumers under 25 years of age (Statistics Norway, Norsk Mediebarometer 2000). But in some of the younger age groups mobile penetration is almost complete, and about 90% of some younger age cohorts have a mobile phone at their disposal.

Mobile penetration in the Nordic area 2000

	Terminals			*Terminals per 1000 pop***	*SMS (million messages 2000)*	*Messages sent pr terminal-year*
	GSM (1000)	*Total (1000)*	*of which pre-paid (1000)*			
DNK	3 196	3 251	1 126	611,8	752,7	231,5
FIN	na	3 754	na	727,7	615***	163,8***
NOR*	3 234	3 368	1 491	747,8	1 240,5	368,3
SWE	6 157	6 338	2 773	715,8	494,3	78,0

Sources: National Telecom Authorities, unless otherwise stated
* Telecom statistics for Norway 2000 are based on preliminary data, published 21. June 2001 by NPT.
** Total population, NOR 1.1.2001 (Statistics Norway, 2001), DNK, FIN and SWE data for 1999 (from Nordisk Ministerråd, Norden i tal 1999 [*Norden in numbers*], Nordisk Ministerråd 2000).
***Finnish numbers: Total subscriptions Statistics Finland 2001, SMS messages applies to 1999, from Ministry of Transport and Communication press release 19.1.2000. For comparison; the number of SMS messages sent in Norway 1999 were about 575 mill. messages.

The dominance of the GSM system is almost complete. The number of terminals based on the analogue NMT system has been rapidly diminishing - in 2000 its highest share was in Norway, where about 4% of the total number of terminals were NMT phones. The relatively high share of the analog NMT system, in particular in Norway, is primarily due to geographical coverage: the NMT 450 system still has the most complete geographical coverage of all available systems. Hence, while the NMT 900 MHz NMT network was closed during 2001, the oldest 450 MHz network will be retained in the future as a supplement to the GSM networks.

Since 1997 the dominant share of new subscribers are subscriptions with terminable, pre-paid SIM cards, 'cash phones', the only form of subscription available to teenagers below 18 years. The share of pre-paid subscriptions was about 40% in 2000, growing from almost nil in 1996-97. The large share implies that these subscription forms have found substantial markets even beyond the sub-25 years customers.

During the last four years the number of SMS-messages being transmitted has exploded, and passed 1 billion in Norway during 2000, despite relatively high tariffs[17], an astounding growth of nearly 150% from 1999. Thus, the *average* subscriber sent more than 350 messages during 2000. This rather simple add-on feature of the GSM-system, a descendent of the paging systems that proved popular in the 1980s for business users, has proved popular outside the paging market. Today SMS is predominantly used by young mobile users, 15-25 years old, led by female users (Telenor Annual Report 2000). The popularity of SMS-messaging has initiated the rapid growth of a secondary entertainment industry, and the introduction of the more sophisticated MMS opportunity may generate even more rapid growth in this industry. This development exemplifies a key feature of mobile telephony, namely the uncertainties involved in predicting the use of services: who would have believed three years ago that this rather rudimentary feature of the GSM system would become a multi-billion-euro industry in the Nordic countries alone? By the end of the 1990s mobile telephony was deeply ingrained in the Nordic population as a consumer life style.

7.1.2 World leading supply of mobile telecom systems - Ericsson and Nokia

By the end of 2000 the two Nordic countries of Finland and Sweden hosted two of the global leaders in the telecom industry, Swedish Ericsson and Finnish Nokia. According to Dataquest, by 2000 Ericsson supplanted Lucent as the leading producer of telecom equipment, due to its position in mobile networks (FT, 1 Mar 2001). Ericsson has a 40% global market share in GSM infrastructure systems, a strong position in other major mobile standards (as TDMA), and was by the end of May 2001 involved 31 of 50 3G infrastructure agreements announced, in many cases as sole supplier (FT, 29 May 2001). On the other hand Ericsson has made substantial losses on the terminal side, severely impacting the overall profitability of the company as profit margins on the system side slips. Its global market share in terminals has declined more than any of its competitors; by the first quarter of 2001 its global market share in mobile terminals had slipped to 6.8%, Ericsson slipping away from its former worldwide no. 3 position in terminal markets.

The contrast to Nokia in terminal markets is huge. Nokia has continued to increase its lead on global terminal markets since the 1995 turnaround. In 2000 Nokia's market share was more than 30%, more than double the share of second placed Motorola. The market share had increased to more than 35% by the end of the first quarter of 2001, approaching the goal set by Nokia of a 40% market share. As with Ericsson, Nokia is not solely a terminal producer. The company also has a viable business in the infrastructure segments of the industry, with network operators and service providers as customers. In 3G systems markets Nokia's target is a 35% market share. Its persistently high profitability may in addition to attractive technological specifications allow Nokia to devise systems of financing operators' investments in 3G systems at stages where the requirements from licensors to 3G licensees are extensive and costly and market potential highly uncertain. According to Dataquest, Nokia was the world's third largest telecom equipment company in 2000, behind Ericsson and Nortel.

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[17] By the end of 2000, Danish tariffs were DKK 0,50, Norwegian ones NOK 1,00 and Swedish SEK 1,50.

What has allowed these two century-old companies, located in two countries with an aggregate population of less than 15 million, to dominate the global mobile telecom industry, when barely 15 years ago both companies were troubled and unfocussed? The attention given these companies in the international business press and in the strategy literature focuses mainly on the management, the owner structures and the strategic choices made by these stakeholders in shaping the commercial success of the companies. Jorma Ollila has frequently been described as something of an enigmatic maverick, since his appointment as Nokia CEO in 1992. The general consensus is that a main part of Nokia's success in the terminal business is that the company saw early that mobile phones would become a consumer electronics item, and that consumer relatedfeatures, such as design, would become decisive competitive factors. A similar view is held about Ericsson. The demise of Ericsson's terminal business was caused by the company *not* seeing this shift. FT recently (FT, 29 May 2001) cited commentators to the extent that Ericsson's phones were held to be over-engineered, Ericsson is "a bunch of engineers who couldn't care less what the phone looks like".

However, there is a more basic point underlying present strategies of both companies. Both companies, as well as their main competitors, today see wireless communication, including mobile communication, as a system technology, across the various related markets for terminals, switching and base systems, and transmission. This system approach points towards an understanding of what allowed Nokia and Ericsson to rise to the top echelons of the global telecom industry. It requires a wider perspective and analysis, however. When the importance of a system approach became evident, it was on the basis of the integrated relations between telecom suppliers and the national telecom operating companies. The PTOs played decisive roles in shaping this, and in allowing the establishment of a technology and strategy platform on which the two companies later built their success.

The system focus is still important in this industry. The extent of Ericsson's terminal business troubles is well known, with Ericsson loosing more than $50 on every one of about 45 mill. phones sold in 2000. The danger of financial spillover to the infrastructure part is clearly real, "there must come a point when they say 'enough is enough – this is threatening out real life blood' " according to financial analyst cited by FT in May 2001. However, Ericsson is not withdrawing from the terminal business. Phone production is to be outsourced, employment reduced by 12,000, but related R&D, design and marketing is to be retained within the company. The establishment of a joint venture with Sony from October 2001 further pulls expectations away from imminent withdrawal by Ericsson. According to the viewpoint of Ericsson, the reason is simple, a withdrawal would leave the 'real life blood' even worse off without terminal expertise in the company than with an ailing terminal business. Ericsson needs to be able to offer phones and systems; "Ericsson would be at a competitive disadvantage if it could not offer operators both phones and systems" according to the former Ericsson CEO Kurt Hellström.[18]

Our argument in this section is that both the 'system approach' of Ericsson and Nokia and the ubiquity of mobile phones in the Nordic countries find their basis in the nature of innovation strategies, culture and governance of the PTO system. Let us go to the historical background for this development.

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[18] Ericsson is now struggling as well with the delays and reduced expectations concerning the introduction of UTMS and 3G telephony world wide. In addition to the misfortunes in the terminal business, this hits the stronghold of Ericsson's position – the infrastructure side. From this point of view – and with imminent indications of changes in the ownership structure of Ericsson – the company starts resembling a merger candidate.

7.3 A brief history of mobile communication19

A century ago the Nordic economies were rather marginal economies, characterised by major out-migration, but also by a vigorous catch-up process involving significant levels of technology import. In the late 19th century, these societies were early adopters of telephones, and in the 1890s had achieved leading positions in the world in telephone densities. This also applied to absolute numbers: in the 1890s Stockholm had the highest absolute number of telephones of any city in the world. So there is a history here, which repeated itself in terms of digitalisation of telecom networks, of introduction of ISDN systems and mobile phone systems a century later.

7.3.1 The antecedents

The world's first mobile telephone?

This historical leadership extended to mobile communications. In 1889 the 13 year-old Stockholm company L. M. Ericsson & Cos Mekaniska Verkstad marketed a new model portable telephone – one of the first portable telephones in the world. The wooden box – approximately 40 x 25 x 30 cm – was essentially a rewrapped standard telephone with conductors to be connected to available fixed telephone wires. This mobile phone was developed primarily to address the needs of one of Ericsson's major customers in its first years, the railroad services, in their need for mobile communication with maintenance work on the track. A large number of these phones were later sold to military authorities when a lighter, more robust leatherbound version was developed during the 1890s. A substantial number of these portables – the early Ericsson mobiles – were sold to British forces for use during the Boer War (1899-1902).[20]

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19 There are many outlines of the history and principles of telecom in general and mobile telephony in particular, generally in the form of introductory or background essays for a discussion of the contemporary telecom business or technology. In addition, most of these, written by US-based authors, have a dominant US focus and tend to under-focus on European developments. An un-biased scholarly study of the technological, political and social history of mobile communication development is still awaited. A recent outline of mobile communication is given in ITU, *World Telecommunication Development Report 1999*, Geneva 1999, while R. Bekkers and J. Smits, *Mobile telecommunications: Standards, regulation and applications*, Artech House Publishers 1999 affords a distinct European perspective on recent mobile telecom developments.

20 A. Attman, J. Kuuse and U. Olsson, **Band 1 Pionjärtid - Kamp om koncessioner - Kris - 1876-1932**, C. Jakobaeus, **Band III Teleteknisk skapandet 1876-1976**. Both in **LM Ericsson 100 år**, Ericsson centennial history in three volumes, published by LM Ericsson, Stockholm 1976. For an updated and more popular history of Ericsson, see Meurling, John and Richard Jeans, **The Ericsson Chronicle**, Informationsförlaget, published on behalf of Ericsson 2001.

“No. 390 This instrument may be used for military purposes and at temporary buildings or places where it is often necessary to shift it. It is provided with combination-set, two dry cells, generator, bell, lighting protector and terminals for line and earth. Weight 9.10 ko.”. *Taken from:* 4th Edition CATALOGUE FROM AKTIEBOLAGET L. M. ERICSSON & Co., STOCKHOLM (SWEDEN) 1897

These innovations readily extended to the first car – or automobile - phone. From around 1910 it appears that Lars Magnus Ericsson and his wife Hilda regularly worked the first car telephone. After Lars M. Ericsson's retirement from the firm in 1901, his wife Hilda wanted to tour the Swedish countryside using another piece of new technology, the horseless carriage. Ericsson, reluctant to leave his farm, soon realized he could take a telephone along.

> "In today's terminology, the system was an early 'telepoint' application: you could make telephone calls from the car. Access was not by radio, of course -- instead there were two long sticks, like fishing rods, handled by Hilda. She would hook them over a pair of telephone wires, seeking a pair that were free . . . When they were found, Lars Magnus would crank the dynamo handle of the telephone, which produced a signal to an operator in the nearest exchange." [21]

These cases have no technological significance for what came later, the solution required a manual telephone system based on open wire blocks 'in the air'. However, they illustrate a concern with mobile communications that has persisted for a century.

Maritime mobile radios

To find the first mobile radios we need to shift from land to sea. The new instrument, with telegrams transmitted over radio link, was soon to prove valuable in maritime transport. Radiotelegraphy stations were soon placed aboard merchant and military ships, in the UK, in the US and in Norway[22].

Coastal and Maritime radiotelegraphy was a rather immediate focus of Norwegian efforts, given its dependence on coastal waters for transport and international trade, as well as its increasingly large scale fisheries and whaling, in the Barents Sea, in the North Sea and in the Antarctic. When the first wireless link of the national telegraph system was opened by Tele(graf)verket in Northern Norway in 1906, it was the second permanent wireless link established in the world. This radiotelegraphy service was extended to international communication with ships at sea in 1908, with coastal radio stations later expanded to cover all Norwegian coastal waters in the North Atlantic. These first services, based on medium wave transmission, were based on short distance radio. On the basis of the network of coastal radio stations, maritime radio telephony was opened in 1931.

Long distance radiotelegraphy was opened in 1927 with short wave radio from Bergen Radio. At the end of the 1950s the functions of the Bergen Radio was transferred to the new Rogaland Radio station, soon to become one of the most busy high frequency radio stations in the world. A quintessential requirement for several of these developments was the invention and development of vacuum tubes. When it was realised that the triode vacuum tubes could play the role as detector, amplifier

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21 Meurling, John and Richard Jeans, **The Mobile Phone Book: The Invention of The Mobile Phone Industry**, Communications Week International, London, on behalf of Ericsson Radio Systems (1994) p. 43

22 The early Norwegian development of radio telegraphy, telephony and broadcasting is told in the 1855-1955 centennial volume for Televerket; Th. Rafto, *Telegrafverkets historie 1855-1955*, Telegrafverket 1955.

and oscillator, the modern era of radio communication could begin. [23] Bergen Radio introduced tubes in 1922 as the first coastal radio station in Europe, at the time when the first radio broadcasting stations opened around the world.

The Norwegian PTO Televerket and its predecessor Telegrafverket was a central actor in these developments. Though there are less direct links between maritime/ship mobile radio and the ensuing growth of land-based wireless communication, than from the development of land/car mobile radio, but they share substantial parts of their history. However, at sea there is no obvious role to play for the architectural innovation that later proved essential for landbased communication, the cellular architecture. On the other hand the links are much more direct from the early development of maritime radio communication to an area of communication technology where the involvement by the Norwegian tele-cluster later was to become substantial on a global scale; in satellite mobile communication.

The grand unification – radio + televoice

From these beginnings, telephone development and radio telegraphy, wireless mobile communication emerged. But this development was not immediate and direct. It required close to a century to accomplish a large scale and viable integration of radio transmission and telephony. The process required substantial developments, technological and non-technological, it required a co-evolution of mobile communication as a technological system with the apprehension of what mobile communication was. It required a development of a host of signalling structures, of handshaking, of duplexing and multiplexing, in other words the technical innovations that are so dense in telecom and signal technology. Land based mobile communication would not surpass maritime mobile communication before the 1980s in numbers of terminals.

7.3.2 From mobile telegraphy to mobile telephony

The start – radio transmission

The usual histories of mobile telephony starts with the use of mobile radio in the fighting of organised crime by the Detroit Michigan Police Dept. during the 1920s[24]. The system was introduced in 1922, commissioned by Police Commissioner William P. Rutledge. Rutledge was "convinced that the automobile had given the criminal an advantage in speed that could not be overcome by police cars controlled by telephone. Gangsters could make their getaway while the booth patrol was still awaiting a telephone call". Hence the new radio technology promised to be a way to catch up with organised crime.

This first system had just a one-way relay of information and instructions from a radio operator at the police headquarters to the vehicles. These first systems were another implementation of radio 'broadcasting' systems that from 1920 were

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[23] The tube-based triode of course points the postwar development of micro-electronics; the transistor is essentially a solid state triode.

[24] The story is told by K. S. Dobson in *How Detroit police reinvented the wheel*, published in Detroit News (available at http://www.detroitnews.com/history/police/police.htm)

initiated around the world, the receivers installed in cars rather than in homes.[25] As we saw above, by the time of the introduction of the Detroit mobile radio system, mobile radio telegraph system had been in use in the maritime sector for two decades. The introduction of two-way radio maritime communication predates its introduction in land use.

It took another ten years before two-way radio was introduced, again with police services as lead users on land. These systems, and the many similar ones introduced around the world in the following decades, were based on a simple architecture of one central high-powered antenna in communication with local receivers in vehicles. This structure severely limited the usability of the systems, and typically they were of interest for organisations where coordination of a large fleet of cars within a restricted geographical area. Police, transport services, ambulance services, and taxi services were frequent users of these private mobile radio systems.

In 1930 the success of maritime radio telegraphy in Norway and the promises of the new radio telephony initiated a discussion in the management of the Norwegian PTO Telegrafverket of the possibility of establishing an inter-urban telephone system on the basis of radio telephony – essentially what became later known as radio link transmission systems.

The second world war had substantial impact on development of many technology areas, including radio communication, which could now move ahead into VHF and later UHF bands. Both in the US and in Europe experimentation with mobile radio and development of local switching systems for these expanded, spinning off from rather immediate military purposes. Not surprisingly, several companies that later developed competences within the area of mobile telephony had substantial contracts with the military on the radio side. A Nordic example is SRA, Svensk Radio Aktiebolag[26], in the early 1980s integrated into Ericsson as Ericsson Radio Systems.

Towards mobile telephony

There are four characteristics of the 'modern' mobile telephony systems as they emerged in the 1970s that distinguish them from mobile radio. The mobile networks were high capacity systems, requiring systematic use of the scarce resource of bandwidth. Secondly, these systems were automatic with peer-to-peer communication without requiring a central operator or communication centre. Thirdly, the mobile systems of the 1970s onwards were fully interfaced to the public switched telephone network (PSTN), so a mobile user could call a subscriber to the fixed network or vice versa. Lastly, the mobile systems of today are 'roaming'

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25 Listening to police radio on ordinary radio sets soon became popular. Examples of commercial radio receiving sets marked 'Police' in the 2 MHz band in this period are frequent.

26 SRA dates back to the 1920s, and for most of its history was owned by Ericsson and the Marconi company. Its dominant business up to and through the 1950s was radio sets, and with its brand name Radiola it blanketed Sweden with radios (see Attman et al (1976), *op. cit.*). Later the radio set activities were sold off, SRA shifting its prime focus to 'professional' radio communication generally, and mobile radio communication in particular.

systems, allowing the subscriber to access the overall system irrespective of which subsystem he or she belongs to[27].

Efficient frequency use required substantial technological development, as well as development of national and international regulatory regimes. The first important step was the invention of a non-technological, architectural approach to mobile radio systems in 1947. Automatisation of mobile radio systems was developed around the same time, and by the end of the 1940s the demand from owners of private radio networks for connections to the PSTN network increased. The regulatory regimes required these connections to be done by the PSTN operator, the national PTO. Here too, the idea was current by the late 1940s. The vision of a 'modern' mobile telephone system thus seems to have fallen into place already by the immediate postwar period. However, it took another 20-30 years to the first attempts to operationalise this vision.

Bell Labs was a centre of many of the developments that later proved essential for mobile wireless communication. Bell introduced the cellular design of mobile systems in 1947, but equally Bell Labs contributed significantly with wider efforts into radio technology and solid state physics. However, most of these ideas did not become realistic for another thirty years; cellular architecture and frequency reuse to enhance capacity of mobile systems, did not come into systematic use before around 1980.

The Swedish Televerket was an early mover on the European scene.[28] In all countries private mobile radio networks were frequent, by the mid-1940s there were about 40 radio networks in Sweden alone, increasing rapidly during the following years. However, few European PTOs seems to have got involved in system development and experimenting. The viability of connecting radio systems to the PSTN network implied a public radio network, and suggested that Televerket should play a pivotal role. In the late 1940s Televerket initiated a project of experimenting with mobile telephone systems, aiming at an automatic network for car phones.

By 1950 the first automatic mobile, non-cellular telephone system had been developed, named System Lauhrén after one of the Televerket engineers responsible for developing the system as a joint project of the Telephone Technology Department (Tekniska byrån) and the Radio Department (Radio-byrån) of Televerket. The system was introduced for commercial use in 1955 in Stockholm and Gothenburg and may lay claim to being the first automatic mobile system in the world.

The Swedish history continued with a new system developed during the mid-1950s, System Berglund, again referring to the Televerket engineer who headed the development (Ragnar Berglund had also been co-leading the development of the first

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27 The characteristics of roaming are outlined further below.

28 The early history of mobile telephony in Sweden is told in more detail in av O. Gerdes, *Nordisk Mobiltelefoni NMT Från trådlös telegraf till mobiltelefon*, Daedalus –Tekniska Museets årsbok [Swedish Museum of Science and Technology Yearbook] 1991. The Norwegian history of mobile communication is summarised in L. Grimsteit and H. Myhre, *The history of mobile communications in Norway*, Telektronikk, volume 91, no. 4, 1995, Telenor, p. 15-20

system together with Sture Lauhrén). Though the Berglund system was developed by 1962, neither the Lauhrén nor the Berglund systemscould be expanded on a large scale, both remaining regional systems. [29] The Berglund system was opened in 1965, with full transistorisation of radio equipment. Though both systems made it into commercial use, and where still in use when the NMT system was developed, the possible number of subscribers were limited.

In 1962 the Swedish Televerket appointed a commission to analyse and to make a proposal "with clarification of related technical and economic aspects, for a suitable system for mobile telephone systems". Though it took another two years before the commission started its work, following the appointment of chief engineer Carl-Gösta Åsdal of Televerket Radio as chairman, this decision proved decisive for later developments in Sweden, and in Norden. The commission included all radio related areas under its agenda, and presented by this a platform for the NMT process, as well as the later MOBITEX system – a packet switched mobile data service – introduced in the late 1980s by the Swedish Televerket.

There is also a line from the Åsdal commission to the introduction of a radio paging service jointly in the Scandinavian countries, based on the CCIR POCSAG-recommendations. Paging systems allowed short messages, typically telephone numbers to be called, to be relayed to pocket sized terminals, the pager, with a small display. Paging systems were introduced in Norway in 1984 and Sweden in 1985. Pagers proved popular, and penetration rates were soon at the top of European rankings. These first systems were analog. A system for digital paging services was developed jointly by the Scandinavian PTOs in the late 1980s.

The geographical position of Norway, its fishing and whaling activity around the world and its large shipping activity led there to a larger focus on maritime communication. With reconstruction after the second world war substantial efforts were put into the development of systems for short range and long range (mobile) maritime radio communication. The highly prioritised reconstruction of Norwegian fisheries during the immediate postwar period, gave a strong impetus to maritime radio telephony. These large scale system developments, partly reflecting the global character of the Norwegian shipping industry, its large fishing activity and extensive sea transport in coastal and nearby waters, gave the coastal radio telephone system and UHF radio stations like Rogaland Radio prominence, even globally. However, these systems remained manual systems, though connected to the PSTN network through operators at the radio stations.

With development of NMT ongoing (see below), the Norwegian Televerket also initiated the development of automatic maritime radio telephony, based on R&D related to the development of NMT[30]. The objective of this work, started in 1978, was to develop a fully automatic coastal telephone system with global coverage. On this basis the relevant ITU organisation for radio communication, CCIR, presented recommendations for technical specifications for a new automatic system, integrated with the PSTN network. This "was a milestone in CCIR's history" (NTRI annual

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29 In the literature, these systems are often referred to by the systematic acronyms they were given later, MTA and MTB.

30 H. Godø, *R&D and technological innovations in telecommunications: Innovation regimes*, Ph.D. thesis Roskilde University Centre 1995

report 1981). The global automated system was never implemented, as the 1982 ITU World Administrative Radio Conference declined the recommendation to set off bandwidth for the system. The experiences in this project nevertheless proved valuable; capabilities and results, as in digital signalling, formed one of the bases for the GSM-effort.

More successful was the efforts of Norwegian Televerket to move into satellite based mobile communication. Again the global position of Norwegian shipping proved the decisive driver. A major system study, *Maritime satellite communication – System study*, was developed in 1969 jointly by two leading Norwegian radio communication companies, NERA and SIMRAD, with substantial activity in the era of maritime communication.[31] Both companies were heavily integrated into the 'new' Norwegian industrial policies that aimed at developing national champions in emerging R&D-intensive industries, where the National Defence Research Institute and its director were central actors. Both NERA and SIMRAD were at the time lead by former NDRI researchers. [32]

The initiative to perform the 1969 study grew out of an explicit national attempt to develop a global technology lead in an area where Norway had natural advantages. The study was a result of more than a decade of systematic policy and institution building of satellite-related research.[33] As with NMT, Nordic cooperation was established, the Scandinavian Tele Satellite Committee was established with Sweden and Denmark in 1961[34]. The Nordic collaboration did not, however, play the strong role it later did in NMT and satellite communication.

The Televerket emphasis on maritime satellite communication gave it a central role in the development of the INMARSAT system, providing a global automated satellite communication service. The work on satellite communication was an international breakthrough for Televerket, with decisive influence on the

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31 NERA, with close ties to Norwegian telecom equipment supplier Elektrisk Bureau, and thus to Ericsson, was an integral part of the Norwegian telecom, as well as defence, complex, with its focus on radio links and communication. Today it is a dominant global company in the area of INMARSAT-based communication, and also continues to have a strong position in its old area, radio link technology. Its position in satellite communication is mainly due to its involvement in these developments from the late 1960s onwards. SIMRAD, today part of Kongsberg Gruppen ASA, was established as SIMRAD – Simonsen Radio in 1947 by a radio engineer Willy Simonsen from the Headquarters Defence Command Norway [Forsvarets overkommando]. SIMRAD's main product portfolio included echo sounders, sonars, and maritime radio telephony, for the fisheries and for the defence. During 1950-1975 SIMRAD was acknowledged as world leader in echo sounders and sonars. Its participation in the 1969 systems study was an attempt to steer the company into satellite communication, an attempt that failed (SIMRAD's history is discussed in K. Sogner, *God på bunnen – SIMRAD-virtksomheten 1947-1997* [Good at the base – SIMRAD activities 1947-1997], Novus forlag 1997

32 There is a wide literature on this period in Norwegian industrial innovation policy, unfortunately most of it in Norwegian. For an overview of this and other epochs in Norwegian innovation policies, see J. Hauknes and O. Wicken, *Innovation policy in the postwar period – Trends and patterns*,STEP June 2000.

33 For an account of this and the history of the Norwegian Televerkets R&D institute NTRI, see J.P. Collett and B.O.H. Lossius, *Visjon – Forskning – Virkelighet – TF 25 år*, [Vision – Research – Reality – NTRI 25 years], Televerkets forskningsinstitutt 1993

34 As seen from this and preceding examples, it seems Nordic or Scandinavian collaboration was the rule, rather than the exception.

development of CCIR and CEPT recommendations, contributing substantial and innovative solutions to ITU. NERA and Televerket developed the INMARSAT earth station at Eik in Norway. When it opened in 1982, automatic switching and connection to the automatic PSTN were provided for the first time. The development work of the Eik earth station has been characterised as 'beyond state of the art' (Godø (1995), p. 58). Televerket/Telenor has always been a significant partner in the INMARSAT organisation, and is today one of the major owners of the incorporated INMARSAT (since 1999), with a 15% owner share. In addition Telenor participates in INTELSAT and EUTELSAT.

Although several private mobile radio networks for land use were established during the 1950s and early 1960s, it seems that the Norwegian Televerket did not focus on the development of such networks before the mid-1960s. Televerket's role prior to 1965 seems to have been limited to certification and license issue for private networks. In the developments of mobile communication, at sea, in space and on land, Televerket's R&D institute, NTRI, and its research director were core intrapreneurial innovation agents in the organisation. NTRI was given substantial leeway and strategic influence as a consequence of the harsh criticisms raised towards Televerket in the national assessment of industrial R&D performed in the early 1960s, a criticism that needed a response. This finds support in the characterisation of Televerket's research activities during the 1960's given by Collett and Lossius (1993). When NTRI was established in 1967, they describe NTRI and its immediate predecessors as a "technological pioneer in a backward Televerket".

However, Grimstveit and Myhre (1995) indicate that the drive for Televerket to enter land mobile radio communication was the interest of private local radio networks to expand their coverage area. Uneconomic use of radio frequencies and costly infrastructures, as well as an increasing conviction in Televerket of a future market for radio telephony for private persons, could only be met with a public radio telephone service it was argued. The first manual public mobile system was introduced during 1966, a system that was definitely not 'beyond' state of the art, but which laid the foundation for a coordinated 'giant leap'.

Similar systems were established or under implementation in all Nordic countries by the mid-1960s. These systems saw rapid growth in demand and number of subscribers, with the consequence of system saturation. Well established formal and informal networks between the Nordic PTOs ensured exchanges of these experiences and ideas of future developments. The stage was set for the next step – the development of the first mobile system with trans-national roaming, NMT. Along the way a trans-Nordic manual mobile telephony system was launched in 1976, easing the growth pains of the former national systems, and for the first time allowing cross-border use of mobile telephones; a Norwegian subscriber was able to use her telephone in Sweden and Denmark – manually controlled proto-roaming.

7.4 What is a mobile telephony system?

7.4.1 System architecture

Basically, mobile telephony is not a system, it is an interface. It is based on radio link between a mobile user terminal and fixed appropriate receivers and transmitters

communicating with a backbone infrastructure network system[35]. This front-end interface is broadly speaking independent of what infrastructure is used, but traditionally the mobile systems were designed as front-ends for the fixed public switched telephone network. Thus, there are four principle functional parts of these mobile interfaces, a user *terminal* or handset operated to get in touch with another party located at a known address in tele space (though location may be unknown in geographical space) communicating with a radio transmission system, termed the *base system*, a *switch* receiving contact information from the base system passing it on along the right highway towards the correct location, and a *gateway* to the infrastructure (cabled) network used for transmission of signals (which may be the PSTN).

The graphical description of the GSM system given here illustrates this structure. A similar depiction may be given for the NMT system, or any of the other contemporary digital systems. The overall structure is more or less the same, though the distribution of functions across the system and the communication systems vary. In the GSM system a substantially larger part of the intelligence in the network, required for signal control and processing, has been delegated to the base station system, while in the NMT system this is almost purely a radio transceiving (transmitting and receiving) system. As is seen from this outline of the gross structure, somewhere in the system there must be someone or something keeping track of the link between tele-space, in which communication signals live, and geographical space in which physical users live. Fixed telephones are no problem, they are – fixed – in both senses of location; the tele-space fixed address – the phone number – stays put at a fixed physical location – its geographical address. The problem is mobile phones, phones – fixed in tele-space – that roams about in geographical space[36].

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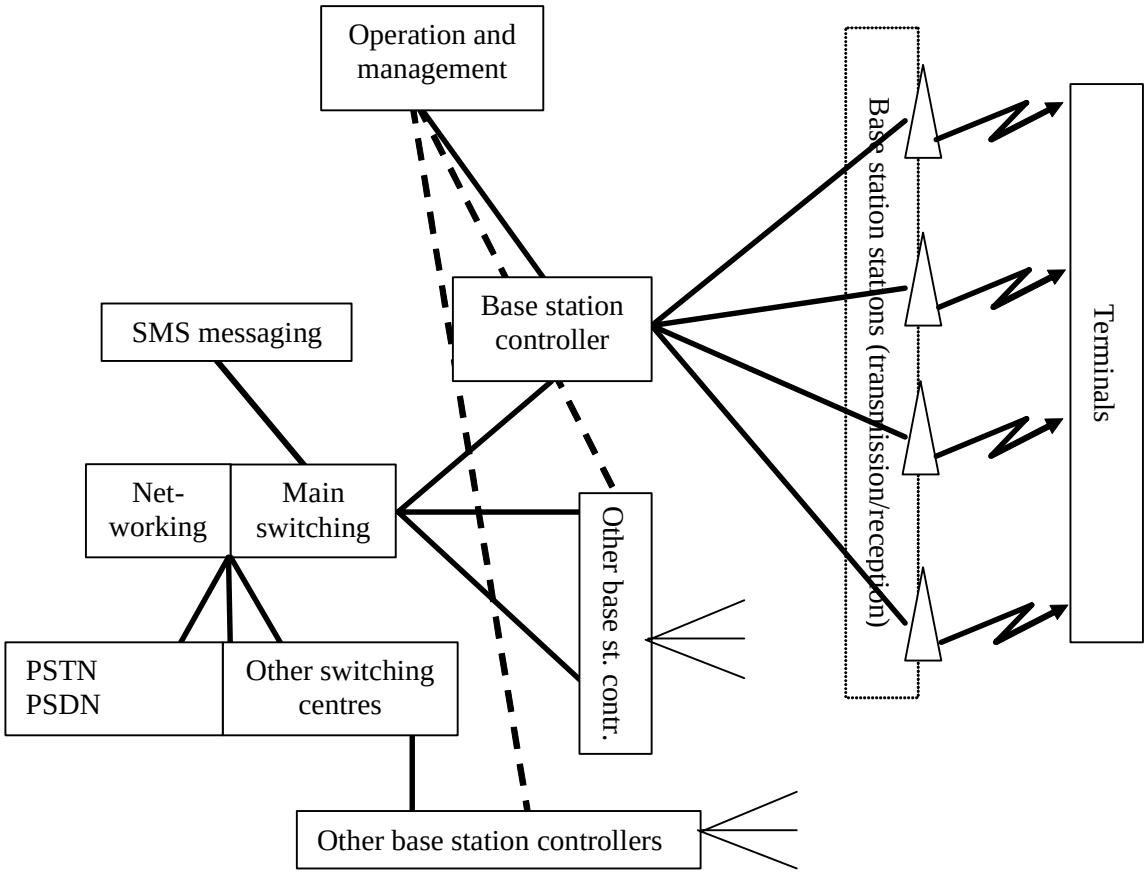
35 There is a huge literature, both for the general reader and the technologically more advanced reader, on the principles behind and the technological and functional structure of telecommunication systems in general, and mobile communication more specifically. A well-written reference point that combines the interest of the general reader with venturing into some aspects of the basic technology is available on the web. Tom Farley has authored a set of extensive essays, available at http://www.privateline.com/, see in particular the two essays *Cellular Telephone Basics: AMPS & beyond*, and *Digital Wireless Basics*.

36 Both of these systems may roam in person-space; there is no identification of the individual user implied. Or in other words, they are independent of who the individual user is. The next immediate step is therefore to fix location in person-space (basically by some unique personal identifier perhaps allied to social security number), with full roaming in the tele and geographical spaces. For some, the glory of 3G telecom is the opening of the path towards this goal.



The idea of *roaming*, a crucial aspect of mobile systems, is that the system keeps track of the terminal's physical location. Imagine the base stations on the upper left are in Oslo. The communication with the phone of a subscriber living in Oslo is controlled by a base station controller and the main switch for the Oslo area; this is the subscriber's home ground. In effect the telephone number of the terminal is treated as an Oslo area number.

When the subscriber leaves on a trip to Paris at somewhere at the bottom of the figure the Oslo and Paris GSM switches must both know that phone is now in Paris. When the terminal leaves its home ground, the home (Oslo) switching system of the terminal keeps a record of where the terminal is at any time (presently Paris), of which switching system it presently belongs to. The switching system that is visited, the Paris switch, handles all communication with the terminal as long as it stays within the territory of this system. The main point for the user about this roaming function, the information exchanges and data management it requires, is that the terminal may be used at any geographical location that is covered by the system and the associated communication standards.

The core role of a radio communication subsystem in the mobile systems implies directly that the early history of mobile telephony is integrated with the history of radio communication. The history of mobile radio communication has been a continuing struggle to increase communication capacity; to ensure high quality signalling, to increase signalling capacity between terminal and radio stations, and to increase system capacity to accommodate increasing numbers of users and subscribers. The battles fought and won here were crucial to the later possibility of launching full-fledged mobile telecom systems. The development of micro-electronics was decisive, for miniaturisation, for allowing digitilisation, etc.

However, there was one severe limitation, the impact of which dramatically shaped the development of mobile communication. Radio communication uses a physical resource, the electromagnetic spectrum. We are swamped by electromagnetic radiation, from natural, as well as man-made, terrestrial sources, and from extra-terrestrial sources. Basically, any band of the EM spectrum can be used only once, by man or by nature, to communicate information at any point in time. The availability of wave-bands for communication purposes is severely limited by natural sources, by established use by man for other purposes and by the absorption characteristics of the atmosphere, all of which vary along the EM spectrum. The outcome is the core need to treat available band spectrum as a scarce resource, which with its immediate spillover mechanisms raises the need for substantial co-ordination efforts. Hence, regulation of band use by the US FCC and similar agencies, hence efforts to develop technologies that allow multiple use of the same bands in parallell.

As all who have listened to long wave and medium wave radio know, different parts of the EM spectrum may propagate widely different distances. Some waves can spread almost around the world, others hardly reach outside the local neighbourhood. This is partly a consequence of the power with which the signal is transmitted, partly how the signal travels through the atmosphere. In some bands the atmosphere is almost like a perfect mirror and signals can travel far by 'bending' around the curved surface of the earth, in other bands it is transparent and signals travel in straight lines, while in yet other bands the atmosphere is almost opaque, absorbing any signal quickly. One substantial advantage of the micro-wave part of the EM spectrum used for mobile communication is that it offers a balance between a rapid attenuation of signals by absorption and transparency; signals reach 'far enough', and they do not go 'too far'. What is 'far enough'[37] depends also on the architecture of the mobile communication system, the architecture determining ultimately determining the capacity of the system. With communication in a certain band, increasing the intensity of the signal (increasing its power) expands the borderline. Shifting to a band where atmospheric absorption is higher with the same intensity, the borderline contracts towards the source.

Inside this borderline, within the 'far enough' area of a transmitter, each 'channel' cannot be used more than once (or a suitable multiple given by the particular multiplexing technology used) in on-to-one communication. Outside this area, the same channel may be used again by another terminal-transmitter dialogue, and the system opens up for *frequency reuse*. This is the basic idea behind a crucial architectural innovation in the development of mobile communication. In 1947 Bell Labs proposed a cell-based architecture of the communication system to allow frequency reuse, and hence increased capacity. Cellular architecture and its alter ego frequency reuse, and their later refinements has been decisive for the development of mobile telephony, a fact that underlies the US use of the term 'cell' phones.

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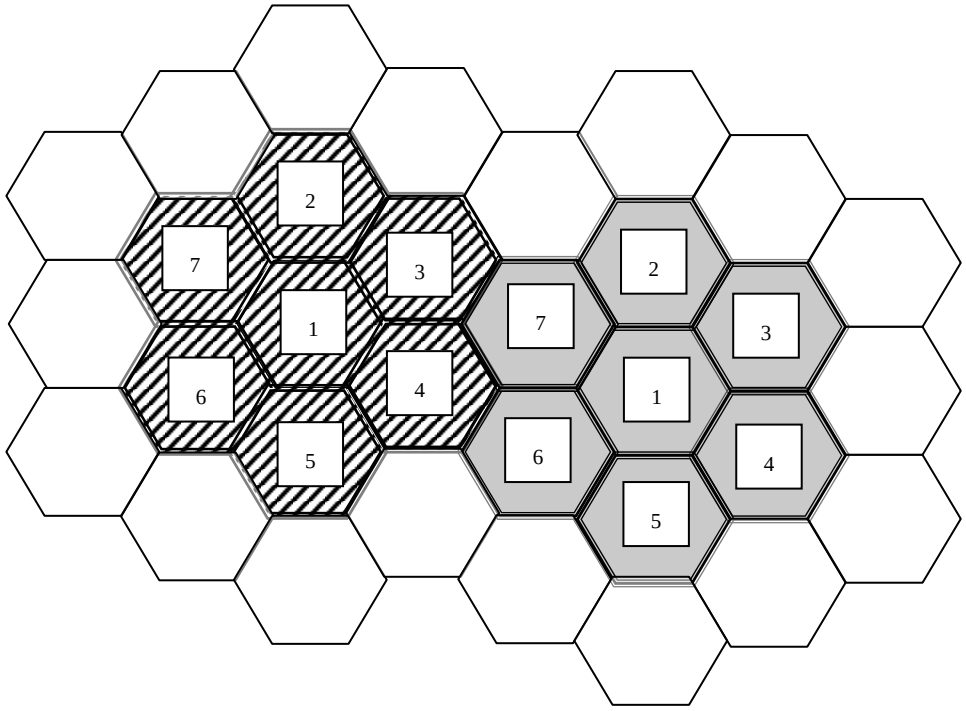
[37] There are of course several other factors in these equations. Typical, 'ballpark' estimates on the basis of 'simple', i.e. non-cellular, architectures imply that reliable communication in a given channel is limited to within some 30 km, with frequency reuse severely limited within 100 km.

Mobile systems of today have four key components; the structure of cells, a network of base stations and antennas to optimise coverage and capacity, base station controllers, or local switches, managing base stations, and the main mobile switch (or switches), communicating with the base station controllers, and with the public



switched telephone network.

The basis of such a system is a distributed network of low-powered antennas, located at base stations, communicating with the terminals. A cell may then reuse frequencies already in use in other cells, sufficiently far away to avoid interference. The cell structure, usually depicted as a simple honeycomb structure, consists of a cells of different sizes. Cell sizes are adjusted to optimise capacity, with small cells in high user density areas, larger cells in more diluted areas, varying from a few hundred meters upwards[38]. The frequencies made available to any base station and cell is a complex function of the system architecture and the local topography of the geographical area to be covered, to reduce interference, and to enhance capacity and signal quality. Increasingly, cell designs are based on a hierarchical cell structure, larger macro-cells containing several micro-cells, each of which may again accommodate pico-cells. The costs of designing and building this cell-based infrastructure is considerable, hence the sigh of relief heard all over Europe when first the German Telecom Authority in June 2001, later many others, allowed shared investments in base station infrastructures for UTMS licensees. Economic design of mobile systems has become a serious issue

The cell structure raises the need for a further function. The expected number of mobiles crossing cell borders increases rapidly as penetration rates increases, and as cells become smaller. As the number of cell crossings increases, the number of crossings while the phone is used increases automatically. But the whole logic of the

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[38] GSM cells are typically ‘small’, less than 10 km, while NMT 450 cells are large, up to some 50 km.

mobile system would be destroyed if the user was required to stay within one cell for the duration of a call, let alone the information overload it would require for the user to know where cell borders were. From the user perspective, the physical outlay of the infrastructure should be invisible. The core concept here is the *handover* function, the function that in a seamless way transfers the exchange between the terminal and the base station system from one base station to the next as the border is crossed. We tend to think of this as a physical border, but in real systems it is an efficiency border; the infrastructure determines in real time the handover on the basis of maintaining overall signal quality for all ongoing exchanges.

All these factors, roaming, cell and user administration, and handover, together with fully digitalised communication, increased transfer rates, and so on immediately suggest rapid escalations in requirements for system overhead, for real time supervision and control. As an illustration; while the functional resources of the NMT base station system was divided roughly 80-20 between radio communication and control functions, the distribution in the GSM 900 base system is approximately opposite; 80-20 in favour of control functions.

Evolution of cell sizes, communication and control technologies, transmission power, efficient batteries, etc. have allowed miniaturisation of terminals: yesterday's 10 kg 'dragables' have become today's 70 g 'pocketables'. From half a million terminals in use around 1985 to more than almost a billion by the end of the century – this is very dramatic growth. As noted initially in this section, systems as NMT and GSM are still basically front-ends of the PSTN system. With new backbone systems, new system interfaces and with the transformation of the PSTN system into full data networks, mobile communication today is perhaps more correctly seen as an integral part of a large scale multi-functional communication infrastructure across all data types, carrier technologies and terminal categories.

7.5 The political economy of NMT

7.5.1 NMT system development

The NMT history proper opens in 1969. A proposal was made to the Nordic PTOs, quickly gaining their support, to develop jointly a technologically leading first generation analog cellular phone system, the NMT system. The NMT system, the first with multinational roaming, was a tremendous success and is still in use in about 30 countries around the world (though by today it is drowned by GSM use in its heartland). In Sweden NMT based telephony still accounted for about 2% of total generated income from all mobile telephony in 2000, PTS (2001). Similar shares apply to the other Nordic countries).

The NMT proposal was made by the director of Televerket Radio (S), Carl-Gösta Åsdal, to the Nordic national telecom operators at their 1969 Nordic Tele Conference[39]. Åsdal had just completed the chairmanship of the Swedish

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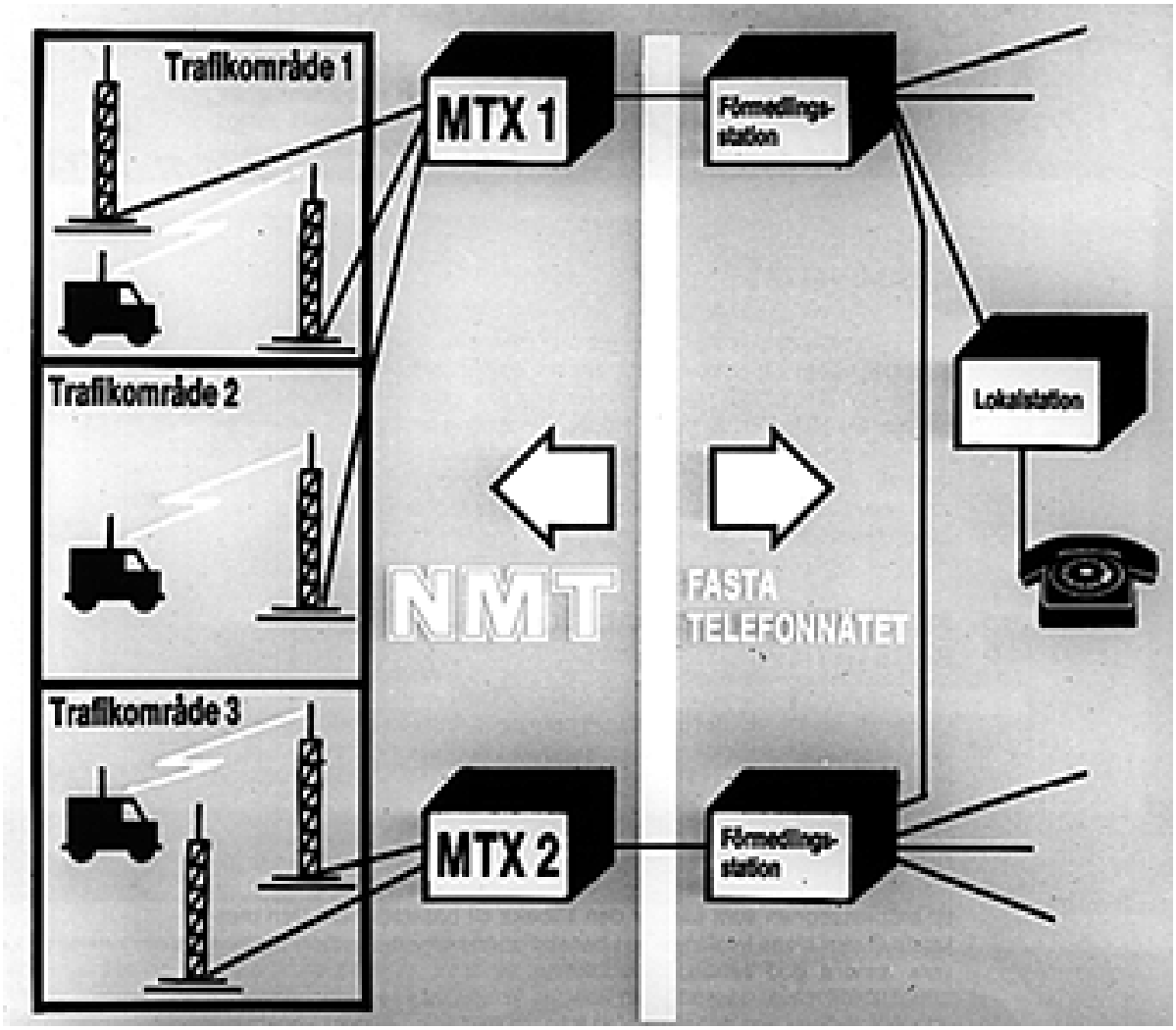
[39] The Nordic Tele Conferences were a cycle of high level joint meetings between the telecom director generals and their agencies in the five Nordic countries. The conferences considered issues of common interest, in terms of telephone charges, development of international telephone networks and cable systems, and systems development and other more technical

Televerket's report *Landmobil radiokommunikation*[40], a report which saw mobile telephone systems as a particular variant of mobile radio communication, on the basis of two decades of experimentation and implementation of mobile telephony. The 1967-report became fundamental in shaping the future technical and system development of mobile communication. Its proposition of the structure of a mobile telephony system was based on a cellular approach and outlined a fully automatic system as the only viable path, based on an extensive consideration of contemporary mobile systems available throughout the world.



An early outline of the principal structure of the NMT system. Depicted are three cells (trafikområde [traffic area] 1-3), with base stations communicating with the mobile terminals, cabled to mobile exchanges (MTX 1-2). The exchanges transfers signals to the fixed telephone network (fasta telefonnätet) through transfer stations

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matters. The first conference was held in Copenhagen in December 1917. An account of the Nordic collaboration and a shift in emphasis from administrative and policy issues to an increasing focus of technological issues during the first 50 years is given in H. Heimbürger, **Nordiskt samarbete på** telekommunikationsområdet **under 50 år 1917-1967** [Nordic collaboration in telecommunications during 50 years 1917-1967], Stockholm 1968.

40 *Landmobil radiokommunikation, betänkande avgivet av arbetsgruppen för mobiltelefonsystem*, [Landbased radio communication – Report given by the working group on mobile telephone system], August 1967.

or gateways (Förmedlingsstation). The fixed network sees the mobile exchanges as 'any other' local telephone subscriber.

At the 1969 Nordic conference the objective of developing a joint public land-based mobile system was adopted, based on common system solutions. It was clearly stated that the objective would require long term work; in fact the whole decade of the 1970s was expected to be required for completion of a Nordic mobile automated telephony system. The work was started in January 1970, with the working party NTR 69-5 with participation from all countries, and chaired by Televerket (S).[41] A first interim target of developing joint compatibility of the existing and planned manual systems was chosen as a way towards a fully automated system. When the NMT system was launched October 1 1981, it was the first multinational mobile system based on a cellular structure, and was recognised as a leading edge technological system. By the end of 1981 10 different mobile terminals (not really handsets at that time) from several international producers were certified for the system, demonstrating a significant interest for this system and the potential it had.

The development of the NMT system and the related specifications was led by the telecom operators, but based on an integral collaboration with the industry. Both national and foreign industry was involved in the development process as early as 1971. The official industrial 'policy' of the telecom consortium was to disclose information on the system and its requirements to open up for international competition on supply of terminals, base stations, switches and communication systems. There was a substantial interest from international industry, and companies like Panasonic (Matsushita), Mitsubishi and Motorola was involved very early in the process

However the potential of mobile transnational communication in the early 1970s was faced with substantial technological uncertainty, and so the task the Nordic consortium undertook may be perhaps best be described as co-ordinating technological development in the face of considerable and uncertainty., with respect both to individual technologies and to the sysem as a whole.

7.5.2 The Nordic supplier industry

As we have noted above the Nordic region today hosts two of the leading global suppliers of mobile systems, including switches, controller systems and radio and terminal systems, Ericsson and Nokia. But it is equally important to note the fact that both companies were for a very long time extremely hesitant about entering this industrial area. This raises a related point, which is that although they were hesitant, others were not. In all the four major Nordic countries there were several enthusiastic industrial entrepreneurs and companies that entered the mobile telephony industry in the early NMT phase during the 1980s with substantial success. All of them, most notably the Danish companies STORNO and AP Radio and the Norwegian company Simonsen Elektro, all with substantial capabilities in radio communication, have since disappeared. Why did Nokia and Ericsson achieve spectacular growth rates during the 1990s, while STORNO, for example, one of the world leading providers

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[41] Its secretary and later chairman, Thorleif Haug of the Swedish Televerket, later became the first chairman of the CEPT special group GSM.

of radio communication equipment in the 1960s, was acquired by Motorola, and then closed down in the early 1990s?

Part of the answer lies in the fact that there were close contacts and even integration between national champion companies on the one hand and the Nordic NMT consortium jointly or the national telecom organisations separately on the other. These networks were to a large extent founded on longstanding relations, with a basis in the substantial technological developments in radio communication and switching and traffic technologies over several decades. In reality this constituted an informal protectionist industrial policy, aimed at securing a national industrial base and providing domestic companies with a dominant position in the emerging industry. In some cases this policy was formulated quite explicitly, if not in words then in deeds (see for example C. Palmberg 1998, Collett 1994). This policy may be seen as a rather natural outgrowth of the national role some of these telecom operators had, with rapidly increasing technological sophistication and orientation since the 1940s, leading to the establishment of substantial technological R&D facilities, and with a strong sense of obligation by these monopolies towards nation-building industrial strategies.

The leading edge character of the NMT system and the role of the NMT system in shaping the GSM system, allowed system and terminal suppliers involved in the implementation of the NMT system to build up relevant capabilities and expertise, besides a substantial market position. In the four Nordic countries Denmark, Finland, Sweden and Denmark, several attempts to build an NMT industry were evident.

7.5.3 NMT industrial policy and NMT industrial practice – Nordic divergence

At the Nordic level, the NMT project was designed to be open to all industrial contributions and supplies. The invitations for industrial contributions were in general widely distributed and information on system design and requirement made publicly available. However, this Nordic policy also included leaving implementation and procurement of NMT systems to the national agencies in each country. This allowed for focused industrial policies, whether implicit or explicit, formal or informal, to come into play. These policies, in these countries as well as in other European countries, had a strong focus on the development of national industrial capabilities, in many countries with a strong element of public ownership or public steering and co-ordination of industrial development. In Sweden the link between Televerket and Ericsson was in place long before NMT project started, and Fridlund (1997) describes the Televerket-Ericsson link as a 'development pair'.[42] The importance of this link was further enhanced by Sweden being, informally, the strategic leader of the Nordic consortium: the Nordic project was launched from Sweden, the project organisation was led from Sweden and the Swedish Televerket's test lab 'Radiolaboratorium' was chosen as the location of the system testing and prototyping towards the end of the 1970s. In Finland there was a similar strong link

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[42] *Development pairs* are long term and institutionalised user-producer relations around the development of new technologies between Swedish engineering companies and procuring public agencies. Such pairs were frequent in Swedish public procurement. They were rationalised by the same kind of arguments as were used for national infant industry support, development of national champions and import substitution policies. The pairs were generally tightly linked around consecutive joint development projects.

between the Finnish telecom agency and Nokia and Mobira (later Nokia Mobile Phones) (Palmberg 1998, Palmberg 1997, Palmberg and Lemola 1997).

So key companies were pulled in into development process at the national level from an early stage. The current domination of two of these, Ericsson and Nokia happened despite the fact that they were not necessarily the most technologically capable companies available at the time. Though there are considerable national variations in the patterns of the interaction with industry, the histories of Nokia and Ericsson have some striking similarities;

- the management of both companies seems in the late 1970s to have been reluctant to focus on mobile telephony,
- a decisive role for both companies' subsequent development was played by partly owned subsidiaries in radio communication,
- during the 1980s both companies became mobile system suppliers, rather than specialised suppliers of subsystems – and both were early movers into this,
- the importance of the national telecom agency and its long term relation to the company is evident. An essential element in the development of the companies was played by these agencies' technological capabilities.

As we shall argue below, it was critical in the new technology for suppliers to be system producers rather than component suppliers, and this is part of the reason for the success of Nokia and Ericsson. It is difficult to determine whether the implicit industrial policy of domestic procurement, of developing national industrial capability, was the primary goal or not. However, what we can say is that the development of the modern Nordic telecom industry happened on the basis of long term relationships between the telecom agencies and industry, against the background of an established and deliberate commitment in wider industrial policies to supporting national industries and companies, combined with a strong belief in the efficacy of technological development led by public ownership and procurement. In the Finnish case the support of the national industry orientation was explicit. In the Swedish case one central actor denies that Ericsson's supply of switching capacity in the NMT system was an expression of supporting national champions. However, the AXE-system that Ericsson had to be convinced to use as base of its NMT system, had been developed jointly with Televerket through a high-profile technological collaboration, even at governmental level, that stretched back 20 years. [43]

Norway seems to be an exception among the three countries in mobile development. The reason for this is that although Norway had leading technology suppliers in mobile telephony, public sector attention in Norway was concentrated elsewhere – on a company called Norsk Data. In fact, Norsk Data (ND) was *the* central element

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[43] There are variations of this story in the literature. However, with the research done by the Linköping group, see McKelvey et al 1998, it seems clear that Ericsson wanted to base its tender to Televerket on the SPC electro-mechanical switching system AKE, and that Televerket threatened that the contract would go to NEC unless Ericsson built AXE into the bid.

of Norwegian ICT policy from the late 1970s. Essentially, it was an attempt to create a major global player in mini-computing, using public procurement within Norway as the basic market. Norwegian Televerket never managed to convince ND that telecommunications should be a central concern, and this is an option simply never mentioned in the literature on the growth and fall of ND (such as Steine 1992). Up to its demise in the late 1980s, ND was highly focussed on hardware – not seeing itself even as a software company, but simply as a hardware producer of proprietary computer technology. At the same time, there seem to have been few attempts to convince the Norwegian parallel to Ericsson, EB (Elektrisk Bureau), of the benefits of entry into mobile communications. It may be that there was a tacit agreement on a trans-national division of labour, which would explain why the one indigenous Norwegian radio firm, Simonsen Elektro never got support for its rather advanced mobile technology. Then, at the transition to GSM, when it was definitely clear that the industry demanded system suppliers, Ericsson's deal with ASEA locked out EB which was the only actor in Norway to enter in alliance with Simonsen. This was significant because the multi-functionality of the GSM system gave rise to a much more top-heavy system. Without system integration, the transition to GSM was almost impossible, and it was failure to become part of the system that caused Simonsen to disappear, along with with STORNO and others.

But in fact, a similar point can be made about Danish development. STORNO A/S and AP Radio were among the major players in development of NMT terminals and base stations from the start. Both were part of the substantial Danish radio communication capability that had developed since the 1940s with a focus on marine radio communication. The Danish radio communication company and telecom consultant STORNO A/S was contracted by the Swedish Tele Board in 1968 to assess automatic mobile systems around the world. STORNO was later awarded a major contract jointly from the five telecom operators as part of the development of the technical structure of the subsequent NMT system in 1972-73 (Gerdes (1991). Eventually STORNO became one of the suppliers of mobile terminals and base stations for the NMT system in the 1980s.

By the 1960s STORNO was the third largest producer of mobile radio-communication equipment worldwide, after Motorola and General Electric. In 1976 STORNO was in fact acquired by General Electric. However GE maintained the related technological R&D in Denmark. STORNO was sold out to Motorola in 1986 and finally closed in the early 1990s, when major parts of STORNOs development capacity was taken over by Nokia. The Motorola GSM plant in Flensburg (Germany, close to the Danish border in a dual Danish/German language region), with a total employment of c. 3000, was originally a major STORNO plant established in 1967. With the reorganisation towards GSM-based production STORNO disappeared completely; the company name was changed to Motorola in 1992.

AP Radio had a similar background and development, coming into mobile telephony from the radio industry. AP Radio was eventually bought by Philips.

Model ap 4007 (NMT 450), AP-radio telephone

The key advantage of LM Ericsson was a longstanding close connection to the national telecom agency, through which it became one of the first global turnkey suppliers of cellular mobile systems. Almost from its establishment in 1876 Ericsson was a major supplier of telephone equipment. Its relation to the national PTO Tele(graf)verket has fluctuated over its history, but since its reconstruction after Ivar Kreuger's death in 1932 and the subsequent expansion and specialisation on telephone switching systems in the postwar period, integrated collaboration and joint development were the rule.

The joint Electronics Committee established between Ericsson and Televerket in 1956 had the task of supervising and coordinating development of electronic switching systems, and later on SPC (Stored Program Control) based systems (as the AKE 12 & 13). Frustrations on achieving efficient coordination of the two organisations, led the two chief executives to decide, at the instigation of by Marcus Wallenberg[44] as the chairman of Ericsson, on the establishment of a jointly held company, ELLEMTEL Utvecklings AB, in 1970. Wallenberg was of course also Chairman of Investor AB, the largest strategic holding company in Sweden, and the main instrument of the so-called 'Wallenberg-sphere', a complex inter-locking set of industrial holdings that together constituted probably the most important industrial grouping within Sweden. That the establishment of ELLEMTEL was a strategic and policy move of very great importance, is shown not just by the fact that the two chief executives and Wallenberg were involved, but also by the fact that acceptance had to be sought at Government level.[45] Through this venture Ericsson and Televerket

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44 Jan Werkelin suggests that the proposal to establish ELLEMTEL originated with Marcus Wallenberg; "At a lunch at the chairman of the Ericsson board, Marcus Wallenberg's, office, chief executive Bjørn Lundvall and the Televerket Director General Björn Bjurel, got the opportunity of putting forward their viewpoints regarding the establishment of a joint development company. Evidently Wallenberg saw advantages outweighing disadvantages and on the same day Bjurel got the acceptance from the Government.", [*Sista AXE-stationen på plats i Älvros i Härjedalen* (*Last AXE station in place in Älvros in Härjedalen*); http://www.telemuseum.se/, dated 19981118]
Marcus Wallenberg was on the Ericsson board as deputy chairman from 1933, as chairman from 1953 until his final resignation in 1980. He was key in saving and restoring Ericsson after the Ivar Kreuger downfall, and later in buying back for Sweden in 1960 the Ericsson shares that had been controlled by ITT since 1932. The Wallenberg investment company Investor AB still, with Industrivärden AB, has control in Ericsson with about 67% of voting rights.
For the insider's view of the AXE story, see Meurling, John and Richard Jeans, **A Switch in Time**, CommunicationsWeek International on behalf of Ericsson Telecom AB 1995

45 The agreement between Ericsson and Televerket was signed on 24 April 1970

joined forces in developing electronic automated stations, electronic switches, terminals for these systems, digital transmission systems etc. In this process the telecoms agency televerket was the driving force behind Ericsson's technological development.

ELLEMTEL's major task became the development of a Program Controlled local station, which became known as the AXE system. The establishment of ELLEMTEL proved to be a decisive move. Ericsson was hesitant to enter the development of what became the AXE system. With ELLEMTEL Televerket had the means of pushing the development of a fully program controlled local exchange system into a first prototype system by 1976 and to a fully operative first version by 1980. By 1998 the AXE-isation of the Swedish fixed telephone system was complete, with 250 AXE stations installed, each with 10 to 60 000 subscribers, at an installation cost of approx. 20 bn SEK[46]. The collaboration through ELLEMTEL implied that Ericsson had the right to market AXE systems abroad, while the Swedish telecom system was supplied through Televerket's joint rights in the system. AXE became a world leading telephone system, in use in more than 125 countries. It formed the crucial backbone in the development of Ericsson into a mobile telecom technology company, in spite of Ericsson's hesitation about entering into its development.

Ericsson's dominant line of activities was in switching and exchange for fixed line telephone systems. During the 1970s this represented the dominant share of sales, and by 1973 the share of sales of switches and exchanges were about 60%, up from about 35% ten years earlier. Since the mid 1970s Ericsson has moved rapidly; in 1973 Ericsson had net sales of about 5 GSEK, by 2000 net sales were more than 50 times higher, about 274 GSEK, about a tenfold increase in real terms. Most of this growth has been during the 1990s when Ericsson became specialised as a mobile system and equipment supplier. Even in 1990 supplies to public telecom operators of stations and switches accounted for about 45% of net sales. By 1996 the share of these sales were down to 19%. In this year, following an organisational restructuring, mobiles systems and equipment accounted for 60% of Ericsson's worldwide net sales. In 2000 Ericsson's sales of these products were about 210 GSEK, or about 88% of total sales.

As mentioned, Ericsson seems to have hesitated to enter the development of the AXE system. A similar hesitation was to emerge during the 1980s, about entering mobile communication. Ericsson's strategic focus until the late 1980s was on Information Systems, with Ericsson Information Systems being the key division in the corporation alongside the business area Public telecommunication (McKelvey, Texier and Alm 1998). EIS was sold off to Nokia in 1988. It was only during the 1990s that Ericsson made the move to become a supplier of mobile technology and systems.

Furthermore, when Televerket contacted Ericsson to tender for exchange systems for NMT in 1977, Ericsson did not base it on the AXE-system, but on the large scale electro-mechanical distribution switching system AKE-13. Televerket gave Ericsson an ultimatum, either deliver an AXE-system, or loose the contract to NEC (Mölleryd 1996, McKelvey et al 1998).

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46 Jan Werkelin *op. cit.*

It was Ericsson's acquisition of SRA, a company that after selling off its consumer market activities in 1964, with its brand name Radiola, became a specialised producer of radio communication equipment. SRA's customer base was dominated by public procurement; radio equipment in defence contracts and mobile radio in collaboration with Televerket. The strategic move by SRA management in the 1960s to focus business away from defence towards civilian activities provided the birth of "Ericsson's nascent mobile telephony business" (McKelvey et al, op cit). Owned since 1927 by Ericsson and the Marconi corporation, it was taken over by Ericsson in 1983 and integrated into Ericssons radio communication division, giving Ericsson access to SRA's expertise on the radio side. SRA also provided the internal agents inside Ericsson to convince to company to base its delivery on the AXE-system, though its use in mobile networks were seen as limited. SRA thus became the second major gateway for Ericsson into mobile telephony.

7.5.4 Telephony and systems supply

A full analysis of this evolution of the Nordic telecom industry, of the emergence of Ericsson and Nokia as global suppliers, the demise of STORNO, Simonsen and others, is beyond the scope of this essay. We note however, that what the Danish and Norwegian suppliers of NMT equipment shared was a main focus on terminal equipment and the radio subsystem. Essentially this implied a focus of the front end, the radio part, of the mobile system, separating it from the 'back end' switching and network parts and also from the interface with the fixed network.

What characterised Ericsson's and Nokia's entrance into the mobile industry was the ability to transform into becoming system suppliers, into having technological capabilities on all related areas of mobile technology, from the PSTN interface to the mobile terminal. The GSMs character as a multi-service system, with voice, data and paging (i.e. SMS) services, in contrast to NMTs single service functionality, has in addition to the shifting of complexity from terminal to base station system, adding further complexity to the network system and providing potential economies in managing the whole chain.

By the mid-1990s, the GSM system was well established on the European scene, and the importance of integrated supply was evident. The table below shows market shares on GSM supplies with respect to switching, base stations and terminals in 1996. The former two are accumulated market shares until the end of 1996, while terminal shares are for sales in 1996.

Market shares GSM suppliers 1996. Source: Bekkers and Smits 1997

	Switching market	Base station market	Terminal market
Ericsson	48%	7%	25%
Nokia	14%	22%	24%
Motorola	1%	13%	20%
Siemens	21%	2%	9%
Alcatel	10%	10%	6%
Lucent	2%	4%	
Matra	2%	3%	
Nortel	1%		3%

By 1996 five companies dominated the GSM system industry, two of which were Nordic companies. In 1996 the C_3 concentration ratios were; 83% in the exchange part, 45% in the base station segment and 69% in the terminal market. Nokia's later success in global terminal sales is well known, attaining about 35% of terminal sales in 2000. The noteworthy point, however, is that all the leading companies were market leaders in at least two of the segments of mobile systems supply. Globally these markets are highly oligopolistic and technologically specialized.

We note further that of the major suppliers world wide of telecom equipment to mobile telephony and associated communication, almost all companies share two features. Generally they are large, globalised and well established at the time when the technology took off (many of these companies already had a century long history). Furthermore, almost all of them grew out of the internationalised and highly oligopolisitic industry of supply of large scale telecom equipment to PTOs and related organisations. The Swedish case of the Ericsson-Televerket development pair is just one among many examples of what formed the basis of the mobile communication industry. As an illustration – only one single company of the ten majors in this industry came into the industry with most of its industrial history tied to the radio side – Motorola.

8. Governance and innovation in Nordic telecoms

Thus far we have simply outlined key elements of the story of the development of cell-based mobile telephone communication in the Nordic area, highlighting the corporate efforts and initiatives of the national telecom operators and the Nordic collaboration between them. This is done with a specific aim in mind, to see these organisations' efforts of developing mobile communication systems as an illustration of the wider technological and industrial strategies, and specifically braoder issues of governance. These issues are tied up with the de facto national monopoly on infrastructure development and service provision held by the telecoms operators. In this section we turn to some reflections on the links between governance and this long innovation trajectory.

What explains this popularity of mobile telephony in the Nordic countries? We argue that there must be several dimensions to any attempt to answer this question. On one level there is the development and supply of an innovative and appropriate technology. The technological dynamism of the Nordic PTO companies, which was integrated with a general set of appropriate capabilities (in radio technologies for example) within the Nordic area. The governance systems of these companies, and particularly their industrial links, made it possible to envisage uses for mobile telephony, and to make radical long-term technological choices. On the other hand, these companies were and are located in societies that were receptive to new technologies, and were quick to see the possibilities that such technologies as portable radio and ultimately mobile telephony offered to those living in Nordic societies.

From the technological perspective, our starting point is a rather simple, but often forgotten, observation. This was a long-term cumulative process, based on sustained commitments. Mobile telephony is not a technology that suddenly appeared as full-fledged first generation systems, evolving directly into second generation systems,

developed more or less from scratch over a short time span during the last two decades of the 20th century. On the contrary, mobile communications are broadly speaking almost as old as the invention of the Bell telephone. Although the idea of mobile telephone communication systems emerged with telephone systems themselves, however, the development of the requisite technologies and systems took almost a century to develop. In fact, with long distance transmission of voice, the conceptual idea of 'on the move' communication was rather simple, and areas where such a system would be valuable were readily identified. However, the technical barriers to achieve this turned out to be huge, and new barriers were discovered as the basic idea was refined to reflect potential opportunities that could be envisaged if the technology and related science progressed.

The reason for this slow process is that the core of a mobile phone system is a radio communication system. A systematic exploration of and experimentation with, and even more wide spread exploitation of radio communication had to await the development of capabilities, science-based insights and technologies, beyond radio communication proper, that would not be systematically available before the 1940s and the 1950s. The development of systems and designs for handling of telecommunication and the mastering of VHF transmission were crucial elements, as were developments in enabling technologies such as electronics.

The hypothesis underlying this paper is that the Nordic telecom administrations – in their capacity as de facto monopoly providers of a wide range of telecom services – were crucial in driving and organising the development of mobile phone systems, first and primarily in the Nordic area, later through their participation in the development of the pan-European GSM standard and system. The possibility of playing this role was partly a consequence of the development of a substantial technological capability during the post-war period. The awareness of new technologies, in electronics, in radio communications etc., and the increasing capability to develop and utilise these, founded a culture in which technological opportunity implied a developmental responsibility. The obligation to be of national and social use, prevalent throughout the Nordic public sector, facilitated this and there was no dearth of potential social and economic areas with needs for a wide range of new telecom services.

The emphasis on economic and social need means that the role of these PTOs in the development of the technologically advanced NMT system during the 1970s was integrated with a deliberate strategy of building national industrial capabilities in these countries. This in turn reflected the dominant industrial policy fundamentals of corporatist industrial development in the Nordic area in the post war period. So during the post-war era the Nordic telecom administrations developed into technologically oriented organisations with a leading role at the national level in several telecom areas. The outcome of this process is well-known. When the NMT system led on to the GSM system a basis had been laid for the emergence of a dominant Nordic industry in the area of mobile communication. We suggest that the various roles played by the national PTOs in this process were indispensable. The question is what these roles really were.

Broadly speaking, two core roles have been suggested. Firstly, the Nordic PTOs played a central role as standards setters. The process of developing the NMT system may then be described essentially as one of developing the necessary technological

requirements for the mobile communication system and the required standardisation of the various communication interfaces such a system involves. Such a model of standardisation in the area of telecoms, the open system approach (OSI), with a layered and modular structure, was central in the ISDN system, and this had a clear impact on development of the GSM specifications. ISDN has even been characterised as the Godfather of GSM (Mouly and Pautet 1992). This role of the Nordic PTOs can also be claimed for the NMT system, even though that system lacked the clear modularity of the later GSM specifications. The basic limitation of some current approaches in explaining the links between the incipient mobile communication industry in the Nordic area and the national PTOs is that they describe these linkages in more or less a-historical terms, and with an arms-length notion in analysing these linkages. However these links were highly organised, and where linkages related to the standardisation process they were able to attain such importance because they developed on the basis of a pre-existing matrix of relations.

A second role of the Nordic PTOs takes as a starting point their role as public agencies whose primary task was the supply of telecom services. The PTOs role in procurement of telecom and network equipment from industry then becomes pivotal for the development of telecom technology. Here, the PTOs state-of-the-art technological competences were central, as were their capabilities in transforming potential user needs into technological specifications for the underlying telecom equipment. Thus, PTOs in their capacity as public procurers of telecom equipment, played a 'lead user' role in the sense of von Hippel (von Hippel 1988). This approach is closer to describing the actual process than the standardisation approach. However, such an analysis needs to be supplemented with consideration of the market structure; broadly speaking the Nordic market for mobile communication technology in the 1970s and 1980s was monopsonistic (see Palmberg 1998 for discussion).

It should be borne in mind that the development of NMT could well have been a dead-end. When the NMT system was introduced in 1980-81, it was widely acknowledged as the best available in terms of up-to-date technological characteristics. The potential for growth in the use of mobile technology was recognised, though on a much more modest scale and limited market scope than what was realised over the next two decades. The Nordic system and its implementation thus had the attention of producers of equipment and terminals world-wide. However, NMT was an analogue system, and the development of the second generation digital systems was already under way when NMT began to diffuse into the Nordic societies.

The transition from analogue to digital was potentially capability-destroying, in the Anderson and Tushman sense. The strategic industrial implications of the technological choices made in the GSM work was well acknowledged by the early 1980s. Attempts to capture the GSM standard for more or less protectionist reasons were made, attempts that might have brought the Nordic countries several steps back. That this possibility was avoided was in large part due to a clear strategic awareness in the Nordic telecom operators of NMT and the technological choices involved, as a just one step on the road towards digital systems. From the start, the Nordic PTOs were actively involved in the development of the GSM standard. In fact, the initial work that led to the establishment of the GSM project in 1982 was seen by the Nordic PTOs as the natural next step – as a 'second generation' NMT. The first chairman of the GSM group, Thorleif Haug of the Swedish PTO, later Telia, had

previously been chairman of the Nordic NMT group and had been involved in the NMT project since its inception in 1970. The transition from the analogue NMT system of the 1980s to the digital GSM system of the 1990s, if anything, even further accelerated mobile leap-frogging by the Nordic countries.

On the technological side, our hypothesis is therefore that the strategies and technology procurements of the telecom administrations, and the formal and informal networks between the administrations and national industries are the keys to explaining why this technology and industry emerged so strongly in the Nordic countries. But it is also important to consider potential users. In the sparsely populated Nordic region, with an aggregate population of just 24 million, shared among five politically and economically integrated countries and three autonomous regions, communications are always a major problem. These are societies with both the resources and willingness to adopt innovations in this field. These were societies in the forefront of diffusion of the telegraph, and of portable radios in the 1950s. Mobile telephony was perfect for a geographically dispersed, mobile population. However, not too much should be made of such a factor-induced explanation of the early penetration of mobile telephony in the Nordic countries. The markets that were targeted during the first period were primarily urban business markets, focused on car phones, an immediate extension of the markets that had been served by former mobile systems. The diffusion was evidently aided by these phones becoming something of a signal maker for the 'yuppie' movement during the mid-1980s. The popularity of the NMT 450 system, and the rapid congestion of capacity in the major urban sites, came as something of a surprise to the Nordic PTOs. The original NMT system, initiated in 1981, soon had to be revised and extended, leading to the introduction of the 900 MHz NMT system in 1986, in the wake of more or less unforeseen demand for the system.

The de-, or rather re-, -regulation of telecom service and infrastructure provision during the 1980s and 1990s has fundamentally changed the role of these organisations in their national context. Can we envisage a similar story unfolding at a later stage in some other emerging technologically led telecom area? Can these organisations, together with national authorities replay this kind of national industrial strategy? Probably not. The fundamental changes in governance structures, devolution of their various standardising and regulative functions and a reduced role as a national technological resource and leading environment are all ultimately linked to the abolition of their de facto monopoly positions.

So how can we relate the development of technological and industrial strategies in the national telecom operators during the last decades to changes in these strategies and to concomitant changes in the governance structures of these organisations? These strategies seems to have changed away from strategic perspectives ultimately based on 'national' considerations, to large extent shaped by technological opportunities, albeit within the framework of the politically acceptable, and beyond private commercial interests of the company. This strategic orientation went hand in hand with the development of new technological capabilities, with an obvious technology-driven backround and orientation. The establishment of the R&D organisation Televerkets Forskningsinstitutt in 1967 is part of this trend, following in the wake of the increased focus since the late 1950s of the potential of new electronics to revolutionise telecom systems and infrastructures. The role of the two *Televerk* in Sweden and Norway at this time was that through their combination of

publicly organised tasks and functions they became system developers, procuring components and shaping a system which in another contexts resembles the concept of a military-industrial complex.

In this context the joint responsibilities of organisations as these was complex. They were infrastructure owners, service providers, regulating and certifying organisations (eg for telecom equipment), as well as their universal service obligations. They were seen, and evidently saw themselves, as part of a social infrastructure or social overhead, and not as profit-seeking service providers. The willingness to embark on the process of developing mobile telephony was arguably a part of this orientation. The new system which ahs emerged places a much greater emphasis on new business development, international expansion, and mergers and acquisitions. In the new governance system, some of thee firms are already facing difficult financial constraints. It is unliklely that the radical development of mobile telephony could be repeated in the new context.

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STEP-gruppen ble etablert i 1991 for å forsyne beslutningstakere med forskning knyttet til alle sider ved innovasjon og teknologisk endring, med særlig vekt på forholdet mellom innovasjon, økonomisk vekst og de samfunnsmessige omgivelser. Basis for gruppens arbeid er erkjennelsen av at utviklingen innen vitenskap og teknologi er fundamental for økonomisk vekst. Det gjenstår likevel mange uløste problemer omkring hvordan prosessen med vitenskapelig og teknologisk endring forløper, og hvordan denne prosessen får samfunnsmessige og økonomiske konsekvenser. Forståelse av denne prosessen er av stor betydning for utformingen og iverksettelsen av forsknings-, teknologi- og innovasjonspolitikken. Forskningen i STEP-gruppen er derfor sentrert omkring historiske, økonomiske, sosiologiske og organisatoriske spørsmål som er relevante for de brede feltene innovasjonspolitikk og økonomisk vekst.

The STEP-group was established in 1991 to support policy-makers with research on all aspects of innovation and technological change, with particular emphasis on the relationships between innovation, economic growth and the social context. The basis of the group's work is the recognition that science, technology and innovation are fundamental to economic growth; yet there remain many unresolved problems about how the processes of scientific and technological change actually occur, and about how they have social and economic impacts. Resolving such problems is central to the formation and implementation of science, technology and innovation policy. The research of the STEP group centres on historical, economic, social and organisational issues relevant for broad fields of innovation policy and economic growth.