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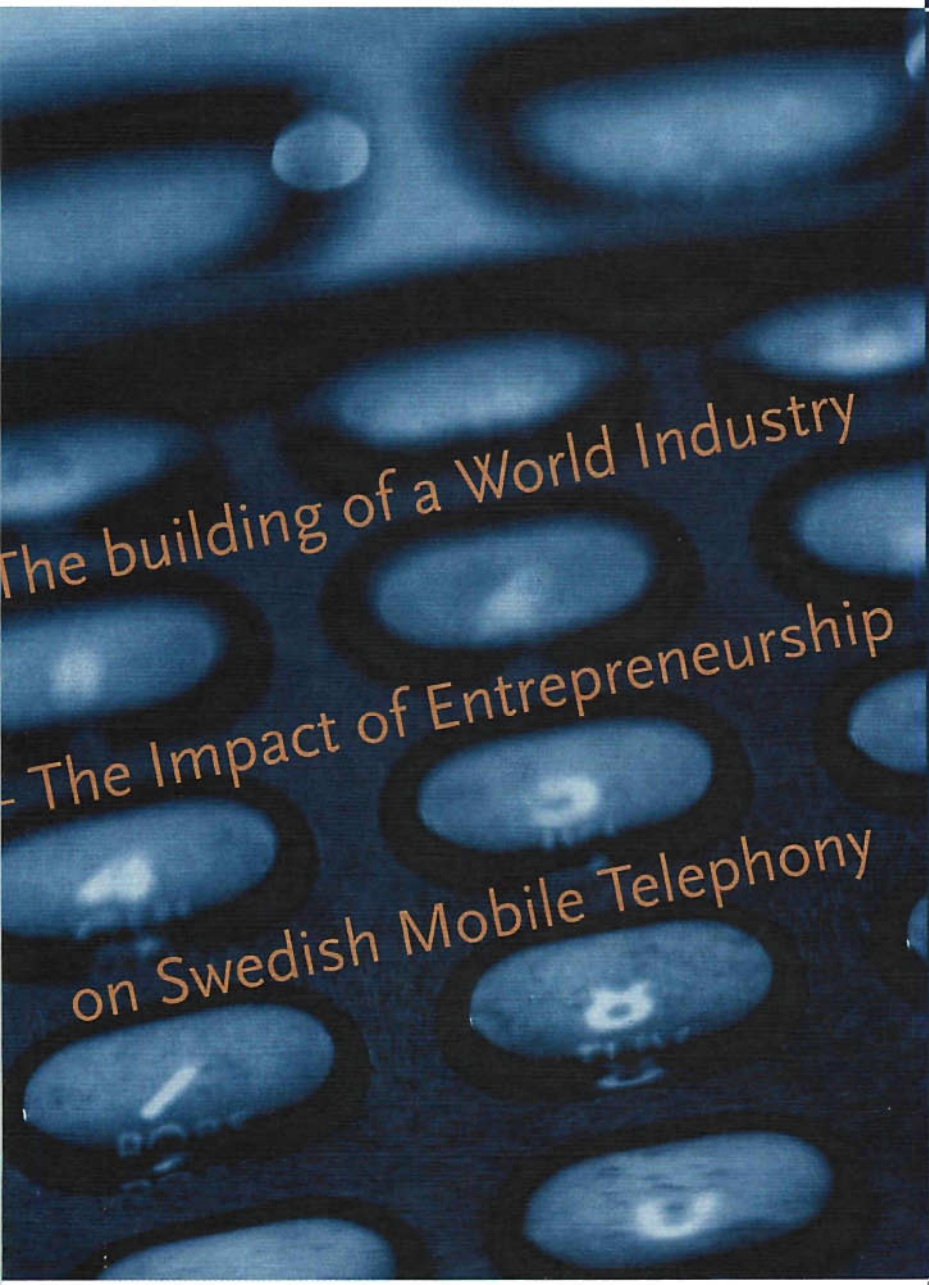
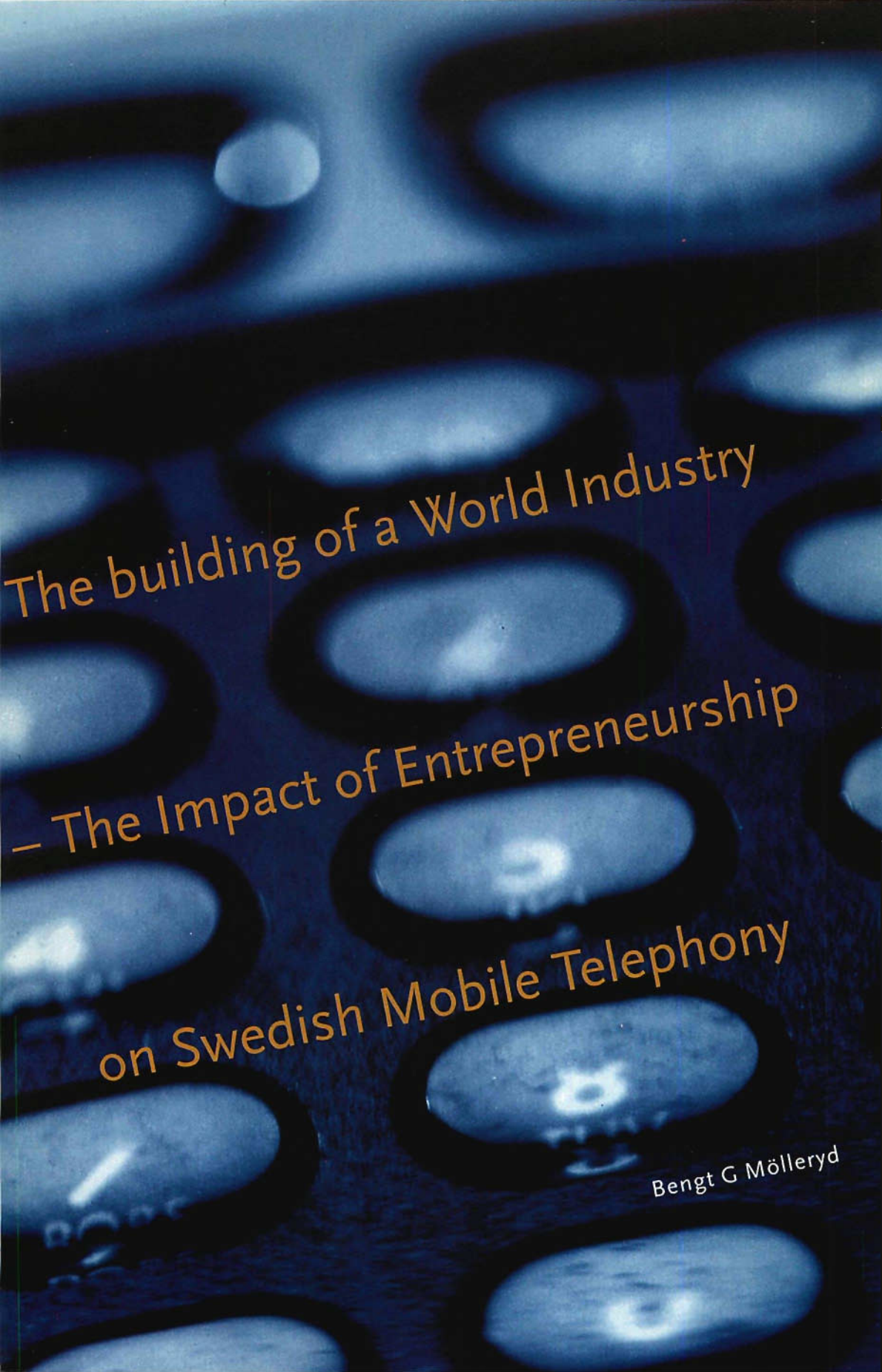


The building of a World Industry
– The Impact of Entrepreneurship on Swedish Mobile Telephony

Bengt G Mölleryd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Publication of this report has been made possible thanks to Bertil Thorngren who also kindled the idea. As regards financing, I would like to thank Telia and the Telekon programme, Allgon, Ericsson Radio Systems and Telia TeleCom. I would like to express my thanks to KFB, Kommunikationsforskningsberedningen (Swedish Transport & Communications Research Board), which financed the underlying research, as well as to Ruben Rausing's Fund.

I would also like to express my thanks to associate professor Staffan Hultén, professor Lars-Gunnar Mattsson and other colleagues at the Department of Marketing, Distribution and Industry Dynamics, EFI at the Stockholm School of Economics, for their most invaluable help as regards the creation of this report.

Stockholm, February 1997
BENGT G MÖLLERYD

Preface

TWENTY YEARS AGO, armed with the requisite radio telegraphist's certificate, I took a heavy radio telephone apparatus to my sailing boat and there installed it in a rudimentary radio cabin. The apparatus actually worked and it was even possible in those days to send e-mail by the Internet – which goes back much longer than most people think.

Actually, the history goes back a long way. The former Swedish Telecom introduced the world's first fully automated mobile telephone system as early as in 1956. The number of subscribers could be counted in hundreds rather than millions for a long time, and not only because the equipment was heavy and expensive. The mere thought that the streets would be filled with pedestrians and cyclists using mobile telephones seemed preposterous to most people. It looked as if the law of nature itself was against it ever happening. The access to radio frequencies was limited and resources were scarce – supporting only a few thousands users, and that was as far as it could go.

However, visionaries could be found, not least in Sweden, where people anticipated that the mobile telephone could be used just as frequently as its wired counterpart. This became a reality due to a number of breakthroughs in technology. New ways were found to re-use frequencies, by dividing geographical areas into small squares (cells), which had their own radio base stations. The transistor technique simplified the manufacturing of smaller and lighter equipment, etc.

Bell Labs in the US may definitely be ascribed the role of pioneer in many of these technical domains. Yet it was in Sweden (and in Scandinavia) that the new technique was first practised – not in the US. The first "cell-radio" system (NMT) was introduced in Sweden and Scandinavia as early as 1981 – together with Comvik's system which was imported from the US. Many years passed before the new technique was accessible in the US, and the same applied to the UK. The Japanese made an early start but the application so far has been on a remarkable low level. Although it is necessary to be at the technological edge, it is apparently not enough.

– Why did this knowledge spread much faster in Sweden (and in Scandinavia) than anywhere else in the world?

– How was it possible, in such a short time, to build that "world industry" that mobile telephony undoubtedly has become – with export figures exceeding those of the car industry?

These are the topics in this TELDOK report, based on Bengt Mölleryd's licentiate dissertation at the Stockholm School of Economics. He claims that no "master plan" could be traced, either to the former Swedish Telecom or the former SRA (present Ericsson Radio). Instead, the development is characterized by a successful interplay between a number of "entrepreneurs", equipped, not only with visions, but with knowledge, ability to take action as well as to take advantage of new openings. Names such as Åke Lundqvist, Seth Myrby, Östen Mäkitalo, Lars Ramquist, Per Siversson and C-G Åsdal can be found among those who have made themselves a name in the history of mobile telephony. Many other extraordinary personal contributions can be seen in relation to technology and the market. They appear in a number of far-sighted companies and organisations, all of which may represent the entrepreneurs.

It might be surprising that many of the pioneers are to be found among large organisations such as the present Telia and Ericsson, and their counterparts in the rest of Scandinavia. However, they co-operated closely with small companies, such as Allgon and Spectronic, which were specialized in important niches, and they interacted with people who created the distribution systems. New networks were established between operators, suppliers and customers, which facilitated a closer approach to new users and customers. Thereby, it was possible to maintain that crucial driving force, which came continuously from new users who were constantly hunting for new as well as for more effective and simpler applications. Together, all these entrepreneurs constitute, what Erik Dahmén calls, a "development block" – more vital than the first visionaries dared to even dream about.

To include users among the entrepreneurs, as I have done in the last paragraph, might be regarded as stretching the point – but it nevertheless seems only right to do so in a TELDOK report. Technical development in intense interaction between users and the market is something quite classic.

I would like to thank Bengt for this excellent account.

BERTIL THORNGREN
CHAIRMAN OF TELDOK

Contents

1. Introduction

Mobile Telephony – a growing business

We do not exaggerate in claiming that mobile telephony has given birth to an enormous market in Sweden, and has developed to become one of the most important sectors in Swedish industry. Daily newspapers are filled with advertisements regarding mobile telephones as well as articles about the business itself. How is it that Sweden has been in the lead when it comes to the development of mobile telephony? What is behind the fact that many Swedish companies are in the lead regarding the business of mobile telephony? Also, why has Sweden the highest penetration of mobile telephones?

One possible answer could envisage a specific meeting, where leading representatives of a few participating companies and organisations prepared a strategy to make mobile telephony a Swedish world industry, a plan that they have since been able to realize. Indeed, this is the sort of scenario one could expect in a textbook about management strategy, except that it disagrees with the reason for the Swedish mobile telephony development.

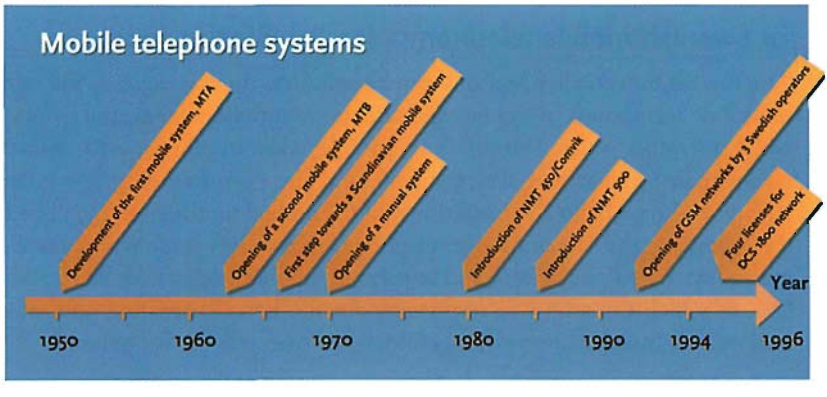
The fascinating fact as regards this development is that the whole time until the mid 1980's – nobody, in Sweden or abroad, believed that mobile telephony would become a success. Mobile telephony was considered to be a marginal market – without any particular future prospects. Now we know better. And the forecasters redress earlier mistakes and fill their forecasts with predictions that mobile telephony – or rather personal communication – will be developing far into the future. For example, the European Commission predicts that the market for private and mobile telecommunication will expand more than the market for fixed telephony.

Of course no such meeting took place where the Swedish mobile telephone industry developed a plan to make a world industry out of Swedish mobile telephony. Instead it was in the 1950's that the basis of the success was formed, when a few persons in key positions had a vision which began to gain impetus. Since then, those people involved have performed in such a way that mobile telephony has developed into a business of great importance (see below for explanation). As for the telephone company LM Ericsson, mobile telephony is the largest sector of activity; Telia regards mobile telephony as a growing business nationally as well as internationally, and when it concerns the private network operators, mobile telephony is synonymous with great expectations of considerable future profits.

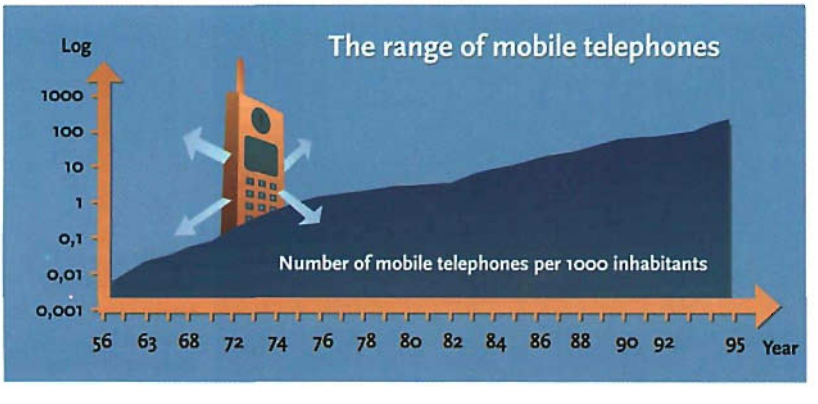
This research shows that the remarkable development of mobile telephony in Sweden may largely be explained by an entrepreneurship which has been carried out by individuals, companies and industrial networks. I will present a number of individuals who have acted as entrepreneurs during the development of mobile telephony. By pointing out individuals I would like to emphasize that the way people perform is of great importance for the development. But at the same time I would like to stress that the development does not only depend on the performance of individuals, but also of companies, which certainly operate with greater resources, and therefore may be able to carry out entrepreneurial activities beyond the range of individuals. Also, when companies cooperate with others, they form networks in conjunction with the development of major projects, for example, the development of Global Systems for Mobile Communication, GSM.

Everybody has underestimated the growth

Mobile telephony in Sweden has its roots in the 1950's when Televerket' (Swedish Telecom) became the world's first telecommunication administration to operate a fully automated mobile telephone system. The instigators of the first mobile telephone system certainly believed that it was technically possible to build a nation-wide network, but considered it to be too



The introduction of various mobile telephone systems in Sweden.



The growth of mobile telephony in Sweden 1956–95 indicated by the number of mobile telephones per 1000 inhabitants, logarithmic scale.

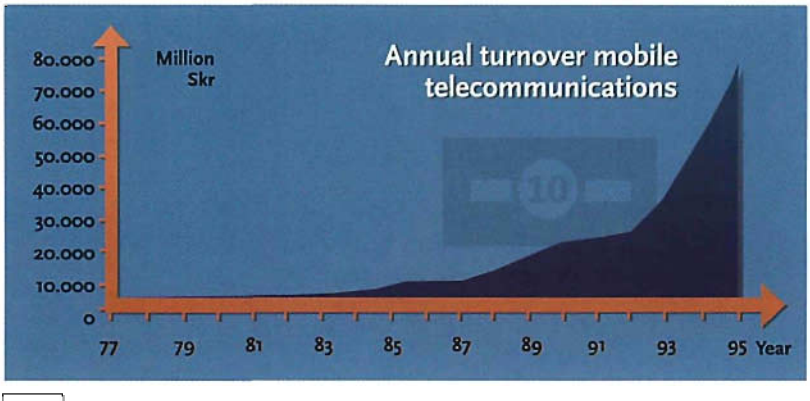
much of an investment to become a reality. During the 45 years of development of mobile telephony a number of systems have been launched creating openings for a huge expansion of mobile telephony.

One of the first forecasts made by Swedish Telecom in 1967 predicted that the number of subscribers, ten years after the introduction of a fully automated system, would become 40,000. When Swedish Telecom in 1981 introduced NMT, they calculated on 40,000 subscribers in 1990, but it turned out to be almost 500,000. Swedish Telecom was no more successful in forecasting the GSM development – in 1990 they believed that by 1994 the number of subscribers would be 25,000, but the real figure was 423,000. It might not be so surprising that the forecasts turned out wrong, since they were built on a low but steady growth without features of dynamic market effects.

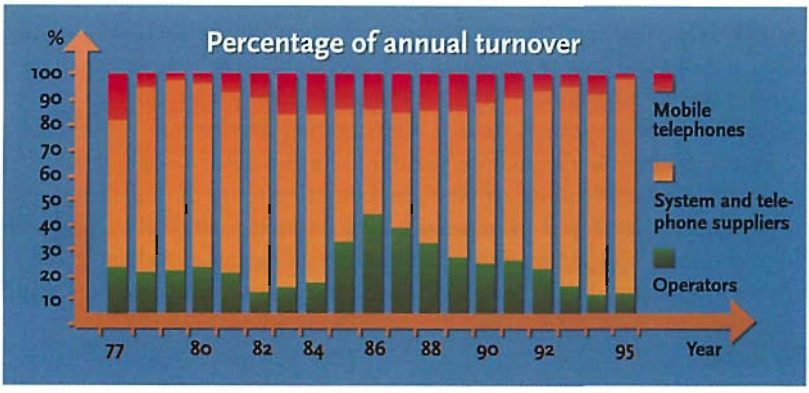
The forecasts served as guidance regarding the development and expansion of NMT. Occasionally this led to the operator being behind with the expansion and that the suppliers did not come up with the required number of systems and telephones. One example of a company which turned the forecast mistakes into a business opportunity was Allgon. At the beginning of the 1980's, Ulf Saldell, technical manager at Allgon, discovered a gap between Swedish Telecom's forecasts and the actual influx of subscribers. He regarded that as a sign of mobile telephony's great market potential, which consequently would result in a huge demand for mobile telephone aerials.

Annual turnover for Swedish mobile telephony –skr 75 billion in 1995

The market for mobile telephony can be split into three groups: 1) the sale of mobile telephones, 2) system and telephone suppliers' sales, and 3) network operators' sales. During 1995, mobile telecommunication's annual turnover in Sweden was skr 75 billion, and the corresponding figure for 1982 was skr 1.8 billion. A breakdown of the annual turnover of 1995 gives the following: the sale of mobile telephones in Swedish trade was approximately skr 1.3 billion; system and telephone suppliers' sales were skr 65 billion, of which Ericsson was responsible for the lion's share, and 96% was sold outside Sweden. Network operators' turnover was skr 8.5 billion.



Mobile telecommunication's total annual turnover in Sweden 1977–95.



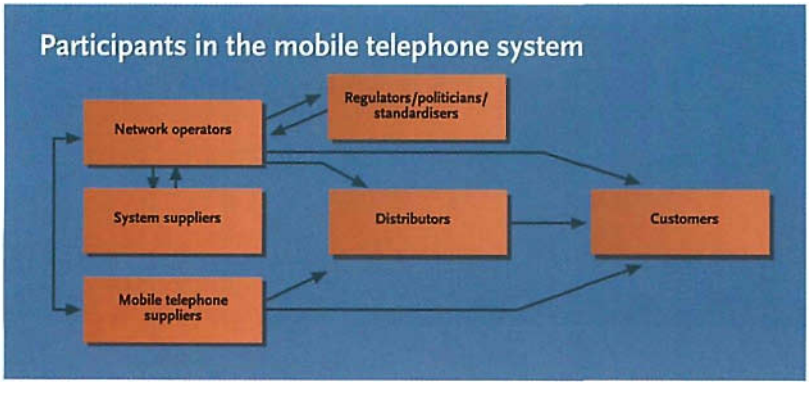
Mobile telecommunication's annual turnover divided into, 1) the market for mobile telephones, 2) system and telephone suppliers, and 3) network operators.

The impact of entrepreneurship

The main question in this report involves the impact of entrepreneurship on the development of mobile telephony in Sweden. In order to answer that question, I will characterize the entrepreneurs in three different ways: as individuals; as companies and as networks. (see appendix). However, I am not only interested in who has carried out the entrepreneurship – but also in which type of entrepreneurship has been carried out. Since I describe a development which covers 45 years, it allows me to study how the entrepreneurial function has changed in time. I can then clarify whether the entrepreneurship has been carried out by individuals at the beginning, and by companies towards the end of the period, or whether networks have gradually been the most important form for entrepreneurship.

Since I characterize mobile telephony as a technological system, in line with Thomas P. Hughes' (professor at University of Pennsylvania in Philadelphia) theory, I not only involve the physical mobile telephone network, but also companies and organisations. This allows me to study connections and dependencies between the different participants involved, as well as subsystems.

These dependencies may be illustrated by network operators who are un-



Participants involved in the mobile telephone system.

able to offer their services unless there are system suppliers who can supply base stations and mobile telephone exchanges, and telephone suppliers supplying mobile telephones. Network operators cannot reach out to people with their products unless there is a functioning distribution. We also find connections between regulators/standardisers and network operators.

From a Swedish point of view, mobile telephony, during the period 1950–95, has developed from being a local business, with both a local system and local companies, into a national/Scandinavian as well as an international industry. In this respect I divide the course of events into three phases:

1) local,
2) national/Scandinavian, and
3) international.

Since this report describes the development in Sweden, it includes relatively few international outlooks. But I will of course discuss the development of NMT and GSM.

A definition of entrepreneurship

In order to establish a definition of entrepreneurship, I refer to the Austrian economist Joseph A Schumpeter's classification of five different types of combinations or innovations:

1) the introduction of a new product
2) the introduction of a new production process
3) the introduction of new inputs (which are being used in the production of other goods)
4) the carrying out of a new organisation of an industry, and
5) the opening of a new market

I will add Staffan Hultén's & L-G Mattsson's two categories (see references):

6) a new type of marketing, and
7) a new distribution channel.

To facilitate the analysis regarding which type of innovation is being used, I will divide the seven different innovation types into three groups: entre-

Type of innovation	Group	Individual	Company	Network
1) A new product	Techniques			
2) A new production process	Techniques			
3) A new input	Techniques			
4) A new organisation of industry	Organising			
5) A new market	Market			
6) A new type of marketing	Market			
7) A new distribution channel	Market			

Entrepreneurial matrix.

preneurship in relation to technique, organising and market.

For each phase I present an entrepreneurial matrix in which I fill-in the identified type of entrepreneurship.

For an individual, a company or a network to be called an entrepreneur, it is necessary that they have executed one of the types of innovation. When I identify an entrepreneur, the question arises regarding the difference between the individual as entrepreneur, the company as entrepreneur, and the network as entrepreneur. There are of course individuals involved in all these cases. To be called an entrepreneur, the individual has to execute one of the seven innovation types while a manager, for example, could perhaps meet the requirements of an entrepreneur (even if he does not meet the requirements of an individual entrepreneur) through his/her company which executes one or two of the innovation types. An individual can then be classified as an individual entrepreneur at the same time that his company has served the function of an entrepreneur. A network entrepreneurship may meet the requirements when two or more companies co-operate in a development or market project. If the entrepreneurship is widespread, entrepreneurs may be found in relation to more than one of the innovation types.

Disposition

In the following three chapters, mobile telephony is divided into three phases: local, national/Scandinavian and international phase. At the end of each chapter I analyse the actual entrepreneurship which has been carried out during the phase. In the concluding chapter I discuss how entrepreneurship has developed in course of time. Moreover, I present a model for a dynamic entrepreneurial development, which I call the entrepreneurial spiral.

2. The local phase

The pioneers

"When you sit in a car driving at high speed, you can connect yourself to the regular fully automated telephone network, and then use all its potentials."
(Handelstidningen [Commercial Journal] 26 November 1953)

Håkan Sterky, Director General at Swedish Telecom in the 1940's, anticipated the possibility to develop the business of mobile telephony with the rapid development of radio and air communication which took place at the time. In the late 1940's, Sterky commissioned Sture Lauhrén and Ragnar Berglund at Swedish Telecom to develop a fully automated mobile telephone system. Together with Ivar Ahlgren from Svenska Radioaktiebolaget (SRA) and representatives from LM Ericsson, they prepared a test system in 1950. The teletechnical part of the system was based on an innovation developed by Lauhrén, and which was patent pending in a number of countries. Berglund designed the radio technical part of the system. The radio equipment and mobile telephones were manufactured by SRA, and the relay equipment was manufactured in Swedish Telecom's workshop.

Doctors test car phones

Sweden was far from alone in developing a mobile telephone system in the late 1940's; manual mobile telephone systems were concurrently being developed in a number of countries. But unlike most other countries, Swedish Telecom decided to develop a fully automated system immediately.

Swedish Telecom's Mobile Telephone System A was complete in 1952–53, after three years work, and the cost was approximately skr 300,000. The system consisted of modified technologies. The new system, having 20 telephones, was tested in Stockholm until the mid 1950's, when the production was enlarged to include four channels and 75 mobile telephones. Among those testing the novelty was Stockholm's Medical Association which installed telephones in four emergency cars. However, the system was not fully reliable and periodically all the telephones were out of order. This forced the emergency doctors to install radio communication in their cars and even redirect the operation via the rescue corps.

Swedish Telecom considered the mobile telephony investment a satisfactory alternative to private radio networks since the radio frequency was used more effectively. Besides, according to Berglund, it was more natural that Swedish Telecom operated the car telephone network since this facilitated connection to the public telephone network.

The introduction of the first car phone system

On 25th April 1956, Mobile Telephone System A (MTA) opened for commercial traffic. It was the first automatic mobile telephone system in the world where subscribers could make or receive calls in a car without the assistance of a telephone operator. A radio base station was placed on the water tower at Lidingö, 90 metres high, which gave the system a range of 30–40 kilometres.

MTA was built on a relay technique and the signal system was designed like a pulse system, where the pulses were sent through a tone switch, which, according to Lauhrén, would ensure a reliable identification of the subscriber. The connection took eight seconds. The network had four radio channels, which interacted in a group with an automatic choice of available channel. MTA worked in duplex (bi-directional traffic) with an automatic speech connection. The mobile transmitters' power factor was 15–25 W and the radio base station transmitters' power factor was 50–100 W. The system used frequencies within the 160 MHz-band. The connection to the telephone network was placed in the telephone station's group selection stage via a mobile telephone exchange.

The developers of the first system were convinced that there was a demand for mobile telephones among transport companies, doctors and businessmen in the major cities. Since Swedish Telecom acted on the principle that the mobile telephone service should cover its own costs, it was already clear from the beginning that this was to become an exclusive service with high tariffs. Swedish Telecom considered it unreal at that time that the mobile telephone was to become everybody's property. But at the same time Swedish Telecom wanted the tariffs to be on such a level that mobile telephones would become an interesting affair for a number of different subscribers, offering a variety of services to the public.

Swedish Telecom did not market the mobile telephone service in a particular way: those who were interested wrote to the company inquiring about the chances of obtaining a subscription. The person in charge of mobile telephony at Swedish Telecom confirmed that the interest in mobile telephony was constantly increasing. In 1954, Swedish Telecom carried out a market survey which showed the interest in mobile telephony among larger companies. Potential subscribers were: bank buses, breakdown lorries, boats and doctors. The bank buses moved from place to place acting as bank offices between the suburbs of Stockholm, and were open an hour at each place. The Swedish Credit bank possessed a mobile telephone, which, according to the bank management, played an important role to their business. The telephones worked more or less satisfactorily when they were newly adjusted – often better in the mornings than in the afternoons. The customs director in Gothenburg spoke of success when testing a mobile telephone. As for the taxi companies, it meant major changes:

"Premiere for dial telephones in four Gothenburg cars", Rune Larsson from Kållered became the first taxi driver in the west of Sweden with a car radio telephone. The whole telephone installation was situated in the boot, "anyone can call him now when he is out on a job. If he wants to talk with somebody he only has to dial, just the way he does at home." (Handelstidningen, 20 September 1956)

Among the subscribers were the city of Stockholm's hospital management, Svenska Handelsbanken, Stockholms Enskilda Bank, Skandinaviska Banken, Sveriges Kreditbank, Freys Express AB, AB Radiotjänst and Stockholm's Medical Association. One of those responsible at the medical association, Dr Stig Valentin, thought it was fantastic to have a telephone in the car, since he could get in touch with patients quickly. But the problem remained that many households did not have a telephone.

Swedish Telecom did not expect mobile telephony to become a "big business", but they expected the business to give a minor profit when subscribers exceeded a hundred. The total investment, in network structure and mobile telephones, which was to accumulate, was almost skr 1 million. Swedish Telecom estimated a revenue of skr 150,000 per year, meaning that the subscribers on average paid skr 1,375 in mobile telephone fees per year.

To begin with, the intention was to let MTA extend along the main roads between Stockholm, Gothenburg and Malmö. But the number series were limited to 1,000 numbers, and an extension was looked upon as far too expensive. MTA was phased out in 1969, and the subscribers were transferred to Mobile Telephone System B.

Further development as from the mid 1950's

The first system suffered from a number of shortcomings: the telephones were unwieldy; connecting-up time was long; the system was complicated to use, and the mobile telephones were expensive. In the late 1950's, Ragnar Berglund claimed that a new system was to replace MTA, and began working on improvements. This resulted in a new mobile telephone system, built on a patent developed by Berglund. Three to four persons were involved in developing the MTB as the new system was called.

As early as in the 1950's there were plans for a nation-wide mobile telephone network, but there was a long way to go before the plans could be implemented. Swedish Telecom considered it unrealistic to have a nation-wide network built only in connection with traffic along the main roads. However, according to Swedish Telecom, it was possible to install radio base stations in larger communities along the main roads, where a demand could be identified, and which could serve the national network at the same time. Swedish Telecom estimated the number of potential customers in larger communities at no more than 30, not counting Gothenburg, Malmö and Stockholm. This meant that MTA could hardly be the choice, since MTA required equipment at the cost of skr 30,000 at the telephone stations, not counting the expensive mobile telephones. Therefore, a system of low initial cost was required, as well as relatively cheap mobile telephones. A system which met those requirements was MTB, according to one of those responsible for finances at Swedish Telecom.

Berglund, as well as other people at Swedish Telecom, showed in their analyses that it was better to invest in the new system than it was to extend MTA. MTB had a cheaper network structure; the system could connect directly to the telephone system, and the switching was faster. The mobile telephones were cheaper, smaller, lighter, and consumed less energy.

Berglund's system, tested as from 1957, included two mobile telephones, and turned out to be satisfactory. As from 1961, the test system included 13 mobile telephones, of which some were used by the security police at Nikita Chrusjtjov's official visit in Stockholm 1964. The Director General of Swedish Telecom possessed an Ericofon (a "Cobra-model") with an illuminated dial – adjusted to the mobile operation – which was installed in his limousine.

In 1965, four-channel radio base stations were set up in Stockholm and Gothenburg, catering for 150 mobile telephones. The network expanded in 1967/68 in Stockholm, Gothenburg and Malmö, which meant 500 subscribers.

The cost of expanding MTB, which had six channels serving 200 subscribers, reached skr 1.5 million, according to the estimate. The proportions of the operation were fairly limited in spite of the network expansion. According to Olle Gerdes, who was engaged in mobile telephony at Swedish Telecom from the 1950's, neither MTA nor MTB were profitable for Swedish Telecom.

MTB used duplex, and operated in the 80 MHz-band. The system had an automatic speech connection and was based on the principal of dual-tone, which meant that an exclusive selection tone identified the mobile telephone. The transition to the fixed telephone network went through the subscribers' relays with a unique subscriber's card for each subscriber. This implied that the system could only be used locally unless the subscriber had a subscriber's card based at several base stations. The mobile transmitters' output power was 15–25 W, and the radio base station transmitters' 50–100 W. The range was 25–30 kilometres from the base station in Stockholm. There was a built-in time-out device which tuned whenever a call lasted more than three minutes, and which boosted gradually until the call was interrupted.

Though MTB could only handle six calls at the same time in Stockholm, it was comparatively more useful from a subscriber's point of view than AT&T's system in New York in the 1960's. This system was not able to handle more than 12 calls at the same time on the whole of Manhattan.

The marketing of MTB was modest, and consisted mainly of advertisements in the telephone directory and at Swedish Telecom's sales offices. The subscribers included photographers, locksmiths, doctors, reporters, service engineers and veterinary surgeons. When the system was phased out in 1983, subscribers were offered favourable terms to switch over to NMT.

AB Nordisk Teleproduktion supplied the mobile radio equipment for MTB, which was transistorized with the exception of the transmitter's driver stage and final stage. With that, the current consumption from the car battery could be reduced considerably. Nordic Teleproduction's aim was to concentrate on mobile radio systems, and the company was the representative of Motorola and the British company Pye in Sweden. Åke Lundqvist, who later became the executive director of Ericsson Radio, began his career at Nordisk Teleproduktion at the end of the 1950's, and participated in the development of MTB mobile telephones and transmitters.

Sector	MTA	MTB
Developer of system technologies	Swedish Telecom	Swedish Telecom
Developer of exchanges	LM Ericsson	LM Ericsson
Developer of radio base stations	SRA	SRA, AB Nordisk teleproduktion
Developer of mobile telephones	SRA	AGA, SRA, AB Nordisk teleproduktion
Period of development	1949-56	1956-65
Opening	1956	1965
Costs	SKr 300,000	SKr 200,000
Termination	1969	1983

Information about MTA and MTB.

Mobile telephones – unwieldy and heavy

Swedish Telecom purchased the first MTA telephones from Svenska Radioaktiebolaget (SRA), and then leased them out to the subscribers. The telephones with the transmitter equipment were bulky and heavy, weighing 40 kilos, and used so much current that the car battery could not operate the equipment. The telephones were also in need of much repair and maintenance.

As for the other system, MTB, it was AGA and SRA which supplied the mobile telephones. SRA also launched a second generation of telephones with wholly transistorized transmitters. The telephones were made of black bakelite with a dial, and the whole equipment weighed nine kilos. The telephones were leased out to the subscribers.

Entrepreneurship in the local phase

Swedish Telecom initiated the development of the first system, and decided to develop its own automatic system instead of copying a foreign system. Swedish Telecom co-operated with SRA and LM Ericsson in developing the system. In spite of the fact that the local phase was technically oriented, the users played an important role. Only larger companies and transport companies could afford the high fees in order to make use of the mobile telephone service. The first system was used by banks and the medical profession, to mention just two. The banks' use of the system is interesting, since, in the mid 1950's, there was no extended office network in the new suburbs outside Stockholm, which meant that bank buses were equipped with mobile telephones serving a number of suburbs.

The individual as entrepreneur

The first phase within Swedish mobile telephony circled around the first systems with their instigators at Swedish Telecom: Sture Lauhrén, who developed the telephone part to MTA, and Ragnar Berglund who developed the radio part. Berglund was also responsible for the development of the second system.

Type of innovation	Group	Individual	Company	Network
1) A new product	Techniques	S Lauhren, Swedish T. R Berglund, Swedish T.		Swedish Telecom SRA-Ericsson
2) A new production process	Techniques			
3) A new input	Techniques			
4) A new organisation of industry	Organising			
5) A new market	Market		Swedish Telecom	
6) A new type of marketing	Market			
7) A new distribution channel	Market			

Entrepreneurship in the local phase.

The company as entrepreneur

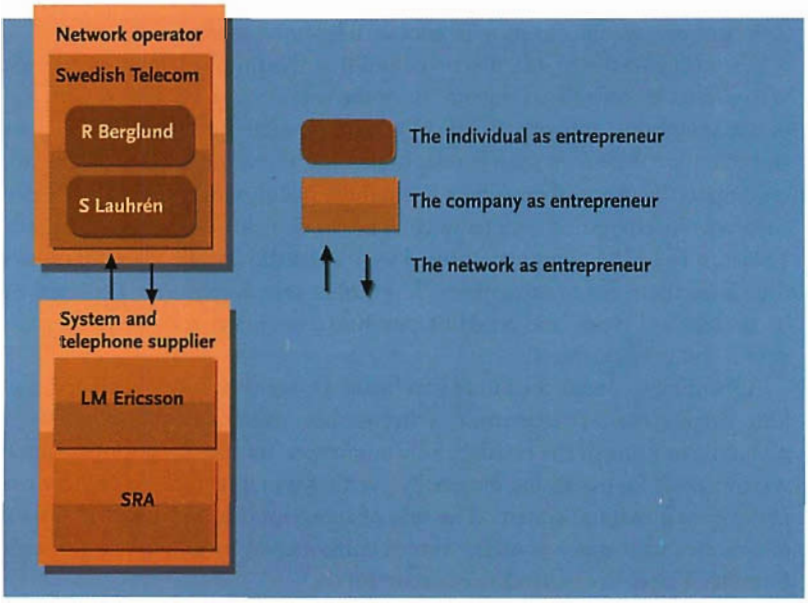
Swedish Telecom introduced a new market by investing in mobile telephony.

The network as entrepreneur

Besides Swedish Telecom, SRA and LM Ericsson participated in the production of the first systems. These companies worked together in the development, which resulted in a new product.

In the local phase, the network operator is the main actor. Within the framework of the network operator, a technique and market associated entrepreneurship of individuals and companies is founded. The connection to system and telephone suppliers is carried out by a technical entrepreneurship within the framework of an industrial network. If the entrepreneurship integrates into the technological system, the following picture emerges.

The low number of entrepreneurial activities in the local phase reflects the modest approach to mobile telephony until the late 1960's. Although the entrepreneurship was limited, it was of major significance regarding future developments.



Entrepreneurship in the technological system during the local phase.

3. The national /Scandinavian phase

The Land Mobile Radio Survey 1967

In August 1967, Carl-Gösta Åsdal, chief engineer at Swedish Telecom Radio, submitted a report regarding mobile telecommunications in Sweden. This report proposed that Swedish Telecom was to supply nationwide mobile telephone and paging networks. The proportions of mobile telephony were looked upon as limited and not very profitable.

The investigation suggested that Swedish Telecom should develop a fully automated national mobile telephone system, and that MTB should be expanded on a regional level, pending the arrival of the new system. Swedish Telecom should initiate and conduct the development and the design, since the manufacturing of mobile telephone exchanges and other products was not expected to reach such volumes that the industry would be willing to invest sufficient capital.

The conclusive reason for Åsdal's proposition was the positive experience from the first two mobile telephone systems, which showed that there was a major interest in mobile telephone services from trade and industry. Moreover, the industry rationalization, which required higher labour efforts in combination with further mobility, was seen as a contribution to the increasing interest in mobile telephony. That was the reason why Swedish Telecom was anxious to provide mobile telephone services.

According to the report, it was natural that the mobile telephone service was offered by Swedish Telecom, since the service was associated with the public telephone network. It was of course possible for customers to own and maintain their own mobile telephones, but there was a big problem, according to the group, if customers owned the telephones and Swedish Telecom was in charge of maintenance. The work team considered Swedish Telecom to be the owner best suited to possess the mobile telephones and then lease them out to subscribers. The mobile telephones were expected to be of standard types, and could be purchased from any telephone supplier after a few modifications.

According to Åsdal, the future was headed towards a fully automated system, despite the fact that most of the mobile systems in the world were manual. But none of the existing, fully automated mobile telephone systems were suitable for expansion nationally. Neither was it realistic to prepare expansion of a manual system. The sale of subscriptions and lease of mobile telephones to the new system were recommended to take place through Swedish Telecom's general sales organisation.

One result of Åsdal's investigation was Swedish Telecom's radio laboratory which began its development under the supervision of Ragnar Berglund and Östen Mäkitalo. Mäkitalo started his career as a designer at the radio laboratory in 1961, working on mobile telephony and stereo radios. They conducted a feasibility study in 1967, which showed that technological progress was needed in order to develop a system according to Åsdal's principles. Mäkitalo considered it better to await the technological development since computer utility was needed to design and operate a sophisticated mobile telephone system. This principle was confirmed by Åsdal, who actively supported the development work at the radio laboratory.

The development of a Scandinavian system

Since other Scandinavian administrations were also planning for fully automated mobile systems, it was not difficult for Åsdal to launch the idea of a joint Scandinavian mobile telephone system at the Scandinavian telecommunications conference in 1969. Åsdal saw the advantages with a mutual system in Scandinavia – a market large enough with 23 million inhabitants – so that the industry would consider it profitable to develop systems and mobile telephones. The Scandinavian administrations decided to attempt to reach a mutual system solution, which was why a working group was set up and given the name the Nordic Mobile Telephone Group, the NMT-group.

The NMT-group had its first meeting in 1969/70. Its assignment was to develop a fully automated Scandinavian mobile telephone system. The development began at the beginning of the 1970's, and the group was working on principles for signalling between mobile telephone exchanges, radio base stations and mobile telephones. But the NMT-group's first assignment was to develop a manual system, ready to be used immediately.

The reason why the group had to work on a manual system was the time it would take to develop a fully automated system, and it was important to offer an immediate mobile telephone service. Many people believed a manual system to be a step backwards, but there was a belief, mainly advocated by Mäkitalo, that it was necessary to await technological improvements in micro electronics before building a sophisticated system.

In 1971, the Scandinavian telecommunications conference approved the plans for a manual system, and decided on new rules which allowed the cross-border use of mobile telephones in Scandinavia. As from the mid 1972s, work groups were established addressing different aspects regarding the system development.

In 1972, the NMT-group commissioned the Danish company Storno, the dominating radio company in Scandinavia at that time, to perform a signalling study, as well as to carry out research on three different signalling methods. (Motorola acquired Storno in 1985.) The study formed the basis for decisions and resulted in the group deciding on digital signalling.

Åke Lundqvist from SRA had told Mäkitalo in 1971 that it was necessary to select digital signalling instead of the five-tone signalling Storno had suggested. Lundqvist's main reason was that the five-tone signalling limited the number of subscribers to 100,000 at the most, and the signalling was pri-

marily made for mobile radios. Lundqvist considered the limit uncalled for, since he had a vision for cordless telephones as early as in 1968. According to Mäkitalo, NMT would have shown a considerable poorer standard if Lundqvist's ideas had not been taken seriously.

Fully automated system to come

In 1973, the Scandinavian telecommunications conference approved of the group developing a fully automated system. According to the group, a mutual system was the only alternative to reach compatibility between mobile systems in the Scandinavian countries. The NMT group stressed that the mobile telephone system should be looked upon as an integrated part of the public telephone network.

In 1975, the group looked at different costs of a fully automated and a manual system. They found that automatic mobile telephones were skr 3,000 more expensive than manual telephones, which cost skr 7,500. The costs for the manual fixed equipment, exclusive of base stations and connections, were estimated at skr 2 million for 5,000 subscribers, and for a fully automated system at skr 2.5 million including costs for development and programming. But in addition there were operators' costs of skr 3 million per year for a manual system, and in a fully automated system the mobile telephones cost an extra skr 15 million.

In time for the Scandinavian telecommunications conference in 1975, the group introduced a proposition for a fully automated mobile telephone system. The system's requirements were:

1) automatic switching and charging – to and from the mobile telephone
2) it should be possible to call any fixed telephone subscriber or other mobile telephones
3) calls should work at home radio base stations as well as at other radio base stations
4) the subscriber capacity should be adequate in order to handle future growth
5) the system should offer automatic search for subscribers (roaming) and automatic switch between base stations (handover).

Doubtful suppliers

Even if the principles are self-explanatory today, not everyone believed that they could materialize. Representatives from Motorola, for example, visited Lundqvist at SRA in 1975 and suggested that they should approach the NMT group together, to make them abolish the requirements for roaming.

In charge of the production of NMT were a group of 10–15 people at the Swedish Telecom radio laboratory in Stockholm as well as two to three persons in Norway. A number of committees studied various parts of the detailed description. The NMT group wanted to find a cost effective and flexible system, which did not require too much computer assistance.

The system's detailed description was completed in 1975, but was further developed until 1977–78. A necessary requirement was that the system

should be able to handle 180 channels. But many of the suppliers were reluctant and doubtful whether this was possible.

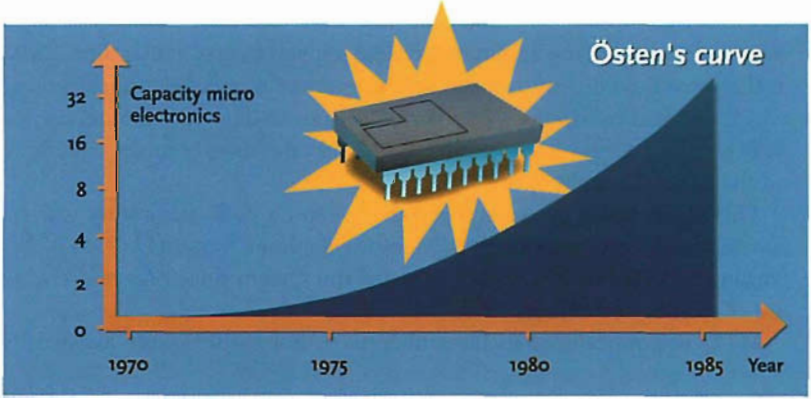
Since the NMT group counted on the need for a sophisticated technique to handle the interface between the mobile telephone and the radio base station, it was necessary to conduct a pilot test. According to the developers, the test system should be handled by one of the administrations, rather than by industry. The group considered the Swedish administration, with Swedish Telecom's radio laboratory, best suited for the test. The pilot system, with comprehensive tests of all exchanges, radio base stations and mobile telephones, ran for two and a half years. The cost was skr 1.2 million, which was split between the administrations.

The group suggested that the subscribers should purchase or lease the mobile telephones from radio suppliers, after the telephones had been type approved. This proposition was supported by the Scandinavian telecommunications conference. No administrations then needed to invest in either mobile telephones, distribution or service networks. Swedish Telecom required a type approval from either the radio laboratory, or the Scandinavian administrations, so that the mobile telephones could be used in the Swedish network.

"Östen's curve"

Östen Mäkitalo, manager of the radio laboratory, visited the famous Bell Labs at American Telephone & Telegraph (AT&T) during the 1970's, and was able to confirm that the radio laboratory was doing equally well as Bell Labs regarding the development of automated mobile systems. According to Mäkitalo, the Americans were concentrating on geographically delimited systems; the Scandinavian system was instead working on the idea of: 1) creating a large surface reach; 2) locating a subscriber no matter where; 3) using the frequencies effectively, and 4) keeping the calls by an automatic switch to a more effective radio base station.

Mäkitalo joined the NMT group in 1975. He had been working until the mid 1970's on mobile telephone system C, which in practice became the Swedish contribution to the standard. Mäkitalo consistently factored in new techniques, which was criticized by his colleagues; people talked about



Östen's curve.

"Östen's curve". Mäkitalo applied Moore's Law, by Gordon Moore – one of the founders of Intel Corporation, which in 1968 postulated that every 18 months, the micro processors' performance is doubled while the price is halved.

Mäkitalo was convinced that the micro processors were necessary for the system to supply handover, where calls could be transferred between radio base stations; roaming, where the system could follow the subscriber's movements in the system, and signal systems, which look after the capacity of the processor.

Mäkitalo was convinced at the very beginning that a small cell technique was required to achieve a network with high capacity and flexibility. But according to Mäkitalo, it was difficult to convince his Swedish and Scandinavian colleagues about the necessity of a small cell technique, since 180 channels were considered to be sufficient. Even if the forecast regarding the increase of subscribers was modest, Mäkitalo's wish was to enlarge the capacity and improve the frequency effectivity by introducing a small cell technique. Mäkitalo had found that the subscribers, during a mobile call lasting approximately two minutes, only "travelled" a couple of kilometres at normal speed. It was not necessary for a mobile system to have a range of some ten or twenty kilometres in the areas of big cities – a few kilometres were enough. By having tightly packed small radio base stations, a frequency could be repeated more often which greatly helped to economize frequencies. Still, it was logical to look after how the frequencies were used. True, small cell techniques brought the need for additional radio base stations, but the higher capacity would amply compensate the extra investment.

According to Bo Magnusson at Telia, it was clear from the beginning that NMT had to expand outside the Scandinavian countries, so that industrial enterprises would become interested in further development of systems and telephones. Swedish Telecom Radio discussed the advantages of NMT in various contexts, to convince operators abroad to invest in the Scandinavian system.

The production of a manual system

Swedish Telecom was well aware that manual mobile telephone systems were very labour intensive and that they were expensive to run. But since the development of the automated system seemed to take a long time, it was at the same time urgent to speed up the national mobile telephone service, which resulted in Swedish Telecom's decision to launch a manual service MTD, during a transitional period. Åsdal was the driving force in working on the manual system.

The Mäkitalo-led group at Swedish Telecom's radio laboratory was responsible for the development of Mobile Telephone System D (MTD). According to Mäkitalo it was easy to install the system since one could make use of existing technology.

MTD was introduced in December 1971. Subscribers were assisted by

operators from cord operated switchboards at six service centres. Each operator filled in a form regarding the subscriber's number and length of the call. The system's radio parts were interconnected with the public telephone network at these service centres. The system had 80 channels, and when fully extended, it would have 110 radio base stations. The system lay in the 460 Mhz band. Aerials to radio base station were located on TV and radio masts, which gave an effective range. MTD lacked roaming and handover. No particular mobile telephone exchanges were needed since it was a manual system, but Svenska Radioaktiebolaget (SRA) supplied selected system components.

To place a call to a MTD telephone, the operator had to know roughly where the subscriber was located in order to direct the call over the nearest radio base station. It was an open system at first; the subscribers were called by their numbers, and everyone had to listen to the calling channel. This meant that other subscribers could also listen to calls in progress. When selective calls were introduced in 1974, no one had to wait for the calling channel but were instead given a signal. Regarding calls from the mobile telephone, the operator was attracted through tone signalling to activate the calling channel. The exchange indicated the relevant base station so that the operator could expedite the call.

A historic settlement – the opening of a mobile telephone market

As earlier stated, the commission of 1967 proposed that Swedish Telecom should be the owner of the mobile telephones. But a considerable investment was required apart from the skr 20 million per year which had been invested in the network expansion. Swedish Telecom did not consider it feasible to obtain enough money through the state budget to purchase mobile telephones. Instead Swedish Telecom began discussing the possibility of breaking the established convention that telecom operators should control all parts in a telephone system, and instead liberalising the market.

In 1971, Swedish Telecom took the big step towards a liberalised telephone market so that telephone suppliers could market their products directly to customers. This was a new policy for Swedish Telecom, which became important for further development. The range of products increased; the competition between suppliers was intensified, and the marketing of the mobile telephone service was stimulated, since distributors – through sales – also contributed to the marketing of subscriptions.

The expansion of MTD began in Lake Mälar Valley and continued gradually throughout the country. Profitability was satisfactory when the number of subscribers were about 10,000, but when they began to reach 20,000, the costs increased immensely, since more than 400 telephone operators were needed.

According to Anders Lundblad at Swedish Telecom Radio, MTD was a learning period for the operators, suppliers and subscribers, which was decisive for NMT's success. MTD was phased out in 1987.

In October 1981, NMT 450 was inaugurated in Sweden. Sales were fairly modest at first; the range of mobile telephones was limited since the type approval was delayed, and few manufacturers had the capacity to deliver.

But only a year after the start, the number of subscribers increased to more than 35,000 in Scandinavia, and traffic growth exceeded projection considerably. As from October 1982, roaming began to function between Denmark, Norway and Sweden. However, capacity problems soon emerged in the network. In 1984, it was difficult at peak hours to get through on the network in Stockholm, so to increase the capacity, the network was modified into a partial small cell system in 1985, with a large number of radio base stations with a short range. This resulted in a capacity ceiling of 250,000 subscribers for NMT 450. According to the original plans, NMT 450 would cover the need until a European system was introduced. But the large number of subscribers created capacity problems, despite the reconstruction into a small cell structure. The NMT group did not believe that the 180 radio channels in NMT could handle the growing traffic in larger cities, despite the small cell technique, which was why the decision was taken to extend NMT to the 900 Mhz band.

The new standard was ready in 1985. It originated in NMT 450, but was in a higher frequency band; it had more channels, as well as a few new components. The system was designed as a small cell system, which gave higher capacity, suitable for hand portable telephones which had not been permitted before, due to their low transmitter output power. At first, the plan was to expand NMT 900 only in the urban regions connecting European highways, since it was too expensive for the network to cover the whole country.

During 1984/85, it was discussed whether it was possible for Swedish Telecom to purchase a fully developed system, such as the American AMPS, or the British TACS, which would give customers access to a considerably larger mobile telephone market. Advocates of this principle could be found within industry, but Swedish Telecom decided to concentrate on NMT. Lundqvist at Ericsson Radio tried, without success, to convince Swedish Telecom to select a standard which was already developed. Lars Ramqvist, Ericsson Radio's managing director, tried as well to convince the Director General at Swedish Telecom, Tony Hagström, to select an AMPS system, but Swedish Telecom rejected that proposition. Ericsson wanted to benefit from the work that had already been carried out, regarding the development of a system towards the American and British standards.

In August 1986, the NMT 900 was opened for traffic in Sweden. The offtake was sluggish at first, since the new system offered subscribers nothing new in comparison with the first Scandinavian system. Not until the launching of hand portable telephones, and the network expansion outside urban regions, did the market grow. The increasing number of subscribers also motivated a network expansion in the whole of Sweden.

Co-operation between industry and the NMT group

During the development of NMT, industry was continuously sharing the specifications. This gave the NMT group an opportunity for technically and economically realistic solutions while suppliers could commence development of radio base stations, exchanges and mobile telephones. When the group held its first information meeting at the end of 1971, some 40 companies said they were interested in developing equipment to the Scandinavian standard. As the work progressed, the NMT group met representatives from a large number of international and Swedish companies. Many Japanese companies were very interested, and according to Mäkitalo, they were not afraid of factoring in future technical development.

In 1977, the NMT group invited tenders from a number of companies. Competing with many others, and especially NEC, LM Ericsson obtained the order with their AXE switches, adjusted for mobile telephony. In September 1978, the telephone administrations in Denmark, Norway and Sweden ordered mobile telephone exchanges from Ericsson.

At first, Ericsson's intention was to offer the AKE-13 exchange, which had been developed during the 1960's, and which had a computer controlled cross bar switch system. But Swedish Telecom did not believe the system to be fully sophisticated, and ordered Ericsson to supply the AXE exchange instead. The digital AXE exchange was developed at Ellemtel, which was Ericsson's and Swedish Telecom's joint company for developments. Mobile telephony was not regarded as a very interesting application for Ericsson, and AXE was originally not meant for mobile telephony.

According to Anders Lundblad, Swedish Telecom Radio, the AXE exchange was not a requirement for NMT, but a good choice considering further expansion. In the early 1970's, the relations between Ericsson and Swedish Telecom were not satisfactory because Ericsson, which was working on a closed radio system, did not believe in a public mobile telephone network. In the co-operation between Ericsson and Swedish Telecom, Ericsson often played a minor role. Swedish Telecom co-operated to some extent with Danish Storno during the early period in mobile telephony development.

In order to expand NMT and GSM, the operators had depended on suppliers developing radio base stations, mobile telephone exchanges as well as other equipment. The radio base stations in the Swedish NMT network had been supplied by Ericsson, or by companies which later became wholly-owned subsidiaries to Ericsson, Mitsubishi and Nokia. Allgon supplied the aerials and other components to the radio base stations. All mobile telephone exchanges had been supplied by Ericsson.

Competition in the network operators' market

Between the years 1965 and 1980, a number of companies operated mobile telephony networks in Sweden. Many of the networks were local, or regional, but some covered a relatively large part of the country, competing with Swedish Telecom. Most of them were smaller companies with mobile

telephony as a side line, but a few of them had it as a principal business. According to Swedish Telecom, the common problem among the private operators was of a financial character, which Swedish Telecom had to solve by keeping the companies alive, in order to avoid subscribers being affected.

Forerunner among private operators was Wikanders Ur & Optik in Jönköping, which operated a private network from the mid 1960's. It was later renamed Telelarm and operated a nation wide network with 500 subscribers from 1969 onwards. The subscribers were offered specific secretarial services such as looking after orders and booking tickets. The mobile telephones could either be purchased or leased.

Another mobile telephone operator was Nordiska Biltelefonväxeln, which operated a network in Gothenburg and Stockholm. The company was established when a few smaller operators merged in 1971.

Svensk Kommunikationskonsult, the general agent for Salora mobile telephones, acquired Telelarm in 1979, and changed the company's name to Företagstelefon. Lennart Lindström who came from the Scandinavian radio central in Stockholm, and who was experienced in the sector of mobile telephony, led the company. When Salora, supplier of mobile telephones to the systems of MTD and Företagstelefon, terminated the agency and set up a business in the Swedish market, the company suffered enormously and almost went bankrupt. But the company soon recovered, and in the mid 1980's Företagstelefon purchased Nordiska Biltelefonväxeln, and thereby got access to a number of frequencies as well as to 1,900 subscribers. Företagstelefon was at the time the only private mobile telephone operator in Sweden.

Kinnevik becomes a mobile telephone operator

In September 1980, Kinnevik acquired Företagstelefon and reorganised it into Comvik. The main owner of Kinnevik, Jan Stenbeck, was engaged in mobile telephony projects in the USA through his American company Millicom. The allocation of operators' licenses in the USA took a long time, which forced Stenbeck to move his attention to Swedish mobile telephony.

Stenbeck and Shelby Bryan started Millicom in 1979 with a vision that wireless communication was to become the thing of the future. The business concept was to make use of the deregulation within telecommunications by applying for licenses, as well as to operate a mobile telephone network together with local partners and investors. In the early 1980's, Millicom, together with other companies, developed a project within mobile telephony in the USA. But the project could not offer any new products and was phased out after a year.

However, the project resulted in Racal and Millicom establishing a network operator association in Great Britain called Racal-Vodafone, which in 1984 obtained the second license for operators in the United Kingdom. Millicom owned at the most 25 % of Racal-Vodafone, but the American company gradually sold their holdings to be able to finance investments in mobile telephone networks in developing countries.

Comvik planned a new mobile telephone system, using the Företagstelefon frequencies to start with, and in October 1980 they applied for a licence

to operate a fully automated mobile telephone system. Swedish Telecom rejected their application. Comvik appealed against the decision to the Director General of Swedish Telecom, who advised that he was willing to allow Comvik to connect the system to the public telephone network, as long as the mobile system was operated manually. In March 1981, Comvik applied for a type approval to operate their radio exchanges manually, which was approved by Swedish Telecom at the end of May. According to Comvik, Swedish Telecom insisted on the equipment being of such a high standard, that Swedish Telecom's own testing equipment did not always suffice.

In August 1981, Comvik introduced their mobile telephone system, which consisted of six Rydax mobile telephone exchanges from E.F. Johnson in the USA. Comvik used aggressive ways of marketing; methods that were alien to Swedish Telecom, which thought that Comvik was not being totally straight forward. In September 1981, when Swedish Telecom discovered that Comvik violated the permit by using an automatic exchange, Swedish Telecom reacted forcefully. According to Swedish Telecom, there was a risk of serious interference to the telephone network, since it was unclear how the signalling was formulated. Swedish Telecom threatened to disconnect Comvik's system from the public telephone network.

Comvik appealed against the disconnection decision to the Director General of Swedish Telecom, and claimed that the company's 15 year old mobile telephone business was threatened. But the Director General found no reasons to alter Swedish Telecom's decision, since mobile telephony was protected by monopoly which concerned "equipment for duplex voice communication over the public telephone network". Swedish Telecom argued that an exemption from that monopoly would create a precedent, resulting in more companies wishing to operate private mobile networks. With that, there was a clear risk of not being able to expand the new NMT system in the more sparsely populated parts of the country. Swedish Telecom claimed that Comvik's aim was primarily to cover areas with a potential for high volume traffic, leaving less profitable areas to the government-owned operator. At this time, Comvik possessed almost 30 % of the new subscriptions.

Comvik appealed to the Swedish Government and asked for a license to connect its automatic system to the public telephone network. Comvik argued that they were specialized in customer related services. Comvik also argued that a rejection from the Government would make customers suffer economically, holding worthless mobile telephones that had cost almost skr 10,000. The company would have to terminate its business and employees would lose their jobs.

Comvik promised that 50 % of the network's mobile telephones would be manufactured in Sweden, which would mean excellent export opportunities for industries. Comvik emphasized that it was not going to change its business since the company and its predecessors had been operating a license for 15 years. So, according to Comvik, the case was not a precedent. Besides, Swedish Telecom should not experience any problems in competing with Comvik, since technically the Scandinavian system was considerably more sophisticated.

Comvik obtains a license

In December 1982, the Government decided to grant Comvik the license and called it an exemption. The Government of course realized that mobile telephony was protected by Swedish Telecom's monopoly, since it had to do with voice communication over the public network, but argued that special circumstances applied, and that it was one way of increasing the competition in the market. However the Government regarded Comvik's activities as limited. There were approximately 2,000 subscribers, which the company anticipated would not become more than 6,000 in 1990. It was not a question of allocating frequencies, which meant that Comvik had to settle for the 26 frequencies they already had at their disposal.

Comvik's network covered the middle and the south parts of Sweden after the first expansion. It was not a cellular network to start with. The company leased and sold telephones, and had their own brand, supplied by E.F Johnson. As from 1983, a model from Technophone was available, developed by Technophone on behalf of Comvik. Technophone was started by the Swedish civil engineer Nils Mårtensson, who worked for SRA in the 1960's and 70's. (Technophone was later to become a big participant in the market; in the beginning of 1991 though, Nokia bought Technophone from Mårtensson paying skr 370 million.) In 1982, Comvik's market organisation was expanded to include their own sales staff. In early 1983, the network was almost nationwide with 140 radio base stations, rented telephone lines, six automatic exchanges and six staffed centrals.

In 1984, Comvik's request for another twelve frequencies was denied by the Director General of Swedish Telecom, and Comvik appealed to the Government. In April 1985, Comvik sent an official letter to the Government promising to create 50 to 100 new openings at their plant in Fagersta if they were allocated another twelve frequencies. In June 1985, the Government decided to allocate another eight frequencies to Comvik; they then had 34 frequencies at their disposal.

In April 1986, Comvik requested the Government to annul the existing limit regarding frequencies, as well as to clarify that there were no main obstacles to allocating Comvik 120 frequencies in the 900 Mhz band.

In 1986, Comvik was allocated another 14 frequencies by the Government. The original system was improved, and during 1986, roaming was introduced between exchanges. In Stockholm the system was reconstructed into a small cell system, which meant that the call capacity was tripled. In June 1987, the Government decided that the exemption regulation was to continue, but that Swedish Telecom should allocate another 16 frequencies to Comvik, meaning that they then controlled more than 50 frequencies.

According to one supplier, Comvik had problems keeping up with the technical development and the company offered few and much too inadequate mobile telephone models. But Comvik explained that their weak position in the market had to do with Swedish Telecom not allocating enough frequencies, as well as the unsatisfactory connection to the fixed telephone network.

Marconi plays an important role for Ericsson

Ericsson had their doubts about a public mobile telephone network in the 1970's since the company's aims were more in line with mobile radio systems. But orders from the Scandinavian telecommunication administrations, as well as from Saudi Arabia, proved the market potential regarding mobile telephony. Ericsson secured a domestic market, which provided a demonstration model for potential customers. Since Ericsson had already established relations with telecommunication administrations around the world, and AXE had turned out to be a success, this meant that the company had a clear competitive edge. Ericsson was soon the dominating participant in the mobile market, a position they secured when the world market expanded.

Ericsson's commitment to the radio sector goes back almost 80 years, to 1919, when Svenska Radioaktiebolaget (SRA) was founded. The company was formed by the telephone company LM Ericsson, Gasackumulator AB (AGA), Allmänna Svenska Elektriska AB (ASEA), as well as three financial institutions with aims to develop and manufacture equipment within radio telegraphy and telephony. The company was directed by Dr. Maurtis Vos, who had been the manager of Telefunken's laboratory for developments in Berlin. In 1921, the company came to an agreement with Marconi Wireless Telegraph Company, which gave SRA access to Marconi's patent and designs within the radio sector. At the same time SRA became the representative for Marconi in Sweden and Marconi became partner in SRA. In 1927, Ericsson bought out the rest of the Swedish owners and then controlled 57% of the company. In 1965, Ericsson increased its share to 71 %, by purchasing a part of Marconi's share holding.

SRA supplied a wide range of products within radiocommunications, serving both the private and the military market. Among the products were transmission equipment for radio, gramophones, TV-sets called Radiola, police radio systems, paging systems, radio link equipment, mobile radio systems, mobile telephones and mobile telephone systems. In 1963, SRA sold the line of business which included broadcasting and TV-sets, and as from then, concentrated on communication radios and radio equipment serving the defence.

Expansion by acquisitions

In 1974 Sonab acquired AGA Mobilradio, which at the time had 475 employees and an annual turnover of skr 30 millions. AGA held an considerable market share in mobile radio equipment in Sweden. The company also supplied the Scandinavian countries and North America. The reason for AGA selling the mobile radio business was that the management considered mobile radio too demanding as regards the sale and service network in comparison with the company's other products, and an international expansion would then require considerable resources.

Sonab was established in 1966, as a part of Statsföretag to market the "Carlsson speakers" – developed by Stig Carlsson. In the early 1970's, the

company began investing in industrial electronics and communication systems. Sonab soon became the leader in mobile telephones in the Scandinavian countries, and in addition with AGA mobile radio, Sonab became the largest company in Swedish radio communication together with SRA. There was a major expansion, but the investment in communication equipment incurred such considerable costs that it caused financial problems for the company.

SRA obtained no orders for radio base stations for the manual mobile telephone system in the 1970's, since its products were not sophisticated enough. In 1979, SRA introduced an automatic car telephone network which had an NMT standard built on AXE, and with radio base stations from Sonab. The same kind of system was delivered by SRA to Saudi Arabia in 1981 – an order worth skr 50 million. The first installation of a mobile telephone system in the US took place in 1983: a network to Buffalo Telephone Company worth skr 25 million. A determining factor in winning that order was that the Swedish Investment Bank took care of the financing.

In January 1978, SRA acquired Sonab with 400 employees and manufacturing and sales departments in a number of countries. SRA was then given access to new products, such as car telephones and components to radio base stations, and to important manufacturing capacity. At SRA it was Ivar Ahlgren (Managing Director 1961–77) and Åke Lundqvist (Managing Director 1977–88) who were responsible for the deal. Lundqvist's strategic planning included the purchase of companies which had the competence in the sector of mobile radio and mobile telephony – a competence Ericsson needed.

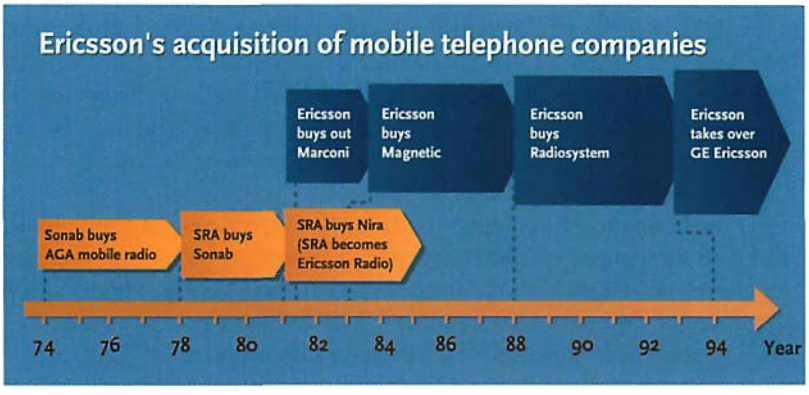
SRA's entrepreneurial role was more on the small scale compared with LM Ericsson's. One reason for SRA investing in mobile telephony despite a certain lack of interest from the management at Ericsson, was that the company had partly been owned by Marconi up to 1982. Not until 1982/83 did SRA became a wholly-owned subsidiary of LM Ericsson and was then reorganised into Ericsson Radio Systems.

The sale of systems

Up to 1982, LM Ericsson and SRA tendered separately for mobile telephone system contracts: LM Ericsson offered mobile telephone exchanges and SRA radio equipment, which meant that the buyers' function was to integrate systems. But as from 1982, Ericsson's aim was to sell systems, an aim provoked by a business deal with the telecommunication administration in the Netherlands. As usual, LM Ericsson was supplying the exchanges and SRA the radio base stations in the expansion of an NMT network in the Netherlands, but the Dutch telecommunication administration was only interested in buying exchanges from Ericsson, and intended to buy radio base stations from Motorola. At first, Ericsson acted positively to this, but Lundqvist, Managing Director at SRA, did not approve, and managed to stop the deal and forced Ericsson not to supply the exchanges unless the Group supplied the radio equipment at the same time. Lundqvist was convinced that if Motorola was to get access to the AXE exchanges, Ericsson's

position would weaken considerably. Finally, the Dutch telecommunication administration decided to purchase the equipment from Ericsson/SRA, but the buyers demanded that the network should consist of the small cell technique, which, according to Ericsson's experts, would take two to three years to develop. Lundqvist then contacted an American friend, with much experience in the business, to find the best developer of cell structures. It turned out to be the American friend, Chandos Rypinski, who played, besides an important role in the expansion of the Dutch system, a major part in Ericsson's success when the company established its position in the US.

Ericsson purchased Magnetic in 1983, and Radiosystem in 1988. Lundqvist believed that Radiosystem complemented Magnetic as a supplier of radio base stations, since Magnetic's technology was out-of-date. Through this acquisition, Ericsson doubled its market share in radio base stations to 40 % of the world market. The purchase of Radiosystem gave Ericsson greater capacity in production, as well as access to more research and development capacity. According to Lundqvist, Hans Werthén, Ericsson's chairman of the board, did not approve of the purchase of Radiosystem, but it turned out to be a very profitable affair in the long run.



Ericsson's acquisition of mobile telephone companies

Magnetic – developed transmitters for MTD

Magnetic was a small company in the 1960's with only a hundred employees, manufacturing a diverse set of communication equipment. One important person in the company was Torbjörn Johnson, who began his career at Magnetic in 1965, developing transmitters for the TV network. He became later responsible for the design and development of radio base stations. In the first procurement of radio base stations for the manual mobile telephone system (MTD), Magnetic received the whole order. In the second procurement in 1979-80, Magnetic had to share the order – worth skr 16 million – with Mitsubishi. According to Johnson, the Japanese company had copied Magnetic's radio base stations after Swedish Telecom had demonstrated the equipment to Mitsubishi's personnel. Magnetic also sold radio base stations to Denmark and Norway.

Under Johnson's management, Magnetic developed NMT radio base stations. After a dispute with the owner, Johnson left the company and estab-

lished Radiosystem. Johnson held a royalty agreement with the owner, which was not kept, so when Magnetic in 1978 received an order worth skr 30 million for products developed by Johnson – without him being compensated – he gave in his notice.

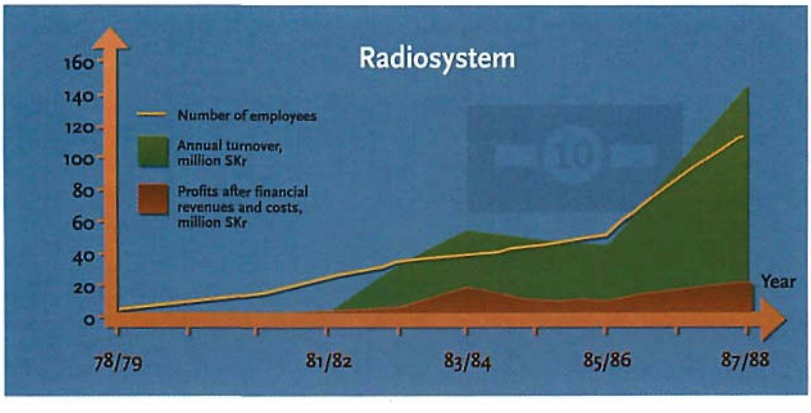
Radiosystem increased its value by skr 465 million in ten years

With skr 5,000 of start-up capital, Torbjörn Johnson established Radiosystem in 1978, together with two colleagues from Magnetic: Tommy Moberg, expert on amplifiers, and Leif Kågström, specialized in filter. Johnson was convinced that mobile telephony was the market of the future, and that those products that Radiosystem planned to develop had a great market potential.

Radiosystem began as a sub-contractor to telecommunication companies and administrations. The business was then expanded to include the manufacturing and marketing of radio base stations, filters, and combiner systems for mobile telephone systems. Radiosystem supplied equipment of different standards, and was a pioneer in surface-mounting, which made the manufacturing cheaper. The company also designed a robot line. Radiosystem engaged around 30 sub-contractors and 500 component suppliers.

In 1981, Radiosystem was the sub-contractor to Ericsson at the time when an NMT network was installed in Saudi Arabia. After much agonizing, Swedish Telecom Radio decided to let Radiosystem supply combiners to the radio base stations for NMT 450, as they offered low prices. Radiosystem later became one of the major manufacturers of radio base stations for NMT.

At the beginning, the company had four employees; after one year seven, and then it expanded quickly. There were 25 people working with developmentwork from the mid 80's. Financial support was given by, among others, the Board of Technical Development (STU) and the Development Association. During a short period STU referred to Radiosystem as one example of a successful technical investment. The company was listed on the stock market in Stockholm in 1986.



Radiosystem's economic development 1978–88.

After establishing in the Scandinavian countries, Radiosystem expanded primarily in Europe. According to Johnson, Radiosystem's success was due to 1) rapid prototyping, 2) rapid product development, and 3) excellent products.

Johnson argued that the mobile telephones supplied to NMT should have been allocated half as high transmitter output powers. This would have meant cheaper telephones and would have reduced the risk of negative side effects, such as skin disease.

In 1988, Ericsson made an offer for Radiosystem worth skr 465 million, which was accepted by the majority owners, Torbjörn Johnson, Managing Director, and Anders Tuvehjelm, chairman of the board. Johnson justified his approval by saying that Radiosystem would have the opportunity to work with a diversified range of products, and that the company would benefit from Ericsson's special competence and capacity in manufacturing. Radiosystem's turnover was Skr 147 million with a profit of skr 20 million. The company had 147 employees.

After the sale, Johnson continued to work for Radiosystem, which was renamed Ericsson Radio Access in 1992. Johnson left the company at the beginning of 1995.

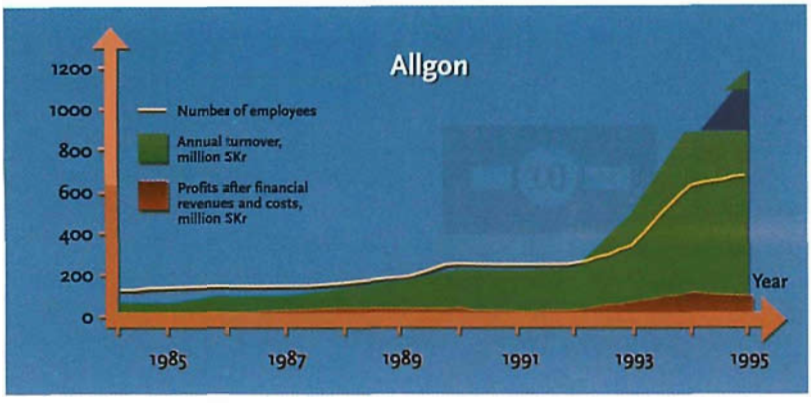
Allgon – from car aerials to mobile telephony

Allgon was established in 1947 and had the business concept of developing and selling radio aerials for cars. The product range was later diversified to include aerials for broadcasting and the expanding the TV-network. In the 1960's, military radio equipment became an important business for Allgon, and the defence became their main customer during the 1970's. In the late 1960's, the Kämpe family bought Allgon. Jonas Kämpe took over management from his father at the end of the 1970's.

Ulf Saldell, expert on wave propagation and earlier employed as a scientist at the defence's department for research, began his career at Allgon in 1974. When discussing with Kämpe, Saldell argued that the company should sell 90 % of the production to the private market instead of the national defence, as was the case during the 1970's. Allgon's management identified two attractive activities for the future 1) parabolic aerials and 2) mobile telephone equipment. The management decided on mobile telephones, since this was a future business with larger margins than the sale of parabolic aerials. Saldell, observing that Swedish Telecom's forecasts were always surpassed in the early 1980's, was in favour of mobile telephony's market potential. From 1982 and onwards, Allgon invested in aerials and various components for radio base stations and mobile telephones.

Allgon's manufacturing is mainly located in Åkersberga together with its head office and development department. Regarding the manufacturing of components, the company uses some 100 sub-contractors in Sweden and abroad. Allgon's narrow concentration forced an establishment abroad, and from 1983–84, export earnings increased. The establishment abroad took place through the acquisition and foundation of local sales companies. But

the internationalisation was far from simple; it took five years, for example, to establish a profitable sales organisation in the US. Out of Allgon's total sales, 96 % is sold outside Sweden.



Allgon's revenue, profit and number of employees 1984-95

Allgon's customers can be found among network operators and manufacturers of mobile telephones and systems. Nokia, for instance, uses aerials from Allgon for all their mobile telephones. Allgon holds 15–20 % of the market for combiners and 30 % of the world market for aerials to mobile telephones.

Mobile telephones – smaller and cheaper

International companies, which supply telephones to various standards, dominate among those companies which develop and manufacture mobile telephones.

Regarding the manual MTD system, which was introduced in 1971, subscribers had to purchase or lease the telephones from a radio supplier. Among those suppliers were AP, Handic, Mitsubishi, Salora, Storno and SRA. In 1974, SRA launched a mobile telephone weighing only three kilos, equipped with frequency synthesis, which meant that it could use all frequencies in the network. Sonab introduced a mobile telephone with a radio base station ranging 40 kilometres, with which a portable telephone could be used.

During the 1980's, the mobile telephone market was fragmented and some 20 suppliers competed for customers. During the first half of the 1990's, Ericsson, Motorola and Nokia have dominated the market. There are smaller suppliers as well, manufacturing special mobile telephones for particular usage. One example is Spectronic, based in Helsingborg, which has developed hand portable computer telephones; another example is Finnish Benefon, a company which has concentrated on portable telephones for NMT 450.

The development of mobile telephones has continuously produced cheaper, smaller, lighter and more sophisticated mobile telephones. When NMT was introduced, mobile telephones were only mounted. Then came

transportable mobile telephones, weighing three to four kilos. Since the first hand portables were launched in 1987, the number has increased, and in 1995 it was more or less only hand portables that were sold.

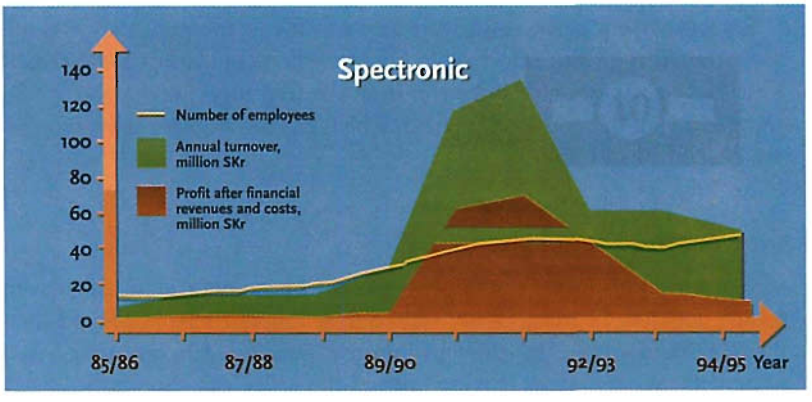
Spectronic – sub-contractor at first

Spectronic was established by Per Siversson in 1972. Its operation includes development, design, manufacturing and marketing of products within telecommunications, specializing in hand portable telephones. The main owner of Spectronic is Executive Director Siversson, while the rest of the shares are split between ten employees.

Spectronic has only 46 employees, most of them being civil engineers, but employs indirectly 200 people as sub-contractors. The assembly of the portable phones takes place along an automatic assembly line. The only component manufactured at Spectronic is the telephone's printed circuit card.

In the mid 80's, Spectronic began developing its own hand portable phone, which was launched in the autumn of 1989. At the same time, Spectronic started co-operating with Siemens, where Spectronic developed and manufactured NMT telephones for the German company. Up to 1992, when Siemens terminated the contract, the company, based in Helsingborg, supplied 20,000 NMT telephones, called Marathon, to Siemens. The co-operation contributed greatly to Spectronic's annual turnover and profitability. It was enhanced by the positive reception that the portable phone, TS 220, obtained. The telephone worked as a cordless data terminal, which could be attached to a telefax and be used as a pager.

During the later part of 1992, Spectronic launched a small powerful hand



Spectronic's annual turnover, profit and number of employees 1985-95.

portable for the NMT 450. In early 1993, the company launched a hand portable, with a built-in data terminal for the NMT 900. The computer telephone made it possible for Spectronic to initiate a number of projects in co-operation with private as well as military users in different countries.

A large part of the company's production is exported to Europe and

Southeast Asia. Some parts are sold with different trade marks which has been the case with Clarion, Facit and Telecom Finland – all are co-operating with Spectronic. The company is planning to launch a GSM telephone at the beginning of 1997.

Distribution

The main interest within mobile telephony has been directed towards technology and the products, while distribution has received less attention. The mobile telephone business has undergone major changes since the market opened in 1971. The biggest change is that specialists have gradually lost their dominating position, at the same time as the customer structure has become more diversified and the technical development has produced new types of mobile telephones. Five distribution channels have emerged: 1) mobile telephone specialists, 2) car dealers, 3) retailers in office supplies, 4) radio and TV shops, and 5) operator shops.

The first people to sell mobile telephones were agents specializing in communication equipment, such as mobile radios. They were to become during the 80's the exclusive group among mobile telephone specialists, together with car dealers and retailers in office supplies. The big influx of subscribers during the 80's, led to a great number of small traders establishing themselves in the business, opening up shops. But many soon got into financial difficulties and were forced to close down. Telephone manufacturers also made attempts to establish themselves as retailers. Ericsson Radio and Nokia-Mobira operated their own shops in the late 80's, but left retailing shortly afterwards.

Until the early 1990's, the retail trade had been designed for small traders. Small local firms were responsible for the major part of the sale. A large number of shops were located in industrial areas because of the connection to radio communication and the mounting in cars.

Since the major participants were active in the distribution to only a minor extent, enterprising traders with only one shop could easily build chains. They have also been able to benefit from the transition from monopoly to competition in the operators' market, which has meant great marketing resources for the distributors.

Geab – from car showroom to retail chain

In ten years Bob Erixon established Geab to become a retail chain with some 20 outlets. In 1984, Erixon started to sell mobile telephones in his father's car showroom. In order to improve business, Erixon offered customers a leasing contract. Erixon opened the first Geab shop in the south part of Stockholm in 1985. For a number of years, that shop was responsible for the biggest sale of NMT subscriptions in Sweden, contracting more than 1,000 new subscribers every year.

After Geab established their second shop in central Stockholm, the company began expanding during the recession in the early 1990's. The company purchased competing retailers, whose profitability was low, and they es-

tablished centrally located shops, which were financed by profits generated by the company. The first ventures outside Stockholm were in 1992, in Gothenburg and Växjö. During 1993, several shops opened up in Stockholm and Malmö. Geab purchased a chain with three outlets in Stockholm in 1994, which meant that they then had 18 outlets. Beside mobile telephones, Geab sold telephones for the fixed network and smaller switchboards for offices and computers.

Entrepreneurship in the national/Scandinavian phase

The investigation into the land mobile radio communication in 1967 can be seen as a starting point for modern mobile telephony in Sweden, and it marks the transition from a local to a national/Scandinavian phase. It is during this phase that Sweden becomes the leading country in mobile telephony.

Sector	MTD	Comvik	NMT 450	NMT 900
Developer of standard Telephone group	Swedish Telecom, (Nordic Mobile telephone group)		Nordic Mobile telephone group	NMT Group
Developer of mobile telephone exchanges		E.F. Johnson	Ericsson	Ericsson
Developer of radio base stations	Magnetic		Allgon, Magnetic, Radiosystem, SRA	Allgon, Ericsson Radio, Radiosystem
Developer of mobile telephones	Sonab, SRA	E.F. Johnson Technophone	SRA/Ericsson Radio	Ericsson Radio, Spectronic
Development period	1970-71		1971-80	1984-86
Costs	Skr 1 million		SKr 10 million for standard and SKr 125 million for system and mobile phones	
Operating period	1971	1981	1981	1986
Termination	1987	1995-96		

Analogue mobile telephone systems: MTD, Comvik, NMT 450 and NMT 900.

The individual as entrepreneur

The above also contributed to C-G Åsdal's engagement in mobile telephony. He directed Swedish Telecom's investment in mobile telephony, and he contributed to the creation of a new industry organisation and a diversification of market products. But Åsdal was far from being the only individual entrepreneur during this phase.

Östen Mäkitalo at Swedish Telecom's radio laboratory, was one of the people who developed and standardised mobile telephone systems. He was a technical visionary who factored in the micro electronics development, and anticipated the manufacturing of a new input to the new system. He played a major role in organising the development at Swedish Telecom as well as organising the production of different standards (new product).

Åke Lundqvist, who was an important person for SRA and its activity in mobile telephony, also became important to Ericsson Radio Systems, since he expanded the market and created a new organisation of the industry.

Lundqvist contributed enormously in bringing mobile telephony forward as an important product within the Ericsson group in the late 1970's, when radio communication only accounted for one or two per cent of Ericsson's total turnover. Lundqvist also argued that SRA/Ericsson Radio should purchase companies with the specific competence Ericsson needed. His most important contributions included his success in persuading Ericsson to apply the AXE exchange on mobile telephony (new input), as well as launching the idea that Ericsson should supply mobile telephone systems and not parts of mobile telephone systems (creating a new organisation of the industry).

One of these companies Ericsson acquired was Radiosystem. The company was founded and established by Torbjörn Johnson in connection with his fundamental ideas around a filter in radio base stations (new products; a new production process).

Per Siversson, Managing Director, and the main owner of Spectronic, created a new business along with the development of mobile telephones, based on the company's core competence (new product).

When Swedish Telecom opened up for the mobile telephone market in 1971, distribution was not of major importance and retailers had to manage customer relations by themselves. Bob Erixon was one of those who established a distribution company in the 80's, and whose company Geab became a retail chain out of a few shops. Erixon established connections between operators, telephone suppliers and consumers, and developed a new distribution channel as well as a new way of marketing.

The company as entrepreneur

With Comvik's establishment in the network operators' market, Swedish Telecom Radio met competition from a company which had sufficient assets for investing in network expansion and marketing. The governmental authorities had not been planning to introduce competition – since Swedish Telecom had a monopoly – but this came as a result of Comvik pressing Swedish Telecom and the Government with the help of a large number of petitions and sophisticated legal procedures. Later on, it ran a number of campaigns for more frequencies. Comvik's establishment brought a new industrial organisation and market expansion, and the company also used a new form of marketing.

Allgon is yet another example of an entrepreneurial company investing in mobile telephony by turning its attention to the market potential, and building upon its knowledge in propagation techniques. Allgon developed new products, such as components and aerials.

When Swedish Telecom opened the market for mobile telephones in 1971, this meant a new industrial organisation and a new market. When Swedish Telecom Radio introduced NMT in Sweden, a new market was introduced.

The network as entrepreneur

One entrepreneurial activity performed by a network is the development of NMT, where the Scandinavian telecommunication administrations together developed a standard. NMT itself was a new product, while the Scandinavian co-operation also meant a market expansion.

Type of innovation	Group	Individual	Company	Network
1) A new product	Techniques	T Johnson, Radiosystem Ö Mäkitalo, Swedish Telecom P Siversson, Spectronic	Allgon	Ericsson Radio Swedish Telecom NMT group
2) A new production process	Techniques	T Johnson, Radiosystem		
3) A new input	Techniques	Å Lundqvist, SRA/ Ericsson Radio Ö Mäkitalo, Swedish T.		
4) A new organisation of industry	Organising	Å Lundqvist, SRA/ Ericsson Radio C-G Åsdal, Swedish Telecom Radio	Comvik Swedish Telecom Radio	NMT group
5) A new market	Market	Å Lundqvist, SRA/ Ericsson Radio C-G Åsdal, Swedish Telecom Radio	Comvik Swedish Telecom Radio	
6) A new type of marketing	Market	B Erixon, GEAB	Comvik	
7) A new distribution channel	Market	B Erixon, GEAB		

Entrepreneurship in the national/Scandinavian phase

The co-operation between Ericsson and Swedish Telecom is yet another entrepreneurial network which has resulted in new products, and which went on within many different activities, such as AXE and NMT.

The entrepreneurship in the national/Scandinavian phase took place within different parts of the technological system and was carried out by individuals, companies and networks. The expansion of mobile telephony during this phase can be verified by the arrival of an organising entrepreneurship, and a breakthrough for a market oriented entrepreneurship.

A large part of the entrepreneurial activities during this phase is based on the entrepreneurship represented by the standardiser. This involves the NMT group as well as the co-operation between the Scandinavian telecommunication administrations, which operate a technique and a market oriented entrepreneurship.

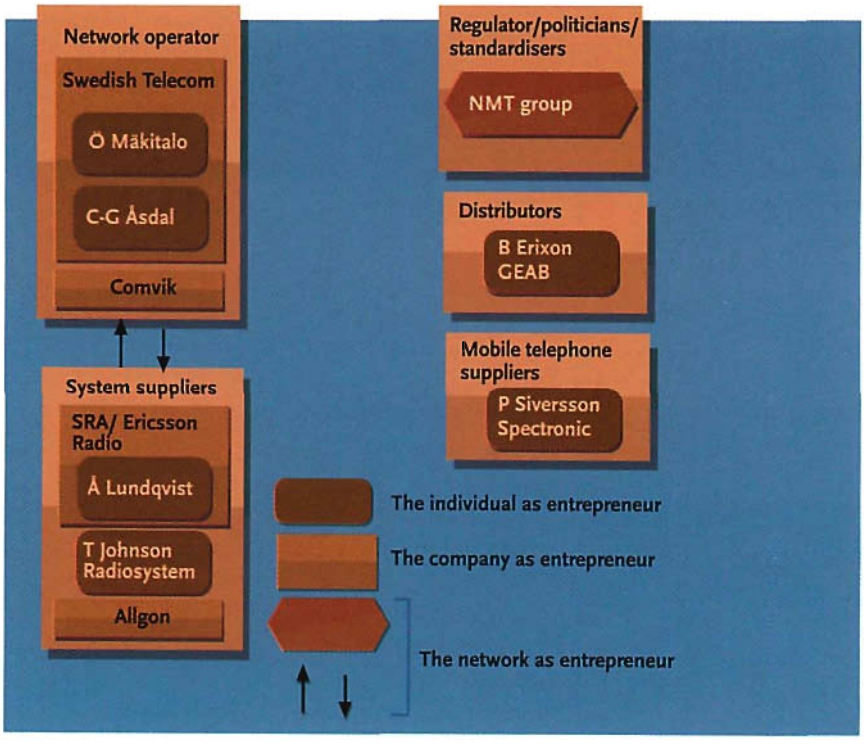
Just as in the local phase, many things circle around the network operator. Mäkitalo's individual entrepreneurship contributed to the design of a technically sophisticated system by Swedish Telecom Radio. The network as entrepreneur can be found in the technically related co-operation between Ericsson and Swedish Telecom Radio. C-G Åsdal, at Swedish Telecom Radio, was another individual entrepreneur who contributed to the establishment of a new industrial organisation by opening the market for mobile telephones in 1971. This solved an immediate financial problem at Swedish Telecom, and it formed the basis of a competing Swedish mobile telephone

industry. The network operator function was also influenced by Comvik's entrepreneurship, which resulted in a market expansion.

Lundqvist's contributions in the shape of a technical, organisational and market oriented entrepreneurship played a major role for SRA/Ericsson Radio, the system supplier, in their break-through in the mobile telephone market. Allgon, the system supplier, operated a technique oriented entrepreneurship and developed new products. Radiosystem's success was thanks to Johnson's technique oriented entrepreneurship.

As for Spectronic, it was Per Siversson who performed the most successful entrepreneurship.

The distributor function was developed during this phase through a market oriented entrepreneurship which was carried out by Bob Erixon at Geab. If we place that entrepreneurship in the technological system, the following picture emerges:



Entrepreneurship in the technological system during the national/Scandinavian phase.

4. International phase

Pan-European system – GSM

As early as 1970, the NMT group discussed a future European mobile telephone system, although the group anticipated difficulties in reaching an agreed standard. The group realized that it would be too time consuming to try to convince Europe that a mutual standard was advantageous. On the other hand, the group saw a possibility of reaching a limited compatibility between different European systems.

A first step towards a mutual European system was taken in 1982, when CEPT, Conference on European Posts and Telecommunications, decided to assemble a group called Groupe Spéciale Mobile (GSM), which was commissioned to develop a mobile telephone standard. Frequencies in the 900 Mhz band were reserved all over Europe. The group was to design a number of interfaces in the mobile telephone system, to facilitate communication between exchanges and radio base stations, individuals and machines. It was not clear that it was to become a digital network until the mid 1980's. A digital GSM meant: 1) improved speech quality, 2) improved combined services, 3) higher capacity, and 4) extended security through encryption.

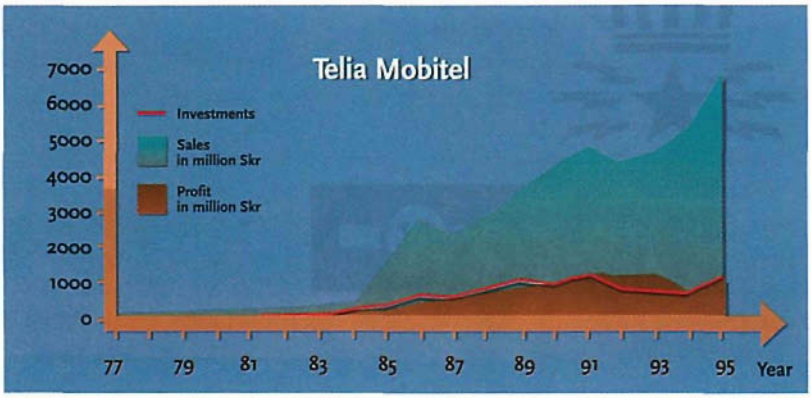
Östen Mäkitalo, in charge of the radio laboratory at Swedish Telecom Radio, participated in the international GSM group until 1988. He drew up the blueprints for a digital mobile telephone system as early as 1982 which, according to Mäkitalo, corresponded fairly well with the final system.

A wide band solution was first discussed, but Swedish Telecom decided early on to concentrate on the narrow band TDMA (Time Division Multiple Access), which divided the frequency spectrum into a number of time slots. At first, Ericsson tried the FDMA (Frequency Division Multiple Access) technique, which divided the frequency spectrum into a number of frequencies, before it decided on TDMA. France and Germany were in favour of broad band TDMA, but the wide band solution required larger investments and was more expensive to run in the remote parts of the countries. In Paris in 1986, the European group tested eight systems: two German, two French and four Scandinavian. The Paris tests were decisive. The group decided that GSM should be based on a narrow band TDMA. The telecommunication administrations signed an agreement which meant that operators were to operate the GSM network as from 1991. The GSM group became a member of the European Telecommunications Standards Institute in 1988. The GSM specifications covering 5,000 pages were ready in 1989. After 1989, further development of a standardisation was initiated, including supplementary services and speech codes.

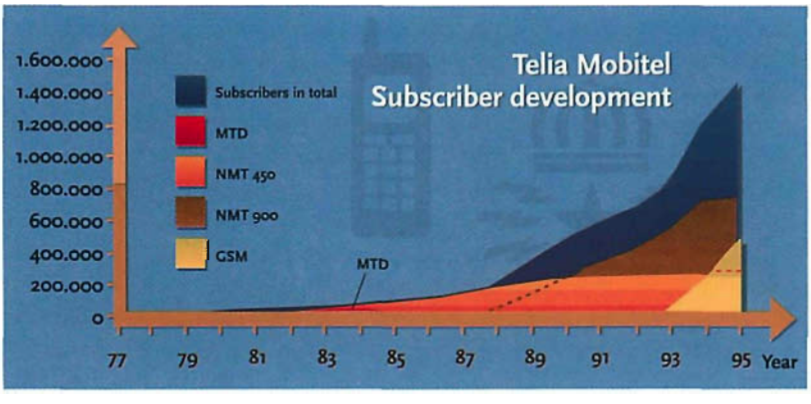
It can be argued that GSM resulted from a parallel development in Germany, France, the Scandinavian countries and the United Kingdom. Swedish Telecom was active in the development of GSM, and held such positions as chairman and secretary in the standardisation group. Comviq participated in the standardisation work from 1988/89.

Telia – mobile telephony a growing activity

Swedish Telecom Radio's annual turnover increased from skr 145 million in 1979 to skr 6.7 billion in 1995. During this period, Swedish Telecom Radio developed from being a civil service department to a competitive company. For the past three years, the company has invested more than skr 2.7 billion in mobile networks. Mobile telephony is the largest business sector, and accounts for more than 80 % of annual turnover.



Swedish Telecom Radio's/Telia Mobitel's economic development 1977–95



Swedish Telecom Radio's/Telia Mobitel's subscriber development 1977-95

The increasing competition in the operators' market has forced the company to introduce a large number of different kinds of subscriptions, which has produced a division of one private and one business market. Marketing as well as payments of commission to retailers have intensified.

Swedish Telecom Radio opened its GSM network in November 1992. The rapid influx of subscribers forced a concurrent expansion. During 1994, the number of subscribers in the digital network exceeded 250,000. In late 1995, NMT 900 had the largest number of subscribers, but GSM was catching up.

Comviq – confident of victory but not profitable

In late 1987, Comvik requested the Ministry of Transport and Communication to establish a digital mobile telephone system and discuss a co-operation regarding the development of GSM. The frequency board put up no obstacles, and in November 1988, the Government licensed Comvik to operate a GSM network. The Government justified the decision by saying that Swedish Telecom's monopoly would terminate in 1990, and that there were no financial obstacles to having two GSM operators. During 1990, Comvik advertised in the daily press about its ambitions as regards GSM:

"During the 1990's, government run Swedish Telecom will meet competition in the mobile telephony market: In 1991, the new European digital system GSM will be launched. Subscribers connected to this network can use their mobile phone everywhere in Europe. In Sweden, Swedish Telecom and Comvik will compete in supplying this service. Comvik is presently building up the GSM network. In the next few years, we will invest at about skr 1.5 billion. Our aim is to capture at least 50 % of the expanding Swedish market for mobile subscriptions." (Dagens Nyheter 17 June, 1990)

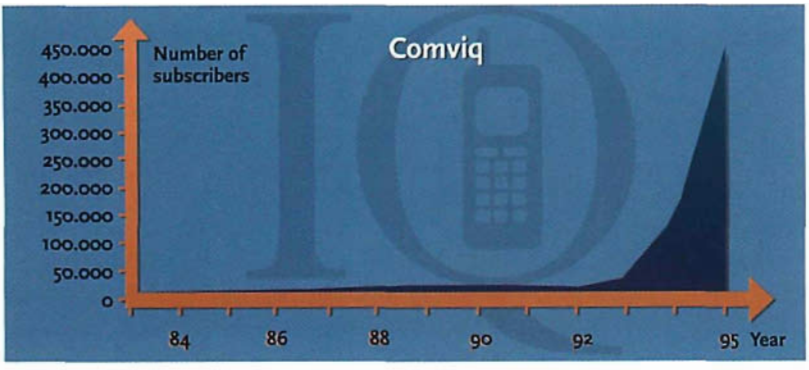
The backbone of Comvik's network is Banverket's fibre optic network. Kinnevik signed an agreement with Banverket in the early 1990's – valid for 25 years.

According to the former Managing Director, Sweden was only big enough for two GSM operators, and Comvik would be one of them, since the company had a great knowledge of the business as well as ten years of experience in operating mobile telephone networks. Swedish Telecom Radio would lose their dominant position on the mobile telephone market with the increasing importance of GSM, since the company possessed insufficient competence in marketing together with a rigid bureaucracy, which hindered control as well as private initiatives.

Comviq, being a wholly-owned subsidiary of Industriförvaltnings AB Kinnevik, opened its GSM network in September 1992. Siemens supplied the mobile telephone exchanges; Motorola the radio equipment, and Digital Microwave the radio link equipment. The expansion was financed by Kinnevik, as well as an international bank consortium. In 1995, the company had invested skr 1.5 billion in infrastructure.

Comviq is mostly sales oriented, and their motto is low cost mobile telephony. The company's aim has been to overtake NMT, and make GSM a natural choice. During the first year, Comviq concentrated on business customers, but after low profits, the company turned to private consumers instead. The company began looking at places where consumers did their shopping, such as shopping malls for Radio & TV. Since then, Comviq has

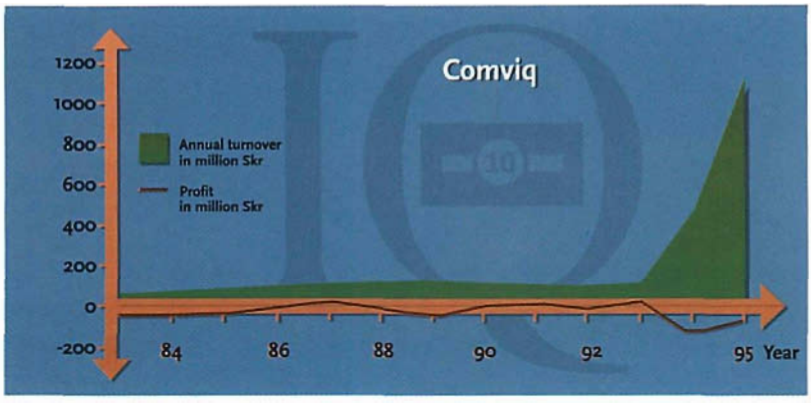
paid large commissions, on average skr 3000 per subscriber, in order to improve sales. This has turned out well, since the influx of subscribers has increased immensely since 1994.



Comviq's number of subscribers 1983-94.

But so far the economic result has been negative. The economic development of Kinnevik's investments in mobile telephony is shown below.

Through Banque Invik in Luxembourg, controlled by Kinnevik, Comviq



Comviq's economic development 1983-95

introduced a VISA card which could be connected to GSM subscriptions. Comviq has regularly used Kinnevik-owned media companies such as television, radio, and the press, to market their services.

NordicTel – decreasingly Swedish

Mats Ljunggren and Ulf Johansson from Ericsson Radio, both experienced in mobile telephony, established NordicTel in early 1989. Their business concept was inspired by mobile telephony's steady growth and future profitability for network operators. Their idea included the design and operation of mobile telephone systems.

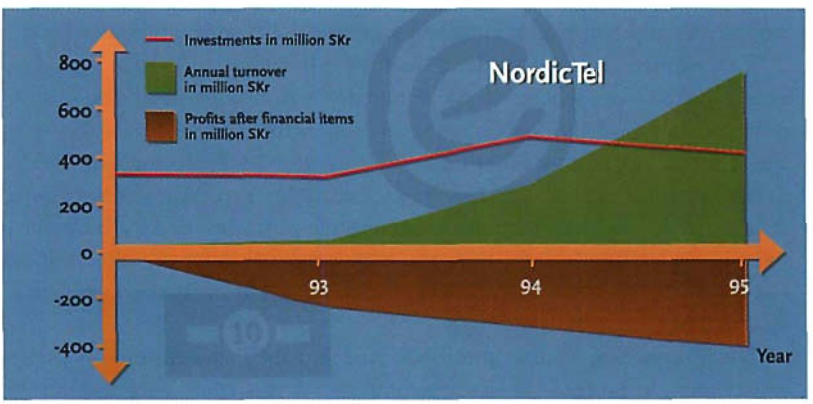
Four major Swedish companies, each investing skr 9 million, were the financiers of NordicTel in 1990. According to Ulf Johansson, chairman of NordicTel, the initiators engaged Swedish large-scale enterprises in order to obtain a stable base for capital and add weight behind license applications.

Ljunggren, Managing Director at NordicTel, believed that the company would succeed because of their joint owners who were good at marketing.

Swedish ownership changed and was gradually reduced until NordicTel's introduction to the stock market in 1994. This began with one of the joint owners, SAS, which sold its shares to the other owners, for skr 9 million. Shortly afterwards, the joint owners sold the "SAS shares" to the British network operator Vodafone, for skr 218 million. The company's estimated value was then skr 1 billion.

In October 1993, the Swedish joint owners sold 51% of the shares in the company to the American mobile telephone operator Air Touch for a price of skr 1.2 billion. This gave the remaining owners Spectra-Physics, Trelleborg and Volvo a capital gain of skr 967 million. The company's estimated value was at the time skr 2 billion.

In May 1994, NordicTel was listed on the stock market. The owners Spectra Physics, Trellswitch Intressenter, Trelleborg, Volvo and chairman of the board Ulf Johansson, as well as Managing Director Mats Ljunggren, sold all or parts of their respective share holdings, equivalent to 23 % of the company. At the flotation, the company's estimated value was skr 3 billion. Including 1994, the owners had contributed skr 916 millions, each in proportion to the number of shares they had. In early 1995, Volvo sold its share holdings, making a profit of skr 576 million from the NordicTel investment.



NordicTel's economic development 1992-95.

In September 1992, Europolitan (the name given by NordicTel to its mobile telephone company) introduced its GSM network. It was not an easy start for Europolitan, since competition was hard, but Europolitan has caught up. Up to 1995, Europolitan has invested skr 1.6 million in infrastructure. But initially, the company planned not to pay commissions in order to obtain customers. Competition between network operators in 1994 forced commissions and other compensations to retailers. During the first six months of 1995, Europolitan paid skr 140 million in commissions.

The Marketing Manager at Comviq claimed that Europolitan's image was practically the same as Telia Mobitel's, which was why Europolitan did not succeed in creating a strong position. This meant, according to Comviq's manager, that Europolitan did not keep up with the competition and had to settle for retailers half as big. On the other hand they managed

to establish stable relations with wholesale dealers, such as Scribona and Enström. In order to strengthen their position in the market and obtain customers, Europolitan started establishing their own retail shops at the end of 1994, called Europolitan stores.

NordicTel's operating license

In February 1990, NordicTel applied to the Frequency Management to allocate frequencies for the expansion of a nation wide GSM network.

The Frequency Management rejected their application claiming that Swedish Telecom Radio had expressed a need for supplementary frequencies for the expansion of NMT 900, as well as it, together with Comvik, already had been allocated GSM frequencies, which meant that competition was a fact in the network operators' market. Furthermore, the Frequency Management argued for extra space for GSM operators, saying that the frequency economy would weaken with a third operator.

NordicTel appealed arguing that the Frequency Management underestimated the technical development and exaggerated the risk of frequency shortage, since there were actually extra frequency bands at hand that NMT 900 used. NordicTel stressed the importance of operating mobile telephone networks in Sweden, for international expansion. According to NordicTel, a rejection would mean encroaching trade liberty together with great economic loss and corresponding advantages for the company's competitors.

To conciliate the Government, NordicTel promised to locate its head office in Karlskrona, which would favour the region with some 100 job opportunities. NordicTel also handed over a memorandum to the Government, including, among other things, a statement by Professor Jens Zander at the Royal Institute of Technology in Stockholm. Professor Zander argued that there should be no technical or economic obstacles for a third operator to be allocated frequencies. True, the total capacity would slightly diminish, but would be compensated through the termination of the frequency ineffective NMT 900.

The Frequency Management rejected NordicTels's argument of encroachment upon trade liberty, claiming that it was customary to limit the number of operators to two.

According to the Frequency Management, whose aim was to establish the same conditions for all competitors, the attitude of the participants had to do with how well competition worked, and with three operators it would consider rules to prevent cartelization or dividing up of the market.

Comviq, with its owner Kinnevik, argued against a license for NordicTel and handed over a number of documents to the Government. Comvik agreed with the Frequency Management, stressing that if one was to give licenses to more operators, this would mean strong disadvantages to the existing operators. The company argued that if the government were to allocate further licenses, this should be done only if based on proven economic benefits to society. The two existing operators would be more than able to meet the demand for mobile telephone services in the Swedish market, according to Comviq. And no other European country had more than two

mobile telephone operators, despite the fact that many countries had a customer base bigger than Sweden's.

The Government decided on the 13th of December 1990 to allocate the requested GSM frequencies to NordicTel. A decisive factor was a statement from Professor Ulf Körner at the Lund Institute of Technology, which explained that there was enough frequency space for yet another GSM operator in Sweden. From a frequency economic perspective, it was better, according to Körner, with only one operator, which would minimize the number of cut off calls, since all mobile telephones had access to all channels. With two operators there would be a greater number of cut off calls than with only one operator. With three operators, the number of cut off calls should increase even further. But the increase would be less when one switches over from two to three operators, than from one to two operators. Besides, if intercommunication is permitted between the operators' networks, meaning that one operator can use another operator's channel without the risk of overload, the result will be a system similar to the case with only one operator from a frequency economic point of view. Moreover, Körner stressed that the allocation of frequencies to a third operator would not cause any problems during the first part of the 1990's, and it would not be until the year 2000 that the frequency administrations would need to take action. The frequencies might then be transferred from NMT to GSM, and a reallocation might be made between the GSM operators.

Another reason for giving a license to NordicTel was that the Government wanted to increase competition in the network operators' market. According to a executive at the Ministry of Transport and Communication, NordicTel was allocated frequencies because it was a trustworthy company with major Swedish owner interests, as well as the company had demonstrated that it was possible to share the frequency space between three operators. The Government also thought that mobile telephony was not a public service, which meant that it was the market and not the Government that should decide the number of operators.

According to the management at Comviq, NordicTel obtained a license to build a third GSM network in Sweden, because the company successfully used pressures from Pharo's board of directors with Krister Wickman in the lead, Camilla Odnoff, the county governor in Blekinge, and Karlskrona trade and industry committee with Rune Andersson and Ulf Lindén.

The Swedish joint owners have, to say the least, obtained a good return from the investments in NordicTel; each company has earned approximately skr 580 million.

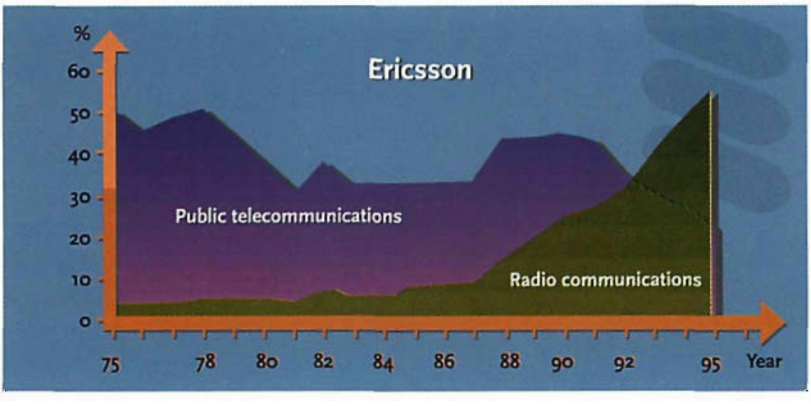
Ericsson – mobile telephony more and more important

In the early 1980's, mobile telephony was responsible for only a marginal part of Ericsson's total turnover. It might not then be so surprising that mobile telephony was looked upon as a sideline, considering that the Group's main business was in public telecommunication. But radio communication has become more and more important to the Ericsson group. The year

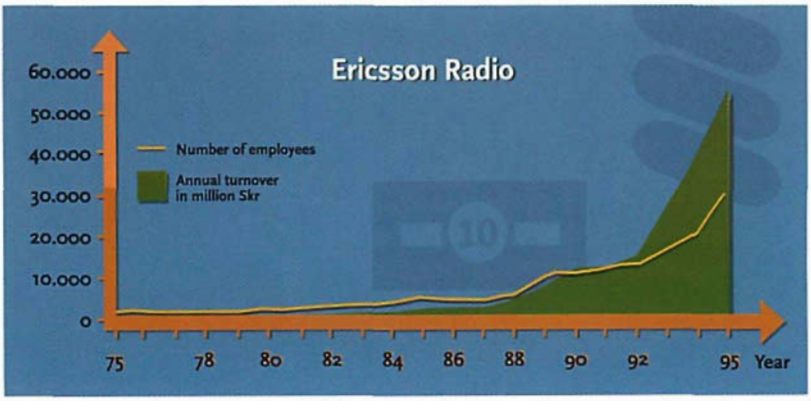
1992 was a milestone when radio communication exceeded public telecommunication and became Ericsson's major business.

Besides being the market leader in mobile telephone systems, Ericsson has managed to obtain a strong position in mobile telephones as well. Until 1989, Ericsson specialized in NMT telephones, extending the knowledge of land mobile radios. Not until 1990 did Ericsson seriously considered manufacturing a variety of mobile telephones. A major step was the foundation of GE Mobile Communications in 1989, together with General Electric, which gave Ericsson access to an established trade mark and a distribution system in the US.

Ericsson holds a 40 % share of the world market in mobile telephone systems, and is one of three major companies trading in mobile telephones. Mobile communication is now Ericsson's most important business, and the key word for future investments is mobility.



Proportion of public telecommunication and radio communication in Ericsson's annual turnover 1975–95.



Ericsson Radio's annual turnover and number of employees 1975–95.

Distribution increases in significance

Development has headed towards mass distribution during the past few years, which means that the retail business has been polarized into one private and one business market. In mid 1993, radio and TV retailers such as Axlin, OnOff and City Stormarknad, commenced investing in mobile telephony. Their breakthrough occurred since private operators were not satisfied with the specialists' sale of GSM subscriptions, which led to operators offering larger commissions and market support. Since radio and TV retailers are used to working with big volumes and with much lower margins than specialists in mobile telephony, the price war was soon a fact. This has meant that the market for mobile telephones has expanded substantially.

Geab expands

As mobile telephone prices decreased, it became more important to be able to handle increasingly large consignments. This suited the expanding Geab, meaning that the company was often the one approached by manufacturers. Geab also used its stronger position to lower supplier costs and to obtain commissions and market support from operators. Despite the fact that GSM had been the instigator of a pan-European market, Geab exclusively purchased mobile telephones from Swedish sales companies. The company now holds a strong market share, which can be verified by the company Swatch, which launched its new mobile telephones through Geab.

The operators wanted to establish more connections with Geab, but required that Geab should submit at least half of the GSM subscriptions to each operator. This meant that Geab had to drop one of the three operators, and since NMT was responsible for a great part of the sales, it was not possible to drop Telia Mobitel; instead the choice was between Comviq and Europolitan. Geab kept Comviq, which was considered the best complement to Telia Mobitel.

Comviq looked for retailers a) willing to invest in centrally located stores, b) who had a system for handling stock, c) who knew logistics, and were good at managing retailing, and d) who had the largest number of customers. Among those were Geab, OnOff and Talkline.

Europolitan, having difficulties in establishing in Stockholm, refused to participate in Geab's campaigns because the operator was not prepared to pay the price, not knowing where the money went. According to Europolitan, it was the operators who partly financed Geab's expansion.

In late 1994, Unisource Mobile purchased Geab paying skr 200 million. Unisource Mobile is a subsidiary to Telia's international branch, Unisource, which Telia owns together with the national telephone companies in the Netherlands, Spain and Switzerland. Unisource Mobile was established in 1994, with the aim of marketing mobile telephone services all over Europe. A first step was to buy Geab, and establish Geab-stores in the rest of the Scandinavian countries before the expansion took place in other parts of Europe.

Talkline – aiming for business customers

The British company Talkline, which was operating mobile telephone stores in Great Britain, established itself in Sweden 1990. The company had a shop at NK department store in Stockholm, offering lease contracts and service contracts, which, according to the present owner, was a good investment, but which came much too early. Due to deficient management and unsound business, Talkline's Swedish office did not do very well.

Recep Celik, who was the manager at Talkline's Stockholm shop, was offered the business to buy when the company had to suspend payments. When Celik took over the business in 1991, he designed a business idea including the sale of mobile system solutions which increased business customers' productivity.

Talkline worked systematically to introduce paging. When paging was accepted later on, the offer also included mobile telephones and now also computers. Talkline had consciously been investing in GSM as from 1991. The company tried hard to influence existing customers found among larger companies. Talkline has a contract with 32 out of the 100 major companies in Sweden.

Despite the fact that operators and telephone manufacturers decided to concentrate on particular mobile telephone specialists, and among those Talkline, the latter had to drop one operator since Celik did not consider it feasible to co-operate with all three. Talkline sells mainly telephones from the three dominating suppliers: Ericsson, Motorola and Nokia.

As from 1993–94, Talkline expanded quickly. The company was then the next biggest retailer after Geab. In March 1994, the company had 30 employees, of which 17 worked in Stockholm; the rest worked in Gothenburg and Malmö. In the mid 1995s, Talkline had 80 employees, and its annual turnover was skr 160 millions. In September 1995, Talkline and Telebaren, which had seven stores in Stockholm for private consumers, merged, and opened "People Cellular & Computers", with some 20 stores in Stockholm and in the south of Sweden. The Managing Director is Recep Celik.

Sector	GSM
Developer of standard	CEPT/ETSI
Developer of mobile telephone exchanges	Ericsson
Developer of radio base stations	Allgon, Ericsson Radio
Developer of mobile telephones	Ericsson Radio
Development period	1982-1992
Costs	SKr 6 billion; Swedish Telecom SKr 200 million
Opening	1991/1992
Network operators	Comviq, NordicTel and Telia Mobitel

Information about GSM.

Entrepreneurship in the international phase

The reason for defining an international phase, besides suppliers being international, is that the systems are international. The different standards of mobile telephones had earlier been incompatible and the market fragmented, but GSM has now not only become a European standard but also a world standard.

The individual as entrepreneur

With the introduction of GSM, competition has increased (from two to three operators) in the Swedish network operators' market. This is a result of an individual entrepreneurship through Mats Ljunggren, establishing NordicTel, and managing to obtain frequencies, creating a new organisation of the industry. Competition has led to operators investing more and more in marketing, which retailers have benefited from. Erixon for example, continued to expand Geab's chain. Other participants appeared, such as Talkline, founded by Recep Celik, who used the increasing market support to develop the distributor role, by creating a new distribution channel and a new type of marketing.

The company as entrepreneur

Many of those companies active in the national/Scandinavian phase have also carried out entrepreneurial activities in the international phase.

Swedish Telecom Radio was very active in the development of GSM, much owing to the work of the radio laboratory (new product). The company has also worked on expanding the market internationally, by establishing operator associations in a number of different countries (opening of a new market).

Even if Comvik and its GSM company Comviq, for their own purposes, argued for competition, Kinnevik had difficulty in accepting that a third operator was establishing itself in Sweden. Since Comvik was already in the market, the company was automatically allocated GSM frequencies. After the GSM start, Comviq aggressively marketed mobile telephony, in order to make a consumer product (a new type of marketing).

Ericsson Radio's success in mobile telephony is mainly due to the company's big investment in research and development, such as digital radio, and its great range of products, which has resulted in the company opening new markets as well as launching new products.

By investing in technical development, Allgon has been able to launch sophisticated products for various niches for system and mobile telephone aerials, and with that, the company has managed to obtain a large market share (new product).

Europolitan introduced a new distribution channel when they opened up their own shops selling subscriptions and telephones.

The network as entrepreneur

In the international phase, the network as entrepreneur has been represent-

ed by Ericsson Radio/Swedish Telecom through their co-operation in developing GSM products. The international group within ETSI, which has developed the GSM standard, is another kind of network entrepreneur.

OnOff, the distribution company, opened a new distribution channel, and applied a new kind of marketing when it started to sell mobile telephones in large quantities, which meant that mobile telephony was now a consumer product. But investments in mobile telephony would not have been possible without the network operators' subsidies and market support, as well as the co-operation with suppliers of mobile telephones. That is what makes it relevant to classify the above as a network entrepreneur.

Entrepreneurship in the international phase.

Type of innovation	Group	Individual	Company	Network
1) A new product	Techniques		Allgon Ericsson Radio Swedish Telecom Radio	Ericsson Radio Swedish Telecom GSM group
2) A new production process	Techniques			
3) A new input	Techniques			
4) A new organisation of industry	Organising	M Ljunggren NordicTel		
5) A new market	Market		Ericsson Radio Swedish Telecom Radio	
6) A new type of marketing	Market	R Celik,Talkline	Comviq NordicTel	OnOff/ Network operator/ Mobile telephone supplier
7) A new distribution channel	Market	R Celik,Talkline	NordicTel	OnOff/ Network operator/ Mobile telephone supplier

During the international phase, a technique oriented entrepreneurship is carried out by companies and networks, which mainly has to do with the network operator Swedish Telecom Radio's and the system supplier Ericsson Radio's various efforts – individually or together.

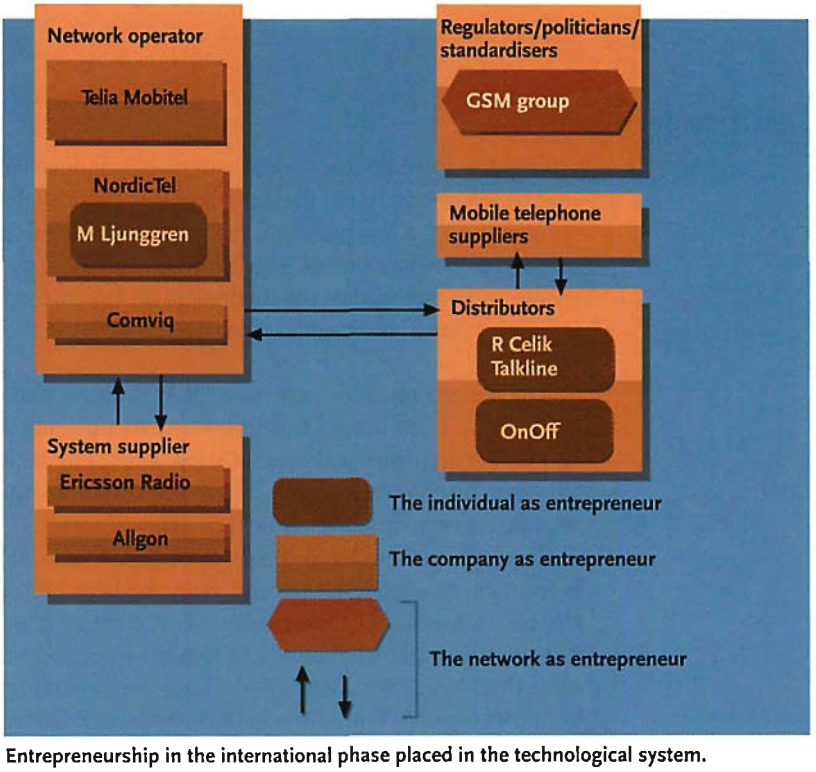
A market oriented entrepreneurship is carried out by individuals, companies and networks. An organising entrepreneurship is carried out by individuals only.

The GSM group as a standardiser is responsible for an entrepreneurship based on networks, where we also find Swedish Telecom Radio and Ericsson Radio. Allgon operates a technique oriented entrepreneurship.

Mats Ljunggren, NordicTel, operates an organising individual entrepreneurship. NordicTel as well as Comviq is responsible for a market oriented entrepreneurship.

The function of distribution is further developed by an entrepreneurship operated by individuals and networks. Recep Celik, Talkline, carries out an individual market oriented entrepreneurship. The company OnOff is, to-

gether with their network operators and suppliers of mobile telephones, responsible for a market oriented entrepreneurship. Placed in the technological system, the entrepreneurship during this phase can be illustrated in the following way.



Entrepreneurship in the international phase placed in the technological system.

5. Conclusions: the leverage of entrepreneurship

Dynamic development

During the three phases – local, national/Scandinavian and international – mobile telephony has undergone dramatic changes. From being a business involving only a few people, it has become a global industry. Mobile telephony has become one of Swedish trade and industry's strongest development blocks (see further the theoretical survey), attracting capital, development and research resources. Sweden has become the world leader in this sector.

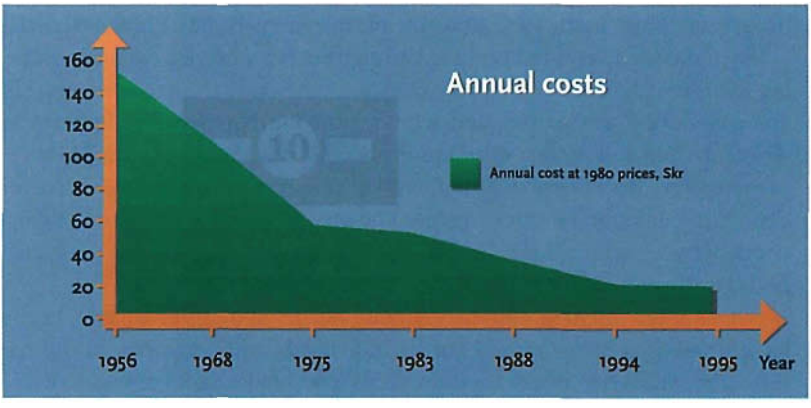
The main companies have been SRA/Ericsson Radio and Swedish Telecom/Telia. The former has improved its competence and has expanded by acquiring companies with special knowledge. The latter has been operating since the beginning of mobile telephony development. Both have co-operated in a number of development projects.

Swedish Telecom has played a major role thanks to the company's early investment in mobile telephony. With the help of Åsdal's investigation in the 1960's, Swedish Telecom initiated the creation of a new national system; but since the company found out that it was not technically possible to realize the plans, they looked for a long-term solution in the Scandinavian countries instead. With the help of the Scandinavian telecommunication administrations which agreed to develop a mutual system, the market was able to expand, attracting system and telephones suppliers. The interest was then further increased by the Scandinavian standard which was established outside the Scandinavian countries as well.

The presence of private network operators during the 1960's and 70's should not be underestimated when it involves the impact on Swedish Telecom's performance. During the 1960's, Swedish Telecom's mobile network had 600–700 subscribers. The private operators had the same number of subscribers. When Comvik made a name for itself, Swedish Telecom was worried. People in leading positions at Swedish Telecom anticipated a risk that the NMT project was going to fail, at the same time as Comvik captured a large market share. But the result was that Swedish Telecom obtained a dominant position in the market – a position the company has managed to maintain over time, although the competition has increased considerably due to the transition to GSM. In late 1994, Telia had 51 %, Comviq 32 % and Europolitan 17 % of the Swedish GSM subscribers. During 1995, the number of clients doubled in the digital networks, and at the end of the year they were just over one million. Thanks to large commis-

sions, Comviq managed to increase its share to 40 %; Telia's share reduced to 45 % and Europolitan's share was an unchanged 15 %. The trend for 1996 shows that Europolitan is catching up on Comviq, at the same time as Telia is keeping its position.

Users' increasing demand for mobile telephones has been one reason for the enormous expansion. But the clients would probably not have bought as many mobile telephones unless the costs had gradually decreased.



Annual cost for using mobile telephones 1956-95 at 1980 year's prices. Figures are based on users calling 1800 minutes per year, and that subscription fees are being depreciated over three years. Source: Official statistics, telephone directories, brochures and private estimates.

Normally, the liberalisation of telecommunications is considered as an initiative taken by the state administration. But the Swedish Government has in principal refrained from interference in mobile telephony, except at appeals of decisions made by Swedish Telecom and the Frequency Management. This has meant that the deregulation in the national/Scandinavian and international phase has been run by Swedish Telecom's competitors to a large extent, and that the Government has acted only reactively. One explanation might be that Sweden – until 1993 – had a limited legislation in this sector, and that there was no intention to introduce the network operators' market to competition. The absence of a focused telephone policy within the mobile sector corresponds well with Dimitrios Ioannidis' (Stockholm School of Economics) claim. He argues that the Swedish telecommunications policy has been one dimensional, with the ability to handle only a few aspects at the same time. The telecommunications policy has gone from equipment oriented to user oriented, at the same time as the rendering of services has been neglected to a large extent.

Development of entrepreneurship

The entrepreneurship in those three phases indicates that mobile telephony has been an uncompleted development block, as well as that structural tensions (which prevent further development) have been operating expansively by stimulating entrepreneurial activities. The entrepreneurship has forced an improvement of the technological system.

The development of the different kinds of market innovations indicates

that technical innovations alone cannot drive a technological system such as mobile telephony by themselves. But at the same time technical innovations are necessary to expand mobile telephony with the help of market innovations.

When we look at the three phases, it is obvious that the extent of the entrepreneurial activities varies among the phases. Not surprisingly the most frequent entrepreneurship takes place in the national/Scandinavian phase. The reason for this is that mobile telephony is going through an enormous improvement, at the same time as a Swedish mobile telephone industry is being established. In the local phase mobile telephony is still a limited business.

Since mobile telephony is going through such a vigorous expansion during the three phases, an interesting question is whether the entrepreneurship changes during this period, and whether the entrepreneurship appears in different shapes. The first question deals with whether the types of entrepreneurship – technique oriented, market oriented or organising entrepreneurship – differ in the three phases. The second question deals with differences between who – the individual, the company or the network – has carried out the entrepreneurship.

A technique oriented entrepreneurship occurs in all three phases. In the local phase it is being carried out by individuals and networks; in the national/Scandinavian phase by individuals, companies and networks, while only companies and networks operate during the international phase. One understanding of this might be that before the technique has been designed, there is also room for individual entrepreneurships, but when the technique becomes more and more complex and widespread (as the case with GSM), companies and networks are responsible for the entrepreneurship.

No organising entrepreneurship is found in the local phase. The reason for this is that the mobile telephone industry is then in its infancy, attracting only a few participants. But in the national/Scandinavian phase, an organising entrepreneurship is carried out by individuals and companies, to be followed by an individual entrepreneurship in the international phase. It is interesting that an individual entrepreneurship gives industry a new organisation in the international phase. This shows that there is room for improvements, and that it is possible for individuals to influence the design of technological systems.

As regards the market oriented entrepreneurship, this is being carried out by companies in the local phase, and in the national/Scandinavian – as well as the international phase – by all three types of entrepreneurships.

The individual entrepreneurship can be seen in all three phases, which means that individuals cannot be dismissed as entrepreneurs whenever a technological system becomes more complex. (Some researchers claim that the development is a result of collective actions which in principal dismisses the individual entrepreneurship.) As examples of the individual entrepreneurs we also find Åke Lundqvist and Östen Mäkitalo, who, together with Sven-Olof Öhrvik, Ericsson Radio, and Lund Institute of Technology, have been awarded the Royal Institute of Technology's first prize. The individual entrepreneur is then growing from being technically oriented into being market oriented. Companies as entrepreneurs are playing major roles in the

other two phases. In the national/Scandinavian phase, companies are responsible for technique and market oriented activities as well as organising entrepreneurships. Networks as entrepreneurs operate entrepreneurship in all three phases, which means that we find technical innovations in all three phases, as well as market innovations in the national/Scandinavian and the international phase.

Referring to the claim which was put forward initially, that making mobile telephony a Swedish world industry was the result of a plan; the development described here shows that the Swedish mobile telephony development could hardly have been a result of a certain strategy; instead dynamic forces have made mobile telephony one of Sweden's strongest development blocks. Regardless of the absence of overall planning, there have been structural circumstances to build on, which have facilitated industrial development. One example is the co-operation between Ericsson and Swedish Telecom (not only in the business of mobile telephony) where the explicit aim has been that of favouring Swedish exports, and at the same time obtaining an effective technology for the Swedish telecommunications network. When developing NMT, Ericsson took advantage of the co-operation between the Scandinavian telecommunication administrations, officially financed, in order to produce competitive products for exports.

This is in line with C-F Helgesson's and D. Ioannidis' (Stockholm School of Economics) claim, discussing the relationship between telecommunications participants and the state, describing it as the telecom triad: Ericsson, Swedish Telecom and the state. Ericsson accepted reluctantly the transition from a manual to a fully automated exchange technology after Swedish Telecom's success in breaking Ericsson's resistance, and with it a new range of technical exports products for the Swedish manufacturing industry was guaranteed. A similar course of events can be found in mobile telephony, which has resulted in Ericsson's success in mobile telephony.

The entrepreneurial spiral

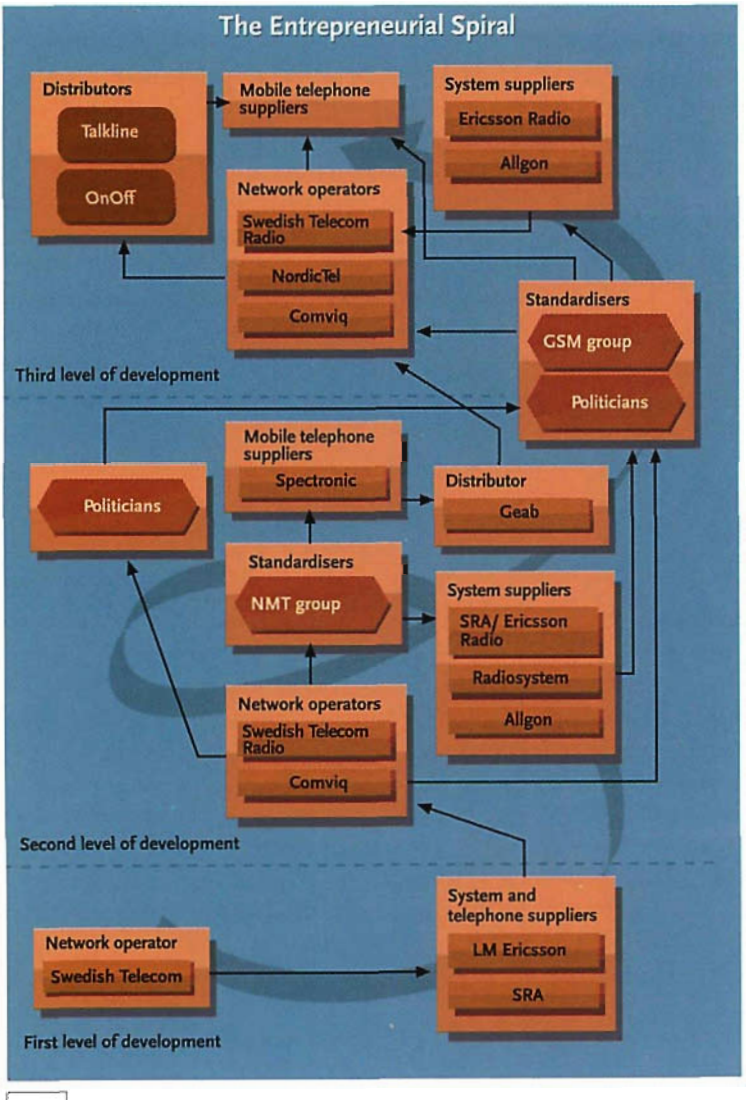
Even though I have not explicitly discussed the interplay between the different kinds of entrepreneurial activities, I have an idea that the entrepreneurships do not occur in isolation; there must be connections between them which allows me to introduce the entrepreneurial spiral. This spiral, consisting of three levels, originates in the entrepreneurship identified in the three phases, and emphasizes the impact innovations have had on the technological system.

What makes the entrepreneurial spiral function is mobile telephony as an invention launched by the network operator on the first level, which gives impulses to system and mobile telephone suppliers. At the same time, a co-operation for further developments is being established between Swedish Telecom, LM Ericsson and SRA. The comprehensive entrepreneurship on the first level influences the network operator on the second level by system and telephone suppliers.

On the second level, NMT as an invention, starts the spiral by the network operator's influence on the standardiser. But this not only produces

new potentials to Swedish Telecom Radio, but also to system suppliers, who get a new platform to work on. Moreover, Swedish Telecom Radio is being influenced by Comvik's entrepreneurship through the private company's activities which have influenced the state-owned operator. The network operator influences politicians, which affects distribution, in the shape of deregulation. This pressure also affects the network operator Comvik, which obtains a larger space for action with the possibility to expand its network.

Not only system suppliers are influenced by the standardiser's innovation; on the second level there is also pressure on mobile telephone suppliers. A new market is being introduced, which affects the operation of suppliers. When mobile telephone suppliers then manufacture new products, this affects the distributors who become anxious to attract customers, which



The entrepreneurial spiral.

signifies that the entrepreneurship characterized by middlemen becomes important.

The transition from the second level takes place through network operators and system suppliers influencing the standardiser on the third level.

On the third level, the standardiser influences the network operators to establish a new digital mobile telephone system. The standardiser also influences the system and mobile telephone suppliers since they are being asked to develop new products for the new standard.

Moreover, network operators are also influenced by distributors on the second level. This concerns the marketing of mobile telephone services by new distribution channels that are launched, as well as a new type of marketing that is introduced. The breakthrough in market innovations basically influences the network operators' activity. It is not sufficient to only offer the service, but to be competitive one also has to be market oriented. Furthermore, system suppliers provide network operators with more and more sophisticated technology. This drives network operators to make use of the complex systems in a creative way. Since mobile telephones are the media for subscribers – the latter being vital to network operators' livelihood – consequently mobile telephone suppliers are being influenced by network operators. The requirements of more sophisticated and cost effective mobile telephones are intensified concurrently with the increase of network operators' activity in innovations. Mobile telephone suppliers, in turn, put pressure on distributors to stimulate the spread of mobile telephones, to make the market grow. Network operators also transfer resources to distributors, who establish new conditions for distribution.

Even though the spiral is a general outline, it shows how mobile telephony develops through entrepreneurial activities and how these activities create chain reactions. This means that the system is moving upwards, continuously changing the point of departure for the participants. This constantly sets a learning process in progress and creates new chances for entrepreneurship. The spiral also shows that the connection between provoked facts and consequences becomes more and more composed concurrently with the system which is being developed. Standardising processes, technical development and market feedback become, on the third level, more and more parallel processes without a distinct shifting of time.

The entrepreneurial spiral also illustrates that mobile telephony has not been developed with the help of only one individual, one company or one network of companies, but in interaction between the different types of entrepreneurs. We have also seen interaction between the technical, the market oriented and the organising entrepreneurship.

In this report we have so far concentrated on what has been, and it is now time to look into the future. My belief is that we have only seen the beginning of a dynamic communication age. What will influence this development are the types of services and products that customers will demand. This leaves open the question as to who will be the entrepreneurs of the future. But already there are unknown future entrepreneurs, working on developing software, which will offer unlimited mobility designed for our increasingly widespread communication.

Appendix

A theoretical survey

According to the Austrian economist Joseph A Schumpeter, economic development is a result of interaction between entrepreneurial activities and technology. The driving forces in capitalistic economies are innovations or new combinations and creative destruction. The latter means that when new ideas are being created, existing structures sometimes have to be destroyed in order to realize all inherent potential. Innovations mean that we create new phenomena or execute existing phenomena in a new way. Innovations might mean the beginning of a development block as well as the creation of new business opportunities. According to Erik Dahmén (professor at Stockholm School of Economics) innovations often give rise to consequences occurring in a different sector than the original. The greater the transformation an innovation gives birth to, the greater the economic significance.

According to Dahmén, entrepreneurship is of major importance in creating development blocks in driving economic development. The concept development block concentrates on the dynamics in the economy, as well as connections between problems and solutions in various sectors. When we solve a technical problem which prevents further development in one sector, new possibilities are being created in other sectors. Mobile telephony, with all its subdivisions, is at present one of Sweden's most important development blocks.

With the help of my research sources I have defined three kinds of entrepreneurships: 1) the individual as entrepreneur, 2) the company as entrepreneur, and 3) the network as entrepreneur.

The individual as entrepreneur

To form the basis of the individual oriented entrepreneurship one can argue that one individual may influence economic events. Jonathan Hughes, (professor at Northwestern University in the US), is one spokesman for this way of looking at it, rejecting the assumption that historical forces and structures are those things which trigger economic development. He argues that there are no masses – only individuals – and that those individuals force economic development.

Another kind of individually centred entrepreneurial theory has arisen during the research of the small-scale business. The owners are then looked upon as entrepreneurs, and the entrepreneurship equals the creation of a business.

The company as entrepreneur

Schumpeter argues that entrepreneurship is not only carried out by individuals but also by companies. A company does not have to be small or new, since entrepreneurship might be carried out in both big and small companies. Entrepreneurship is not limited to companies, but may also take place within public organisations.

Another sign, according to Schumpeter, that a company is being entrepreneurial is that it has the ability to respond creatively, to do something different from normal routines. According to Dahmén, the entrepreneurship signifies a force in the development by the entrepreneurial operation which generates and reacts to business opportunities.

The network as entrepreneur

The network approach emphasizes the relationship between companies. Two major spokesmen for this view are Jan Johanson (professor at Uppsala University) and Lars-Gunnar Mattsson (professor at the Stockholm School of Economics). One basic idea according to this view is that inventions and innovations happen in networks – not in, but between, companies – and in order to make an innovation successful, the network has to be mobilised. The entrepreneurship is only seen through networks: by connections to other participants, which give access to resources that have not been available earlier. Anders Lundgren and Lena Nordenlöw (Stockholm School of Economics) emphasize the network view on every kind of entrepreneurship. They contrast the "inside and out" view which dominates how we look upon entrepreneurship with an "outside and in" view, where surroundings form the basis, and where development is a result of mutual action.

The basis of mobile telecommunications

Telecommunications involve a transfer of information through light, or in the shape of electromagnetic oscillations via wires or radio waves. Radio communication means that radio waves are being used, a kind of electromagnetic radiation that occurs in different wave lengths.

A central part in a mobile telephone system includes the mobile telephone exchanges. They handle the communication over the mobile network and they look after the transition to the fixed telephone network. The communication between mobile telephones – functioning as radio transmitters – and mobile telephone exchanges takes place via radio base stations. These can be found on high buildings, specially designed masts, or on other high places, since the radio coverage then improves. The communication between radio base stations and exchanges takes place either through fixed connections, which may be a part of the public network, specially designed cables or via radio links. The network's capacity is determined by the number of accessible channels, which increases if the radio base stations are placed near each other. One important function is roaming, meaning that the system checks the whereabouts of the mobile telephones as well as facilitating the transfer of calls to the mobile telephone. Handover means that the system, during a call, is able to connect a call from

one radio base station to another.

Mobile telephone standards – among which the largest are the analogue AMPS, NMT, and TACS, and the digital GSM, PDC and D-AMPS – involve mobile telephone systems designed according to certain principles. Therefore it is not possible to use equipment with one specific standard, such as the American AMPS, together with equipment with another standard, such as the Scandinavian NMT. But improvements indicate that several kinds of systems will be compatible later on, for example GSM 900 and DCS 1800.

Legal requirements

Unlike other countries, Sweden has gone from one situation with no or limited regulation, to another situation with increasing regulation within telecommunications. Regulations were few before the new telecommunication Act and the revised Act on radio communication were introduced on 1st July 1993.

In the late 1970's, debaters began to question whether it was warranted for Swedish Telecom to have the monopoly over the public telecommunication network. According to a decision of the Swedish Parliament in 1980, Swedish Telecom was gradually to open up the telecommunication market for competition, and its monopoly should be limited to: 1) equipment for speech communication, exchanging information between people over the public network, and 2) modems for data communication. The first deregulation took place as early as in 1971 when the market for mobile telephones was opened. The year 1981 saw the arrival of competition in the network operator market.

When the National Post & Telecom Agency was established in July 1993, the exercise of authorities was separated from the operational and commercial functions within telecommunications. The National Post & Telecom Agency is responsible for the Swedish telecommunications system, such as the allocation of frequencies. Before it was the Frequency Management at Swedish Telecom Radio which was responsible for the allocation of frequencies, regulated by Swedish Telecom's statute, the radio law, as well as the Government's notification on radio transmitters. But neither the radio law nor the notification on radio transmitters included instructions when the Frequency Management was to issue licenses; instead the allocation was dependent on economic aspects declared by the Frequency Management. Swedish Telecom's supporting idea, in line with the company's interpretation of the concept frequency economy, was to reduce the number of operators providing the same kind of service. Appeal against the Frequency Management's decision, came first to the General Director of Swedish Telecom and secondly and finally to the Government.

Since Swedish Telecom has been responsible for the allocation of frequencies, and has been a heavy user, the company has played a dual role; a role criticized by many, especially by the new actors in the telecommunications market. The European Commission's green book from 1987 supported the new companies' criticism of the old statute. The green book pre-

scribed that the allocation of frequencies within the EU as from the 1st July 1991, should be administered by organisations separated from telecommunication administrations. In August 1991, the Frequency Management was separated from Swedish Telecom Radio forming an independent authority at that time, which later was incorporated into the National Post & Telecom Agency.

Abbreviations

CEPT	Conference on European Posts and Telecommunications
D-AMPS	Digital Advanced Mobile Phone
DCS	Digital Cordless System
GSM	Groupe Spéciale Mobile – Global System for Mobile Telecommunications
ETSI	European Telecommunications Standards Institute
FDMA	Frequency Division Multiple Access
MTA	Mobile telephone system A
MTB	Mobile telephone system B
MTD	Mobile telephone system D
NMT	Nordisk Mobil Telefon
PDC	Personal Digital Cellular
TACS	Total Access Communications System
TDMA	Time Division Multiple Access

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1. Over the years the appellation has been Televerket (Swedish Telecom), even when the official name was Telegrafstyrelsen (Telegraph Administration), or Kungl Telegrafstyrelsen (Royal Telegraph Administration). On 1st July 1993 Swedish Telecom was established as a company and the name was changed into Telia AB, and Televerket Radio (Swedish Telecom Radio) became Telia Mobitel AB.

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