Entrepreneurship in Technological Systems – The Development of Mobile Telephony in Sweden

Bengt G Mölleryd

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1.1 Sweden in the forefront

If one were asked to pick out one of the more significant innovations of the last decade, Internet and mobile telephony would certainly be among the main candidates. They are both pervasive technologies with wide social and economic implications. This study focuses on the latter, mobile telephony with all its sub-systems, which is regarded as a technological system. This choice presents an opportunity for addressing central issues concerning economic and industrial development and for exploring the forces behind the development of technological systems.

When examining economic development, it is relevant to introduce the concept of entrepreneurship. Entrepreneurship has positive connotations. The actions performed by entrepreneurs contribute towards the spawning of new firms and the prosperity of existing organisations. One way to apprehend the dynamic effect of entrepreneurship is to capture its presence in growth industries, for example information technology or telecommunications. Europe definitely lags behind the US in information technology. The picture is quite different, however, when it comes to telecommunications, both as regards the industry as a whole and mobile telecommunications in particular, largely due to the leading position held by the Nordic countries.

Mobile communications constitutes a truly dynamic market, as it is currently in a state of perpetual growth. The annual growth in mobile telephone subscribers has been impressive as table 1 exhibits. Industry experts anticipate that the total number of mobile subscribers will surpass the installed base of fixed telephones in the world, currently about 700 million, within in a year or two and that a figure of one billion mobile users will be reached by the year 2004.

Year	Annual growth in percent
1969	46
1970	59
1971	21
1972	123
1973	74
1974	59
1975	60
1976	32
1977	26
1978	20
1979	13
1980	16
1981	12
1982	23
1983	47
1984	45
1985	40
1986	39
1987	37
1988	41
1989	44
1990	37
1991	22
1992	15
1993	25
1994	66
1995	45
1996	22
1997	29
1998	30

Table 1 / **The annual growth of the installed base of mobile telephone subscribers 1969-98 in Sweden**

Source: Swedish Telecom, Industriförvaltnings AB Kinnevik, Europolitan

These projections make compelling reading. Prior to the mid to late 1980s, there were few, if any, who thought that mobile telephony would become a universal phenomenon. The telecommunication industry itself was incapable of foreseeing the potential demand from people to have mobile telephones in their cars or in their pockets, whichever, facilitating ubiquitous communication. However, as Bowler (1997) underscores, it is common for the direction of the development to be misjudged. People and firms are not particularly good at recognising potential which is why it is not surprising that most inventions never turn out to be of any significance. Nevertheless, some phenomenon or products take off and become establish contrary to expectations, and the extraordinary development in mobile communications is a case in point.

One could claim that mobile telephony is one of the most important innovations to hit Sweden since World War II. It has emerged as a substantial market of immense importance for the Swedish economy. Sweden ranks with Finland in having among the highest penetration rates of mobile telephone subscribers in the world and where a few firms hold leading positions in different markets for mobile communications.

For the Ericsson Group, for instance, mobile communication represents the largest business area. Ericsson holds a dominant position in the market for mobile systems, with a world market share of over 40 per cent, and captured 14 per cent of the global market for mobile telephones during 1998.

Mobile communication is likewise a growing business for Telia, nationally as well as internationally, and the operator has interests in 18 mobile telephone network operators around the world. The mobile communications operation has been quite profitable for many years.

Mobile telephony also represents a profitable activity for the network

operators, Europolitan and Netcom with Comviq, and provides them with a stable cash flow and strong earnings. This is reflected in the strong development in their share prices on the Stockholm Stock Exchange. Numbers of other firms active in supplying different components to the mobile industry have also succeeded in capturing positions on this dynamic market. Among them are Noalto, which supplies details for mobile telephones to Ericsson; and Allgon, which supplies equipment for radio base stations and antennas for mobile telephones. Sales of mobile telephones also represent a substantial business for the retail sector in consumer electronics. Moreover, a growing number of information technology firms, such as Cetronic and Sendit, are developing and marketing a broad variety of software applications for mobile communications, e.g. integration of mobile communication and the Internet.

Given that mobile telephony has become of such importance for the Swedish economy, it is relevant to inquire into how this has been accomplished. What forces have been involved and who facilitated this development?

1.2 Forces behind the development

This study analyses the role and characteristics of entrepreneurship behind the development of the mobile telephone industry in Sweden since the 1950s. It is an account of how an area within the telecommunications industry undergoes a fundamental transition from being primarily the preserve of engineers, working with technical issues with a long-term perspective, to becoming a market characterised by fierce competition, a technology race, successive innovations, dynamic market effects and internationalisation.

This process of change is commonly largely attributed to deregulation. To a limited extent its course has been directed by a strategy formed by politicians and policy makers. However, the explanation is not just that simple, as this study will show. The study interprets the process as resulting instead from entrepreneurship, both on the part of established participants as well as by new entrants having the capability of capitalising on an emerging market.

I would like to underpin three factors which influence the development and the outline of this study:

1) Mobile telephony – which is often seen as a recent phenomenon, launched sometime in the 1980s – has a considerably longer history, however, as this study will show. The development of the first mobile telephone system was initiated as early as 1950, which means that the advancement of a Swedish mobile telephone industry extends over half a century. The introduction of mobile radio goes back even further, as the Chicago police used mobile radios in the 1920s to improve their chances of

catching criminals like Al Capone, while the Swedish police force was equipped with mobile radio in the early 1940s.

2) Mobile telecommunications could be regarded as a network technology or an infrastructural system like, for example, the railway networks, the fixed telephone network, and grid being thereby dependent upon several interrelated products. It is therefore relevant to approach mobile telephony as a system since it not only involves a single firm but consists of a number of firms or organisations and technologies that are interconnected and inter-dependent. By regarding it as a network technology, it implies the existence of network externalities, influencing the price and cost structure for the industry (Shapiro and Varian 1999). A well-functioning technological system such as mobile telephony rests on strongly positive and reciprocal external economies, which tie together users, suppliers, and competitors (Carlsson and Jakobsson 1997, p 270).

3) Mobile telephony – which is not confined to artefacts, such as telephones, terminals, radio base stations, switches, system components, because the service or function that mobile telephony accommodates is equally essential. The feature that mobile communications provides could be labelled mobility, which is characterised by connectivity and the feasibility to communicate irrespective of location. This is the essence of mobile telephony and something that captures a basic need among individuals and a fundamental social quality. To communicate while mobile was an option previously open to only a limited number of professionals; today, it is available to anyone wanting to exercise it.

In spite of the significance of the mobile service, focus has hitherto primarily been on the mobile telephones as such. This is largely because the distribution has been formed around the sales of mobile telephones rather than round the marketing of the mobile service. It is therefore relevant to include distributors as well as users in order to embrace the scope of the mobile telephone industry.

1.3 The impact of entrepreneurship

As entrepreneurship is a pivotal concept for this study I would like to clarify how it is used here. First there is the concept of entrepreneurship which is the overall function for creating economic development (Schumpeter 1955). Then there is the entrepreneur, the economic agent who accomplishes entrepreneurship. It is a temporal capacity because it is required that an entrepreneur carries out an entrepreneurial activity. This is further elaborated in the theoretical framework.

Entrepreneurship is predominately used in reference to small firms and to their founders and leaders, implying that entrepreneurship is an activity only performed by individuals. However, I propose, with the support of the literature survey that I present in the theoretical framework, that entrepreneurship could be defined as a function that could be carried out by a broader variety of agents. This enables me to characterise entrepreneurship in three different ways, originating from three sources: 1) the individual as entrepreneur, 2) the company as entrepreneur and 3) the network as entrepreneur. By using these three sources of entrepreneurship in an analytical framework I accomplish an analysis as to how the entrepreneurship could be attributed in the development of mobile telephony in Sweden. Moreover, I am interested not only in who has carried out the entrepreneurship, but also in which entrepreneurial activities or innovations have been accomplished.

Since I describe a development that extends over 50 years, it enables me to analyse how entrepreneurship has developed over time, to search for patterns in when the three sources of entrepreneurship occur and in the types of the entrepreneurial activities performed at different stages in the development.

1.4 Network technology – technological system

Mobile telephony, as I stated previously, is an example of a network technology, which makes it relevant to characterise mobile telephony as a technological system. By applying Hughes' (1987) notion of technology systems I involve in the analysis not only the physical mobile telephone network, but also firms, organisations, as well as users. This facilitates an analysis of connections and interdependencies between the different participants and sub-systems. The close connections between different sub-systems mean that innovations are generated in several steps in a sort of a chain reaction. Although complete new types of mobile telephones (portable, handportable, dual mode) are innovations as such they could also initiate subsequent sequences of innovations like for example: new performance of network operators' activity, new distribution channels and new usage patterns.

1.5 Course of events divided into three phases

In order to unfold the emergence of the Swedish mobile telephone industry this study takes a long-term perspective and starts with the first steps in the forming of a mobile telephone industry in the early 1950s, and covers its development up until the late 1990s. Mobile telephony has undergone a

tremendous expansion during this time-span. Schematically it could be said to have developed from being a local business with local systems covering a limited geographical area into being a national and Nordic affair, with a national mobile network based on a Nordic standard, and then into becoming an international industry, with several international or global systems in operation.

I therefore find it appropriate to divide the course of events into three phases: 1) local, 2) national/Nordic, and 3) international.

This division reflects the extension of the various mobile telephone standards in operation over the years. It is not only relevant for the underlying technology, however, it also reflects how the market has evolved and the activity range of the firms involved. Although the division basically follows the time path, the phases are partly overlapping and therefore not strictly sequential. The advantage in dividing the development into three phases is that it facilitates the presentation of the vast quantity of empirical material and gives a structure to the account. Moreover, it makes it more manageable to carry out the analysis of the entrepreneurial activities.

1.6 Research question

The modest projections and the low expectations that characterised the mobile telephone industry up until the late 1980s makes it appealing to examine how Sweden has accomplished the feat of now being in the forefront of this industry. This raises several interesting questions relating to the force behind this development, for instance, how did it come about that several Swedish companies succeeded in being frontrunners in this business and how is it that Sweden now has one of the highest penetration rates in the world for mobile telephones.

This study is basically driven by my fascination in discovering how this development has come about. What today is self evident and something that every one believes will continue to grow in the years to come was originally an area few believed would ever be of any great commercial interest. In spite of these unpromising prospects there were those working within this area, both individuals and firms, who laid the foundation for a significant industry which today represents a growing market for Swedish firms nationally as well as internationally.

Besides the ambition to present a comprehensive account of the unfolding of the Swedish mobile telephone industry there is a theoretical purpose with this study. Given my interest in searching for the forces behind the development and in unravelling the relationship between individual and collective action,

entrepreneurship is a pertinent theoretical construct that I will employ in an analytical practise.

Entrepreneurship has generated a broad set of theoretical propositions which is why I take it as point of departure to formulate theoretically valid definitions of entrepreneurship and to utilise these in an analysis of the development of the Swedish mobile telephone industry.

In contrast to what dominates the entrepreneurship research area, which has a focus on studies of specific firms often with one time observations, this study embraces an entire industry and its relevant participants which I label as a technological system. My point is to show that entrepreneurship is not an isolated phenomenon because it appears in a context and in this case within the boundaries of a specific technology. Besides searching for the occurrence of three sources of entrepreneurship, I am also interested in exploring whether entrepreneurship functions as a coordinating mechanism in the development of the technological system. It concerns how the entrepreneurial activities taken together form the advancement of the technological system.

Even though a number of markets exist, some of which I have listed below, they only embrace a part of the development because it is a process captured through external economy, competence flow and collaboration. It could be referred to as an industrial network.

There is a network operators market where customers enroll as subscribers and where mobile telephones communicate. There is a market for mobile telephones and accessories to end-users. There is a market for wholesale trade in mobile telephones. There is a market for airtime where service providers can bundle the mobile telephone service. There is a market for mobile systems with switches and radio base stations. There is a market for consultants and system integrators and there is a market for firms working within mobile communications. Moreover, there is a market for standards on an international level. Even though this catalogue is not fully comprehensive it gives an idea of the broad scope of mobile telephony. Over time the definition of the market develops, influencing the activities of the participants in the technological system, and the overall development is a kind of market process.

I am interested in innovations which taken together move the technological system forward and I therefore classify them according to which type of innovation they are and discuss the magnitude and impact of innovations on the technological system.

Given my interest to analysing the development it is relevant to discuss the relationship between the central two theoretical constructs in the study: entrepreneurship and technological system. Is the one creating the other

and vice versa? My main focus is on the technological system, entrepreneurship being seen as the independent variable creating a certain level of change. I discuss this issue in the analytical framework. Moreover, I discuss whether I discovered any pattern or variation in the development of the sources and types of entrepreneurship.

Concluding this section I present my research question for this study: *How did entrepreneurship over time contribute to the development of the Swedish mobile telephone system?*

1.7 Positioning and contribution

As I link entrepreneurship theory with technological system this study addresses central questions for the industrial development and the technological system fields. I contribute with concepts and understanding of how a technological system evolves and the interdependence between different participants. Since I explicitly address the question of entrepreneurship in the development of a system context, this study could also specifically be of interest for the National System of Innovation research area. Moreover, I also aspire to make a contribution to the field of industrial networks as this study discusses technological development and entrepreneurship in a systemic perspective.

Entrepreneurship is a problematic concept and with the broad spectrum of definition that exists it is a challenge to use it in an analysis such as this. However, the heterogeneity of entrepreneurship theories makes it possible to pursue a study such as this where I combine three different perspectives of entrepreneurship. Within the entrepreneurship literature there is a lack of longitudinal studies (see discussion below) exploring the existence of entrepreneurship over time. Focus is either on small business firms or their founders. It is rare to find a study exploring entrepreneurship within a particular industry, meaning that entrepreneurship is somehow a connected and not an isolated phenomenon and that the source of entrepreneurship can change over time. This makes it possible to discuss how individual and collective action complement one another in the development of a technological system. I therefore presume that this study could be a contribution to the area of entrepreneurship theory.

Furthermore, it is my hope that this study could be of use to scholars pursuing research into the mobile telephony industry. This provides an argument for presenting a comprehensive account of the Swedish mobile telephony industry from its origin.

1.8 Research within entrepreneurship

Research within the area of entrepreneurship could be said to focus on two areas, at least according to the Journal of Business Venturing, the main journal within this area. The first area relates to questions surrounding small business start-ups, new ventures, venture capital, incubators, franchising, growth of individual firms, creation of organisations. The second area relates to issues concerning the individual entrepreneur, the psychology of entrepreneurs, the personal characteristics of entrepreneurs, personality traits, self-efficacy, and habitual entrepreneurship.

Even though case studies exist within the entrepreneurship area, this study takes on a different approach compared to the issues listed above. It is also rare to find similar studies within the entrepreneurship area. Notwithstanding, there are certainly studies on technology systems and development but entrepreneurship is not placed in the center, as it is in this particular study (see for example McKelvey 1994).

Hill (1995) argues that there is a need for more studies of entrepreneurship across different types of industries and organisations. By carrying out rich, qualitative, in-depth studies Hill points out that we could identify potentially important variables, develop hypotheses and propose classificatory schemata. Gartner (1995), and a number of other authors, point out that there is a lack of long-term studies of entrepreneurship, calling for longitudinal studies on entrepreneurship. By doing this historical study of entrepreneurship using the case study methodology it is feasible to relate a comprehensive story of the development extending over half a century.

1.9 The scope of the study

This study primarily relates to the development of mobile telecommunications in Sweden. Concentration on Sweden is appropriate as I go from the specific to the general, and include international activities when it is part of the development. Moreover, the ambition with this study is to generate theoretical propositions which could work as input to future studies and learn from one particular case.

Although it would have been interesting to analyse the entire world market for mobile telephony or at least to concentrate on the development in specific countries. Finland would have been a particularly interesting case, since Nokia, like Ericsson, is a frontrunner in the mobile communications industry. However, I have chosen to restrict this study to Sweden due to time and space constraints and limited access to the wider data.

1.10 Disposition

This study is organised as follows. The following chapter presents some general aspects of mobile communication and on the legal requirements. Then follows a chapter where I describe the methodological framework and sources of information. In the chapter thereafter I discuss the theoretical framework, present theories on technological system, innovations and entrepreneurship, and present an analytical framework.

The three chapters that follow comprise the emergence of the Swedish mobile telephone industry divided into the three phases; local, national/Nordic and international. I present and analyse entrepreneurship and its effect on the technological system in each phase.

In the concluding chapter, I discuss and analyse entrepreneurship in the three phases and how the technological system has evolved. Furthermore I present an entrepreneurial spiral, and a suggestion for future research.

2. About mobile communications

In this chapter I present some concepts that I use in the study, and present some general aspects of the field of enquiry.

2.1 Terms used

Mobile telephony is the main term I use in this study. It can refer to the total service or to the area. It can be synonymous with mobile telecommunications or mobile communications, cellular telephony or wireless communication. Even though the term wireless communication is normally used in relation to local access technology for the fixed network, it is also often used to refer to the entire area.

The artefact that the customer uses is called a mobile telephone, a hand portable, a mobile handset, a pocket telephone or a cell phone. The term terminal is often used in relation to telephones and refers to any kind of device that can be connected to the network. I predominately use the terms mobile telephone or handportable.

Technological system is a central concept in the study comprising the entire industry including the physical mobile telephone system. When talking about a mobile telephone system or a mobile telephone network I refer to the complete operations including all its parts. The term network is used in two respects, one referring to the physical network, and the other as a construct referring to interconnecting activities between different participants.

2.2 Several systems

Mobile telephony in Sweden has its origins in the 1950s when Swedish Telecom[1] became the world's first telecommunication administration to operate a fully automated mobile telephone system. As the following table

[1] Through this study I use Swedish Telecom concerning the period up until 1 July 1993, and after that I use Telia. Even though if mainly concern the mobile operation which has been managed in Swedish Telecom Radio, or later Telia Mobile, I choose to just call it Swedish Telecom or Telia. Before the company was named Televerket, Swedish Telecom the official name was Telegrafstyrelsen (Telegraph Administration), or Kungl Telegrafstyrelsen (Royal Telegraph Administration). On 1st of July 1993 Swedish Telecom was established as a company and the name was changed into Telia AB, and Swedish Telecom Radio (Swedish Telecom Radio) became Telia Mobitel AB.

indicates, a number of mobile telephone systems have been launched during the ensuing 50-years of development, creating openings for a huge expansion in mobile telephony.

Table 2 / **Different systems introduced during the development of mobile telephony**

Decade	
1950s	Development of the first automatic mobile system, MTA
1960s	Opening of a second automatic mobile system, MTB. Private systems started.
	First steps toward a Nordic mobile system
1970s	Opening of a manual system, MTD
1980s	Introduction of NMT 450, Comvik enters the market
	Introduction of NMT 900
1990s	Opening of GSM by three Swedish operators
	Four licenses for DCS 1800 are allocated

A way to measure the diffusion of mobile telephony is to indicate the number of mobile telephone subscribers per 100 inhabitants, referred to as the penetration rate. To illustrate the expansion of mobile telephony from 1956 up until 1998 the following table gives the figure for every five years from 1956 to 1985 and then the annual figure.

Table 3 / **The diffusion of mobile telephony in Sweden 1956-98 indicated by the number of mobile telephone subscribers per 100 inhabitants.**

Year	Penetration in per cent	Year	Penetration in per cent
1956	0,0004	1990	5,6
1961	0,0018	1991	6,7
1966	0,0024	1992	7,7
1971	0,011	1993	9,6
1976	0,14	1994	15,7
1981	0,3	1995	22,8
1986	1,5	1996	27,9
1987	2,1	1997	35,8
1988	2,9	1998	46,6
1989	4,1		

Source: Official statistics, annual reports and corporate material from Swedish Telecom/Telia, annual reports from Industriförvaltnings AB Kinnevik, Netcom Systems and NordicTel, Europolitan.

It took for example 29 years before 1 per cent of the Swedish population had a mobile telephone, while it took only another 8 years to reach 10 per cent, and then it really took off.

1.3 The significance of mobile telephony

Mobile telephony has become an important factor in the Swedish economy and a mobile telecommunications industry has evolved. It comprises a broad spectrum of firms varying from network operators, system manufacturers and suppliers of different sub-technologies to service firms.

The market for mobile telephony can be divided into three sub-markets: two concern retailing with the retailing market for mobile telephones and other terminals, and the market for network operations. The third sub-market concerns the manufacturing of system, system components and mobile telephones.

During 1998, mobile telecommunication's annual turnover in Sweden was SKr 150 billion, the corresponding figure for 1982 was SKr 1.8 billion. A breakdown of the annual turnover of 1998 gives the following: network operators' turnover was SKr 16 billion and the sale of mobile telephones in Swedish trade was approximately SKr 3.1 billion. System and telephone suppliers' sales were SKr 132 billion, of which Ericsson was responsible for the lion's share. The following table illustrates the growth of mobile communication. It is interesting to observe that the turnover on the market for mobile telephones decreases despite the tremendous growth, since the price for mobile telephones have continuously fallen.

Year	Network operation	Mobile telephones	Systems
1981	212	33	785
1982	226	262	1423
1983	321	330	1558
1984	470	418	1956
1985	1537	635	2580
1986	2815	789	2813
1987	2441	732	3017
1988	2869	1 227	5012
1989	3637	1 866	8219
1990	4313	1 958	11774
1991	4883	1 842	12484
1992	4458	1 597	15178
1993	4744	1 962	26181
1994	5974	3 941	41416
1995	8525	4 291	56897
1996	9246	4 256	79955
1997	12211	3 739	113718
1998	16269	3 109	131725

Source: Annual reports 1981-98

Table 4 / **Annual turnover for the network and mobile telephone market, and system suppliers in Sweden 1981-98 in million SKr**

1.4 Projections

One of the first forecasts produced by Swedish Telecom in 1967 predicted that the number of subscribers, ten years after the introduction of a fully automated system, would come up to 40,000. [2] When Swedish Telecom introduced NMT in 1981, it calculated on having 40,000 subscribers in 1990, but the number turned out to be almost 500,000. Swedish Telecom was no more successful in forecasting the GSM development – in 1990 the company believed that by 1994 the number of subscribers would be 25,000, but the real figure was 423,000.

It is perhaps not so surprising that the forecasts totally misjudged the development, since they were based on an assumption of low but steady growth without features of dynamic market effects. The influence of competition and the effects of improved technology were not taken into consideration, nor was the impact of new distribution strategies, such as the introduction of subsidisation of the sale of mobile telephones, and the users' growing appetite for mobile communications anticipated.

The forecasts understandably guided the cautious development and expansion of the networks and were instrumental in fostering the misconception among the business community and politicians of mobile telephony being just a niche market.

The continuous underestimation of the demand for mobile telephony occasionally led to operators lagging behind the expansion and suppliers not coming up with the required number of systems and telephones.

1.5 Standards

Mobile telephone standards – among which are analogue AMPS, NMT, and TACS, and digital GSM, PDC and TDMA – involve mobile telephone systems, which are designed according to certain principles utilising certain frequency spectrums. Therefore it is not possible to use equipment with one specific standard together with equipment with another standard unless the mobile telephones are constructed to handle multiple standards, so called dual or multiple mode mobile telephones.

TDMA, earlier called D-AMPS, is the dominating digital standard in the US. TDMA is a digital development of the AMPS, which like GSM uses Time Division Multiple Access Technique. The digital standard PDC from Japan is also based on the TDMA technique. WCDMA is the foundation for the third generation of mobile telecommunications standard.

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[2] Televerket, Land mobil radiokommunikation. 1967 (Land mobile radio, report published by a work group for mobile telephony, Swedish Telecom, August 1967).

At the end of 1998, 132 million subscribers was connected to GSM networks in 132 countries, and 4.5 million to NMT networks in 40 countries. The total number of mobile telephone subscribers in the world was 304 million. The comparable figure for 1988 indicate that there were 0.7 million NMT users, which represented 18 per cent of the entire 3.9 million mobile telephone subscribers in the world.

1.6 The basis of mobile telecommunication

Telecommunications involve a transfer of information through light, or in 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 at different wavelengths.

Central to a mobile telephone system are the mobile telephone switches. They handle the communication over the mobile network and look after the transition to the fixed telephone network. The communication between mobile telephones – functioning as radio transmitters – and mobile telephone switches takes place via radio base stations. These can be found on high buildings, specially designed masts, or on other highly elevated locations, since the radio coverage then improves. The communication between radio base stations and switches takes place either through fixed connections, which may be a part of the public network, specially designed cables or via radio links. The number of accessible channels, which increases if the radio base stations are placed near to each other, determines the network's capacity. One important function is roaming; meaning that the system checks the whereabouts of the mobile telephones and facilitates the transfer of calls to the mobile telephone as well. Handover means that the system is able to connect a call from one radio base station to another while the call is taking place.

1.7 Legal requirements

Unlike other countries, Sweden only had a few formal regulations covering telecommunication services prior to the liberalisation of the market, as Swedish Telecom had a de facto monopoly and was assigned the right by the Swedish Parliament to issue instructions for the telecommunications area. The situation changed with the introduction of the new telecommunication act and the revised act on radio communication on July 1, 1993.

In the late 1970s, Swedish Telecom's monopoly over the public telecommunication network began to be called into question. However, the first

deregulation took place as early as in 1971 when the market for mobile telephones was opened by Swedish Telecom enabling mobile telephone suppliers to market their products to end-users. In 1980, the Swedish Parliament decided that Swedish Telecom should gradually open up the telecommunication market to competition, and that 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 year 1981 saw the arrival of competition in the network operator market on a national scale. However, the first private mobile telephone operator started as early as the mid 1960s.

When the National Post and Telecom Agency was established in July 1993, the exercise of authority was separated from the operational and commercial functions within telecommunications.

The Frequency Management at Swedish Telecom Radio was previously 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. However, neither the radio law nor the notification on radio transmitters included any instructions as to when the Frequency Management was to give out licenses; instead the allocation was dependent on frequency economic aspects declared by the Frequency Management. Swedish Telecom's supporting idea, when the company interpreted the concept frequency economy, was to reduce the number of operators providing the same kind of service. Any appeal against the Frequency Management's decision was first directed to the General Director of Swedish Telecom, and secondly and finally to the government.

Swedish Telecom played a dual role, being itself an extensive user and at the same time being responsible for the allocation of frequencies. This dual role came under criticism, particularly from the new participants in the telecommunications market. The European Commission's green book from 1987 supported the new companies' criticism of the old statute. The green book declared that the allocation of frequencies within the European Union as from July 1, 1991 should be managed 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 was later incorporated in the National Post & Telecom Agency.

The National Post & Telecom Agency is now responsible for the Swedish telecommunications system and for the allocation of frequencies. A revised Telecommunication Act was introduced on July 1 1997, adjusted to the increased competition and the development within the European Union.

3. Methodological framework

"In the social sciences, we are but rarely in a position to speak of clear-cut causes and effects. Instead we mostly have interaction between the elements of the social system."

Schumpeter (1946, p 410)

3.1 The case study methodology

In this chapter, I present the research approach I use and discuss some methodological issues. This study is based on the case study methodology, with emphasis on what is commonly referred to as qualitative research.

Before I elaborate on the case study methodology let me say a few words on the issue of qualitative versus quantitative research methods. Despite the fact that it is common to draw a demarcation line between quantitative and qualitative research, I see no point in treating them as mutually exclusive, because any research project could certainly benefit from using both approaches. This study comprises some quantitative elements, but the qualitative material clearly dominates. Qualitative methods are characterised by that data acquisition and analysis occur simultaneously and interplay to a large extent, as the researcher is part of the social context and strives to accomplish a comprehensive picture. Moreover, qualitative approaches are commonly interpreted as focused on processes, content and understanding. Qualitative methods are predominately inductive, which suits development of concepts, hypothesis and theories as opposed to the testing of existing theories (Merriam 1994, p 33). While quantitative methods imply that the researcher retrieves empirical and quantifiable data which is inserted into statistical form and analysed in a formalised way, the outcome being subsequently examined in relation to testable hypothesis.

What are the characteristics of the case study methodology? And why is it appropriate to use the case study methodology in a study like this?

No one generally accepted definition of the case study methodology exists. A number of scholars have made different propositions as to how the methodology should be interpreted, see for example Yin (1994), Merriam (1994) and Valdelin (1974). However, an idea of the main characteristics of the case study methodology can be gained from the following expressions: appropriate in the understanding of complex development processes, suits longitudinal studies, and is inductive in its character.

Among the scholars who have written about the case study methodology, Yin is perhaps the most renowned and his view on the issue has been widely spread. According to Yin, the case study approach should be seen as:

> *"An empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident."* (Yin 1994, p 13)

Significant for the case study methodology is that it consists of an in-depth empirical study of an inductive character, which facilitates a deeper understanding of development processes. The phenomenon is somehow embedded in a social context, as Yin emphasises, and so the case study researcher has to uncover structures and processes. The case study researcher is guided by questions such as: who, what, where, how, and why (Yin 1994, p 5). They relate to processes, why and how something has happened, and what has developed and why.

Merriam's (1994) view on case studies corresponds to Yin's and he characterises the case study methodology as:

1) heuristic, leading towards insight of the phenomenon under study,
2) particularistic, aimed at a specific situation or phenomenon,
3) descriptive, the description of the phenomenon studied is extensive and detailed, and
4) inductive, concepts and hypothesis are generated from the information that the researcher has access to.

Both authors emphasise that case studies should give insight, and argue that the researcher should embrace the specific, or what Merriam calls particularistic, instead of drawing from a large sample. It is therefore consistent that case studies are descriptive and inductive in their character.

Valdelin distinguishes between reconstructive case studies that study something that already has occurred and registered case studies that are based on ongoing processes. This case study is a reconstructive one as it unfolds a development extending over 50 years.

Yin (1994, p 4) classifies case studies as exploratory, descriptive and explanatory. This case study is descriptive as it unfolds a development over time. Moreover, I analyse the development through an analytical framework that makes it relevant to see it as an explanatory case. It could also be said to be an exploratory case as I aspire to generate concepts and interpretations with application beyond this particular case.

A decisive factor for the extensive use of the case study methodology is its advantage for historical studies, covering development over time. It is common to analyse events chronologically and case studies, according to Yin (1994, p 116), could even be considered to be a special form of time series analysis. This is supported by Easton (1995, p 385) who sees the case study method as an appropriate way of providing longitudinal data as it focuses on changes over time.

3.2 Outcome of case studies

The epistemological standpoint for singular case studies designates that the validity of the result is not automatically enhanced if the number of cases is increased, since one case study, given that it is accomplished in a professional manner, could give a highly interesting scientific result. It is also a matter of allocation of resources, as there is no point in undertaking a greater number of case studies with the same amount of resources, since it will just result in more breadth rather than depth in the analysis (Easton 1995, p 382).

The end result in a case study is based on the information that is collected and on the analysis that is carried out continuously (Merriam 1994, 137). Implicit in a case study analysis is an attempt to explain a phenomenon which, according to Yin (1994, p 110), "is to stipulate a set of causal links about it". Although it is far from unproblematic to carry out the descriptive part of a case study, Yin (1994, p 102) points to the great importance of strengthening the analysis side of the case study, as it is the least developed and at the same time the most difficult aspect in the practice of case studies.

Merriam (1994, p 140) underlines that several analytical and interpretation levels are feasible in a case study. The outcome of case studies is certainly of vital interest in estimating the theoretical value of the methodology, and how the researcher can go on from the findings in a specific case to make propositions of general interest. Yin (1994, p 10) stresses that case studies are generalisable to theoretical propositions rather than to populations or universes. Yin (1994, p 31) uses the concept *analytical generalisation*, by which he means that an established theory is used as a template to compare the empirical findings from a case study. It should be contrasted with the

positivist way of generalising results, which Yin refers to as *statistical generalisation*. The distinction between the two concepts is essential for the case study methodology. Merriam follows this line of thinking by stating that qualitative case studies are appropriate primarily to develop new theory rather than to test hypothesis. A similar view is expressed by Valdelin (1974) who states that the case study methodology is appropriate for generating hypothesis and theories. Valdelin emphasises that it is not possible to generalise the result from one investigation, but it is rather the hypothesis or theories generated from a study that could be generalised. In more general terms Brunsson (1981, p 106) stresses that the main purpose with research is to develop concepts, approaches, and to generate theories. The task for researchers, according to Brunsson, is not to offer perfects models of reality but rather concepts and constructs which could handle the reality.

3.3 The rationale for using case studies

The motive to initiate a case study, according to Merriam (1994, p 57), is often provided by a researcher's encounter with a praxis problem. It could also be that the researcher finds no other appropriate means of pursuing the research and therefore chooses this particular approach. It is also certainly influenced by the research question, research design, the research environment and research tradition. Within business administration, which is the field I work in, the case study approach is an established way to pursue research. This is why it is an attractive choice when conducting longitudinal studies. Moreover, the knowledge building and the exploration are essential factors in performing case study research. The desire to cover contextual conditions also contributes to the use of the case study methodology (Yin 1994, p 13). This is underpinned by Easton (1995, p 381) who refers to case studies as exploratory devices. Exploratory research and a variety of research methodologies may be needed as the case study researcher commonly seeks to understand processes that have not been studied previously. This is in line with this study, which is of an explorative character rather than hypothesis testing. Despite the fact that the case study methodology is a distinctive form of empirical inquiry, Yin (1994, p 9) points out that several research strands are sceptical towards this particular approach. However, it is the dominate research approach in studies on technological development processes, which is why I am confident that it is suitable for a study such as this.

Why is it appropriate to use the case study methodology to analyse the development of entrepreneurship? My intention is to study the emergence of the mobile telephone industry by examining the role of entrepreneurship

and obtain an understanding of the development over time. The use of the case study methodology enables me to give an account of the emergence of the Swedish mobile telephone industry in a longitudinal study, covering a development process stretching over 50 years. It corresponds to how Valdelin (1974) defines the case study as a form of empirical investigation, characterised by a thorough examination of few investigation objects from various aspects with several sorts of data covering long time periods. Cooper (1995) underpins that longitudinal studies seem particularly promising in giving us insight into founding variables. It is appropriate to characterise this study as being longitudinal as it is the development of the technological system that is the unit of analysis, which means that different companies, taken together, appear over time to form the development of the technological system.

The account in the subsequent case is extensive because I incorporate the entire mobile telephone system, with all its different sub-systems over a long time period. It could therefore be argued that this case has more width than depth. However, my ambition has been to grasp the complexity of the emergence of a technological system and concentrate on major innovations rather than to document every single detail in the development. It is in line with Merriam who emphasises that it is important to delimit the investigation and defines the case as a limited system. Schumpeter (1976) underscores that one has to study systems over time and not only at a given occasion, and that it is not sufficient to study a specific part of a system since it is a prerequisite to incorporate the entire system. Furthermore, Aldrich and Zimmer (1985) underscore that entrepreneurship is a process and must be viewed in dynamic terms rather than in cross-sectional snapshots, and entrepreneurship requires linkages or relations between key components of the process.

To sum up, given my interest in exploring how a technological system evolves over time and in investigating the role of entrepreneurship in the development, the case study methodology seems to be an appropriate method, as it allows my study to embrace an entire system rather than to a limited number of variables.

3.4 Sources and interviews

Fontana and Frey, (1994) consider interviews as one of the most acknowledged and efficient ways of obtaining an understanding of the activities of human beings. According to Merriam (1994), interviews are the dominating source in qualitative case studies. This is underpinned by Yin (1994, p 84)

who holds that interviews are one of the most important sources of information for case studies.

The case presented in this study is based on a large number of interviews with representatives from different companies and organisations (see reference list for interviews). The interviews have been semi-structured with prepared questions, where the respondents in some cases have had the questions sent to them in advance, and in other cases have been given them at the start of the interview. Most of the interviews were carried out by the author together with other researchers (Per Andersson and Staffan Hultén). This made it possible to vary questioning and helped in the taking of notes. We made a practice of taking notes throughout the interviews, immediately following which we worked with the proper interview minutes, compared them and thereafter revised a final version.

I met with some of the respondents on more than one occasion. I did not send the interview minutes to respondents for comments. However, a number of the respondents have read texts, articles, case studies, book chapters and reports that I have written and have commented on them.

Apart from the interviews, the underlying empirical material has been drawn from a very large number of written sources, such as public statistics, books, annual reports, newspaper articles, journals, trade journals, public inquiries, investigations, government Bills, and material from archives (see list in appendix). Official documents and annual reports for the various companies have been important sources. As I have searched extensively for relevant information about the development of mobile telephony in Sweden, I have been able to put these sources together to present a comprehensive picture of the development.

Criticism of sources

A research strand within history called "the source critical school" distinguishes between two categories of source material: documents being remnants and relational sources. Remnants comprise documents or other relics originating from the historical process studied. These objects are not used for what they say but are considered as the ultimate proof that an event has occurred. Relational sources are narratives and accounts giving the participants' observations and interpretations of an event. Relational sources are used by researchers to support statements in documents about the state of things (Jarrick and Söderberg, 1990). Moreover, historians put forward the following claims on sources: concurrence, independence, non-tendentious and realism. The demand for concurrence means that a

contemporary source is preferable to one from another time period. The request for independence means that the value of a source decreases if based on other sources as it becomes less independent. The claim for non-tendentiousness means that the researcher should avoid biased sources as they may give a misleading account; if they are used the tendency should be clearly indicated. The claim on realism means that an unreasonable or absurd statement should not be accepted (Jarrick and Söderberg, 1990).

The historical material I use in this study comprises of written as well as oral sources. I do not claim to have worked out a fully objective description of the course of events but I have striven to present the main features as accurately as possible according to the historical method and the material that I have had access to.

The idea of objectivity could be questioned, that facts of the world are essentially there for study. I rather subscribe to the notion that it is not feasible to present an objective picture of a historical development because what is taken to be objective knowledge and truth is the result of perspective, and that knowledge and truth are created and not discovered. This line of reasoning is based on constructivist thinking which emphasises the pluralistic and plastic character of reality (Schwandt 1949, p 125).

By drawing on a large number of different sources I have tried hard to make the historical account as unbiased as possible. Given the large number of interviews and the very great number of documents used in this study I have been forced to exclude a lot of material. A thorough examination of the material has facilitated the exclusion of tendentious material.

This is a retrospective study, which constructs or forms a model of the development. By comparing statements from several interviews and numbers of written sources, and thereby using them as relational sources, I have been able to base this study on solid ground. This is further emphasised by the fact that I have made more than one interview with several people and conducted this study over a long time period and worked with a extensive source material.

I treat the empirical description in the subsequent three phases as inputs to the analysis where I use the classification framework to identify entrepreneurs and entrepreneurial activities. The framework functions as a device to sort the material instead of acting as a guide to which empirical material is included in the empirical presentation.

3.5 The research process

At an early stage in the research project I met a number of individuals who had been involved in the development of mobile telephony in Sweden. I

became curious to find out what had enabled this development and what forces were involved in bringing about a Swedish mobile telephone industry. My attention was also drawn to the role of relationships between different organisations and companies within the mobile telephone industry.

The research process, which has been stretched out over time, has not been a linear one. It has rather resembled how Merriam (1994) characterises the qualitative approach as developing over time, and that ideas, working hypothesis and intelligent guesses guide the researcher in focusing on some issues of information that are then used to revise or verify the assumptions that are made. The direction of this study evolved after the author had written a number of case studies for teaching purposes about the development of the Swedish mobile telephone market. Concurrently, I observed that the trend in research was developing towards structural explanations playing down processes and thereby substantially limiting the action space for individuals. This provoked my interest for analysing the dynamics between individual and collective action, and testing the appropriateness of entrepreneurship theory. The research question emerged from 1992 and was a result of the initial work that gave me a preunderstanding of the mobile telephone system.

It is a reconstructive and longitudinal study but as I have followed the mobile telecommunication industry closely during the 1990s when I have been working on the research project and it covers the development up until 1998 it has some special features. The majority of the interviews have been conducted during the first part of the 1990s laying the foundation for this study, and I have met with some of these persons at several occasions. I have been involved in the mobile industry itself and followed the development within this industry closely. This means that I have been able to accumulate extensive knowledge about the Swedish mobile telephone industry, which has been an advantage in undertaking this study.

4. Theoretical framework

4.1 Introduction

This chapter presents the theoretical framework I use in this study. It consists of three parts: theories related to systems, innovation and entrepreneurship. By elaborating on different theories within these areas I am able to work out an analytical tool that is used to analyse the subsequent case study covering the development of mobile telephony in Sweden.

This study covers technical and economic change addressing the role of entrepreneurship in the development of a technological system. The point of departure for this study – which could be expressed as a postulate – is that entrepreneurship plays a key role for technical and economic development. This statement is based on solid scientific ground since it is the theoretical foundation of Schumpeter and Kirzner etc., which means that I do not question whether entrepreneurship is a vehicle for economic and technical development. It is taken for granted. Nevertheless, it is an open question what form entrepreneurship takes. As the subsequent theoretical discussion shows there exist a number of different propositions on how entrepreneurship could be interpreted. It basically concerns the agency of entrepreneurship and what action constitutes entrepreneurship. I take advantage of the wide scope of theoretical notions of entrepreneurship by formulating three sources of entrepreneurship. I thereby partly handle the problematic entrepreneurship concept. However, it does not state what constitutes entrepreneurship, which makes it relevant to address questions on theories of innovations. As this study primarily concerns technological and economic development in a factual development it is appropriate to give Schumpeter's notion of new combination a central role. The aim is to search for innovations that have made a difference in the development and thereby contributed to the advancements of the technological system. In order to get an understanding of innovations I examine various innovation

theories, discuss the impact of innovations, innovation strategies, continuous innovation, and co-evolution.

The ambition with this study is to understand and describe development processes in a context which makes it relevant to introduce the idea of systems. The idea of system is pervasive in social sciences and explicitly states that it constitutes a whole and that it has a boundary. Here it is labelled a technological system, similar to an industry, but it comprises other elements and institutional factors as well.

A conclusive argument for including users in the analysis is that the role of users in the development of a technological system is that it makes it feasible to complete the system, and incorporate the demand side into the analysis. Moreover, the liberalisation of the telecommunications market means that market forces, in the form of users, should be playing a more central role for the direction of the development. By incorporating users into the framework I can analyse the interplay between technology and market. This can contribute to a better understanding of the dynamism behind the technological development.

By integrating three sources of entrepreneurship with innovation theories and the notion of technological system I am able to capture the dynamics in the development of a technological system. I regard entrepreneurship as the vehicle for change by moving the technological system forward through the introduction of innovations. The technological system is the unit of analysis, which places entrepreneurship into a context. I argue for the necessity of combining individually and collectively oriented notions of entrepreneurship in order to capture the development of a technological system such as mobile telephony. The point here is that changes are endogenously created and that the development is somehow co-ordinated through a governance structure.

These streams of theories, taken together, could be integrated into an approach to analyse the development of a technological system. This makes it relevant to embark on a theoretical survey, divided into three sections: systems, innovations and entrepreneurship, culminating in the presentation of an analytical tool.

4.2 Technological system

Since I set out to analyse the mobile telephone system in Sweden I am interested not only in how the various company and organisations have developed but also how the entire system has evolved. A decisive argument in regarding mobile telephony as a system is its systemic character, and because the different parts are highly dependent upon each other. As I am

particularly studying Sweden it is relevant to raise questions related to geographical aspects, and the national economy for which telecommunications unquestionable plays a vital role.

> *"Telecommunications networks like motorways in the fifties, electricity in the beginning of the century, railways in the nineteenth century, canals in the mid eighteenth century are becoming the basic infrastructure of the modern economic system. The universality, quality, reliability, efficiency and cost conditions of supply of telecommunications services are becoming a structural precondition for economic systems to grow into the information economy."* (Antonelli 1992, p 6)

The system concept

The idea of regarding a business area, an industry, as a system and technologies as interconnected into systems is far from new. The term system refers to complexes of elements or components which mutually condition and constrain one another, so that the whole complex works together, with some reasonably clearly defined overall function. This line of thinking is based on system theory, initiated in the late 1940s with Shannon and Weaver's seminal book "A mathematical theory of communication", whose aim was to understand everything from animals, groups, organisations, and society by regarding them as systems.

System thinking applied to practical problems is referred to as a systems approach. This approach recognises that organisations, factories, highways are made up of components having unique properties, capabilities and mutual relationships (Churchman, 1968). A central concept in system theory is boundary, that systems have an inside and an outside, and that the system has to establish some kind of relationship with the environment. The concept of system originating in cybernetics has had a wide influence on social sciences and will be widely used in this study.

Development block

Dahmén (1950) introduced the notion of the development block, which refers to "a sequence of complementarities which by way of a series of structural tensions, i.e., disequilibria, may result in a balanced situation" (Dahmén 1989, p 111). The unbalanced situation could be reflected in price and cost signals in markets, which are noted by firms and may give rise to new techniques and new products. Incomplete development blocks generate both difficulties and opportunities for firms (Dahmén 1989, p 109). Entre-

preneurial activities eliminate structural tensions and promote development blocks (Dahmén 1989, p 112).

Innovations, as well as creating new business opportunities, could be the beginning of a development block. When a technical problem which has prevented further development in one sector is solved, new possibilities are created in other sectors. Dahmén (1991b, p 131) stresses that innovations often initiate changes and chain reactions outside areas where they originally appear, since new technology, techniques and new materials often find applications that the developers never anticipated from the beginning.

New development blocks were created around a widening of electrification, the diffusion of automobiles. Mobile telephony, with all its subdivisions, could be considered as one of Sweden's most important development blocks as been acknowledge by many authors (Eliasson 1995, Granstrand 1993, Hultén and Mölleryd 1992, 1995).

Structural tensions is a central concept in Dahmén's approach, by which he refers to the fact that depressive pressure in stages is premature as long as the complementary ones are missing, and that the development potential will be released as soon as the missing stages have come into place or are expected to do so before too long (Dahmén 1989, p 111).

Two notions of technological system

In the following I present two notions of technological systems which is a way of comprising an industry into one context. The first one emphasises some kind of generic knowledge that could be utilised or applied into different industries. The other one is more close to combining technical aspects even though social factors are incorporated. I suggest that they could be considered as complementary to each other.

The first notion of technological system was developed by Carlsson and Stankiewicz and was elaborated from the development block concept. Carlsson and Stankiewicz define a technological system as:

> *"a network of agents interacting in a specific economic/industrial area under a particular institutional infrastructure or set of infrastructures and involved in the generation, diffusion and utilisation of technology"*
>
> *(Carlsson and Stankiewicz 1991, p 111).*

There are three central components for this definition: economic competence, clusters/networks and institutions (Carlsson and Jacobsson 1997, p 266). This approach emphasises knowledge or competence flows and networks, and new technological systems emerge since new networks

are created. Carlsson and Stankiewicz (1991, p 111) state that entrepreneurs and critical mass can turn these knowledge and competence networks into development blocks. Based on this idea of technological system, the reciprocal flow of information in a technological system may well result in a blending of visions and technological expectations of the future among various actors. The sharing of vision may then lead to a reduction of perceived risk and a quasi co-ordination of investments between formally independent actors (Carlsson and Jacobsson 1997, p 270). The primary interest is on competence flow and the know-how to perform different general techniques rather than to study specific industries. In other words, focus is on general purpose areas which have a significant impact on the economy rather than on the regular flow of products and services.

Thomas Hughes has a slightly different view on technological system. He emphasises large physical and technical systems, although Hughes stresses the significance of social components and organisations in the system. Hughes' perspective is based on system approach, and the system's boundaries are arbitrarily chosen to suit the analysis. According to Hughes (1987, p 51) technological systems contain messy, complex, problem-solving components, and they are both socially constructed and society shaping. The idea of social construction implies that concepts and perceptions of technology are shaped by social forces rather than technical or scientific propositions. Hughes' technological system consists of a large number of different sub-systems.

The components of technological systems, according to Hughes (1987, p 52), are socially constructed artefacts invented and developed by system builders and their associates. System builders or entrepreneurs have the ability to construct or to force unity from diversity, centralisation in the face of pluralism, and coherence from chaos. They could be described as heterogeneous engineers (Hughes 1987).

Hughes (1987) emphasises that the role for people in technological systems, besides inventing, designing, and developing systems, is to complete the feedback loop between system performance and system goal and in so doing correct error in system performance. Since components of a technological system interact, their characteristics derive from the system. For example management in a technological system often chooses technical components, which Hughes (1987) refers to as physical components (artefacts) in a technological system, that support the structure, or organisational form of management. Over time technological systems strive to gradually incorporate more and more of the environment into the system as it is a way of eliminating sources of uncertainty.

As technological systems expand and grow reverse salients develop.[3]

3 A salient is a protrusion in a geometric figure.

Reverse salients are components in the system that have fallen behind or are out of phase with the others (Hughes 1987). Hughes underscores that when a reverse salient cannot be corrected within an existing system, the problem becomes a radical one, the solution to which may bring a new and competing system. Hughes emphasises that as systems mature, they acquire style and momentum.

Hughes (1994) is critical towards technological determinism in its belief that technical forces determine social and cultural changes, and towards social construction in its presumptions that social and cultural forces determine technical change. Instead Hughes prefers the concept of technological momentum as it infers that social development shapes and is shaped by technology, and thereby "avoids the extremism of both technological determinism and social construction by presenting a more complex, flexible, time-dependent and pervasive explanation of technological change" (Hughes 1994, p 104).

Proponents of technological determinism and of social construction often use technology in a narrow sense, according to Hughes (1994, p 102), and only include physical artefacts and software. Hughes (1994, p 105) uses the term technical to refer to physical artefacts and software, and by technology he refers to technological or sociotechnical systems, where the latter do not have a technical core (hardware and software). The point is that social and technical factors interact within technological systems.

Technological systems, according to Hughes (1987), do not become autonomous even after continuous growth and consolidation because they acquire style and momentum. With technological momentum Hughes (1994, p 108) refers to the fact that acquired skill and knowledge, special purpose machines and processes, constitute enormous physical structures and organisational bureaucracy. Hughes (1994, p 112) underscores that a technological system can be both a cause and an effect; it can shape or be shaped by society. As they grow larger and more complex, systems tend to be more shaping of society and less shaped by it.

Interaction and network approaches

Industrial marketing research noticed early on that interaction over time between buyers and sellers is an important characteristic of industrial markets. It was also discovered and emphasised that interaction with customers/-users within commercial exchange relationships played an important role in technological development. See e.g. Håkansson (1982) and for a survey of the early development of the interaction and network approaches, Johanson and Mattsson (1994). In the industrial network approach the dynamic role for technology development of interaction within networks of actors interconnected over time is stressed (e.g. Håkansson, 1987).

A central assumption in the network approach or "market-as-network" in marketing is that innovation takes place between producers and suppliers, as well as between producers and users. This could be, for example, in the form of mutual adaptations between suppliers and customers (Håkansson and Snehota 1995, p 60). Relationships affect innovation processes and the use of resources. For example, new uses for resources are developed as a result of interaction between producers and customers (Håkansson and Snehota 1995, p 137).

Ford (1998, p 227) thinks along similar lines and stresses that managers should use relationships to gain access to the resources of their customers and suppliers, and that they should come together and develop new products. The basic idea is that development takes place between companies in business relationships (Ford 1998, et al p 229). Moreover, Ford (1998, et al p 244) emphasises the importance of the interaction between suppliers and customers in the technological development.

The significance of users

With users I refer to people or agents who actually utilise the technology. von Hippel (1988) emphasises that it is necessary to replace the notion that innovative activities are only carried out by manufacturers. A broader range of sources of innovations should be considered such as users, customers, distributors, and suppliers. von Hippel uses the concept *lead users*, which means those users who

> *"face needs that will be general in a marketplace, but they face them months or years before the bulk of that marketplace encounters them. Lead users are positioned to benefit significantly by obtaining a solution to those needs."* (von Hippel 1988)

In analysis of technological systems, focus is predominately on the supply side which makes it is compelling to incorporate the users into the analysis. Among the researchers interested in issues related to the meaning of technology and how it is interpretated W. Bijker is prominent.

Technology has at least three different layers of meaning for Bijker (1995a, p 231): physical artefacts, human activities and knowledge. This implies that technology not only apply to hardware technology but also to social technology. Sociotechnical ensembles is the term Bijker (1995a, p 242) uses, and he analyses technology and society as an intimately interconnected, heterogeneous ensemble of technical, social, political and economic elements. Bijker (1995b, p 326) prefers to use the word ensemble

instead of system because it conveys the unstructured character of the relation between technology and society. Bijker (1995b, p 269) argues for the necessity to analyse technical change as a social process, and use analytical concepts such as relevant social groups, interpretative flexibility, closure and stabilisation.

Bijker (1995b, p 273) describes the activities of engineers and inventors as heterogeneous system or network building. However, Bijker emphasises that it is not only engineers but also all relevant social groups who contribute to the social construction of technology, all stable ensembles are bound together by intimate social and technical links.

Bijker (1995b) eloquently sets out the social construction process on how the interpretation of a particular technology changes over time. Depending upon how the technology is interpreted different user groups can consider using it. The same approach could be used to characterise the advancement of the usage of mobile telephony, and how the definition of mobile telephony has been continuously reformulated. It could even be appropriate to refer to it as entrepreneurial users, those who stretch the boundaries of how the technology is used and thereby extend the market.

User-producer approach

Lundvall (1992a), who emphasises knowledge and learning, underscores the significance of the interaction between users and producers. This is in line with von Hippel's (1988) notion of lead users. Lundvall stresses that the interaction between the supply and demand side contributes to the development and innovative activity. To facilitate a productive interaction between producers and users it requires that users are competent, and that there is a balance between the two sides. In case the producers have access to superior financial resources and technical competence, according to Lundvall (1992c, p 54) it is likely that producers develop innovations that are too costly and not particularly well suited for the needs of users.

Lundvall (1988, p 365) states that the end users, such as workers, consumers and the public sector to have an important role to play in the innovation process. According to Lundvall, competent users could enhance the innovative capability of a National System of Innovation. Lundvall labels this as the user-producer approach. The user-producer approach, according to Lundvall (1988, p 367), could be useful in clarifying how the different stages in the chain of innovation relate to each other in various parts of the economy. A vital part of innovation process is interactivity (Lundvall 1988, p 349).

An innovation that has been developed and introduced will only diffuse if information about its characteristics is transmitted to potential users. For

organisations and firms this is a question that could be solved through interaction and information exchange (Lundvall 1988, p 350). To succeed with the development and marketing of complex and specialised equipment it is necessary to cooperate with users during the process of innovation (Lundvall 1988, p 353). Lundvall (1988, p 356) stresses that the "innovativeness and the competence of users and producers are important qualities which might stimulate the other party". Very competent and demanding users have provoked radical innovations in areas where the volume of expenditure has been minuscule. This is supported by Dosi who underlines that a significant amount of innovations and improvements are originated through "learning-by-doing" and "learning-by-using" (Dosi 1988, p 223).

To sum up on systems

I have presented theories on systems and particularly technological systems, development blocks and the role of users in technological development. The technological system is a concept central to this study as it enables me to incorporate the various participants into a context, and analyse the inter-dependence between the different participants. I also capture the development of products and services in the mobile telephone system. However, knowledge flows simultaneously between the participants in the technological system. I would like to stress that users play a decisive role in the development of technological systems. There are numerous users in this industry, because receivers of products or services are users. It could for example be network operators that use products that system suppliers produce. However, these products are often produced in collaboration with operators if they have the ability to formulate relevant requirements for the products. Moreover, the end-users, the ones who actually use mobile telephones are certainly highly interesting because, depending upon how they utilise the technology, it gives the rate of diffusion and determines how mobile telephones are apprehended. This is an important part of the development, which makes it relevant to discuss innovation theories.

4.3 Innovations

What is innovation

Innovation means to successfully bring something to economic life, and implies the creation of new phenomena or execution of existing phenomena in a new way. Before I present a categorisation of innovations let me introduce some different views on innovation. I start with Schumpeter's

(1955) notion of new combinations covering five different areas which have had a significant impact on the understanding of innovations. The innovations are of five different types, namely

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 any industry, and
5) the opening of a new market.

Dosi (1988, p 222) defines innovation as "the search for, and the discovery, experimentation, development, imitation and adoption of new products, new production processes and new organisational set-ups", and it involves some sort of perception of yet unexploited, technical and economic opportunities.

According to Lundvall (1992b, p 18) the application of new knowledge into the economy could be seen as innovation. McKelvey (1997, p 201) regards innovations as knowledge-seeking activities that aim to develop novelty of economic value. Lundvall (1992a, p 8) states that all innovations reflect existing knowledge, although combined in new ways. This means that innovations could make the current stock of knowledge obsolete, taking on a new development path. Innovations are by no means restricted to technical innovations because Lundvall (1988, p 366) emphasises the significance of social innovations. This leads to the fact that complex and systemic innovation calls for extensive interactive learning processes. Nelson and Rosenberg (1993, p 4) define innovation as the process by which firms master and put into practice product design and manufacturing processes that are new to them. This implies that it concerns a lot more than doing research and development.

Moreover, innovations are also complex phenomena, Van de Ven (1995) stressing that:

> *"... a long sequence of events must take place for an innovation to occur, a complex network of competing and co-operative relationships have to exist for innovating enterprises to flourish."*

Four categories of innovations

The important role played by innovations for the new economic theory was manifested in the seminal book "Technical Change and Economic Theory", published in 1988, to which Christopher Freeman makes a significant contribution. In this book Freeman and Perez (1988, p 46-47) present an

excellent definition of innovations where they distinguish between four categories of innovations:

1) Incremental innovations occur more or less continuously in any industry or service activity although at various rates in different industries and countries. It depends upon a combination of demand pressures, socio-cultural factors, technological opportunities and trajectories.

2) Radical innovations appear discontinuously and are usually the result of deliberate research and development activities in enterprises and/or university and government laboratories. Radical innovations often involve a combined product, process and organisational innovation.

3) New technology systems, represent far-reaching changes in technology, affecting several branches of the economy, as well as giving rise to entirely new sectors. New technology systems are based on a combination of radical and incremental innovations, together with organisational and managerial innovations affecting more than one or a few firms.

4) Changes in techno-economic paradigm. Some changes in technology systems cause such far-reaching effects that they influence the functioning of the entire economy.

Similar classification schemes could be found among other scholars who have written about innovation. The difference is naturally in choice of words, but the meaning is about the same.

To begin with, the first two categories concern small, every-day changes, what Freeman and Perez refer to as incremental changes, and big or radical changes. They make no differentiation between technical and market related innovations, because it could be any of them. Hughes (1987) distinguishes between retention and fundamental innovations, the latter leading to the creation of new technological systems, while the former means that existing systems are improved or extended. Dahmén (1991b, p 130) makes a similar distinction and underlines that despite the fact that innovations are commonly related to spectacular technological and technical advances they have to be broadened to include the multitude of small day-to-day improvements. McKelvey (1994, p 221) underscores that incremental technical changes occur regularly in a market economy, whereas radical changes appear

occasionally and affect many other technologies and industries. Changes tend to be cumulative, even incremental and go in certain directions according to McKelvey (1994, p 20), but occasionally dramatic changes take place, leading to a discontinuous development. Utterback (1994, p 189) states that technological competition predominately concerns incremental improvements, leading to the fact that firms that are able to move slightly faster than their competitors and able to serve customer demands better than their competitors achieve a competitive advantage.

Moreover, Utterback (1994, p 26) underscores the significance of dominant design, which he sees as a result of the interplay between technical and market choices, and that it has a strong influence on technological innovations that take place within the same industry. Utterback (1994, p 217) stresses that incremental innovation is of significant economic and competitive importance. Utterback (1994, p 80) criticises the linear model of innovation as innovations do not occur in the same way in all companies. Product innovation and process innovation are interdependent, and when the rate of product innovation decreases the rate of process innovation starts to grow (Utterback 1994, p 83). Teece (1988, p 268) indicates the extent of dependence between the innovation and the surrounding system by distinguishing between stand-alone innovations, which can be introduced without any changes of equipment or parts and systemic innovations, which require considerable adjustment to other parts of the system. In cases with technological interdependencies it is likely that the commercialisation of an innovation will require investments in several different parts of the system or industry (Teece 1988, p 269).

For the third category, Hughes (1987) underscores that when a reverse salient cannot be corrected within an existing technological system, the problem becomes a radical one, to which the solution may bring a new and competing system.

With the fourth category, based on the idea of long wave theory, Freeman (1992b, p 196) refers to technological revolutions which occurs when several new technology systems have such pervasive effects on the economy as a whole that they change the style of production and management throughout the economy. Dosi (1988, p 224) uses a slightly more narrow concept which he calls technological paradigms, seen as a pattern for solution of selected techno-economic problems based on highly selected principles derived from the natural sciences, which define the technological opportunities for innovations and the procedures on how to exploit them.

Science and innovations

Even though advanced technical innovation is often interpreted as causing dramatic changes, Lundvall (1992a, p 12) underpins that a discovery may be technically advanced but have a limited economic effect if it is never utilised for products or production of marketable goods or services. Conversely, a limited technical change could have an immense economic force, for example by drastically reducing production costs or by making a previously specialised product accessible to a larger market. A similar idea is presented by Nelson and Rosenberg (1993, p 8) who underscore that successful innovation in high technology industries is rather a question of design of product characteristics than a matter of invention.

Although grand innovations are played down, Nelson (1994b, p 235) emphasises that firms must innovate to stay competitive. Firms active in industries where technological innovation is important have to be equipped with a set of core capabilities in R&D, such as skills, experience, and knowledge of the personnel in the R&D department. It is commonly accepted that innovating agents tend to innovate close to what they already do and know. Agents' abilities to search for and identify opportunities will largely depend upon their perceptions of opportunities, their competencies, and their information relationships with others. Innovating agents' ability to generate novelty is partly dependent on technical and economic competencies and knowledge and partly on their interoperation of environmental conditions. Moreover, the production, procurement, marketing, and legal departments in organisations must have the capabilities to support and complement new product and process technologies based on R&D (Nelson 1994b, p 235). Firms have to choose innovation strategy to handle the increasing pressure to stay competitive. Nelson and Winter (1982, p 294) distinguish between two different innovation strategies: *science-based industry* and *cumulative technology*. In the first case a firm's innovation strategy is based on general development, while in the latter case the firm is building on progress that the firm has made by itself.

4.4 National System of Innovation

The starting point for the National System of Innovation (NSI), which is a framework to analyse the development of innovative activity in a nation, is that knowledge is the fundamental resource in the economy and learning is the pivotal process (Lundvall 1992a, p 1). Knowledge is defined very broadly and in principal comprises everything that concerns how to pursue conscious human action that could be codified. Moreover Lundvall underlines the significance of knowledge that is inside people's head and there-

fore not possible to codify, which commonly referred to as tacit knowledge. According to Lundvall a National System of Innovation:

> *"is constituted by elements and relationships which interact in the production, diffusion and use of new and economically useful knowledge and that a national system encompasses elements and relationships, either located within or rooted inside the borders of a nation state" (Lundvall 1992a, p 2).*

A similar idea is presented by McKelvey (1994, p 224) who states that "retention and transmission of knowledge, techniques and behavior within the population of individuals doing innovative activities are necessary to carry out technological innovation". The evolution of knowledge is to a large extent cumulative and develops along certain trajectories (Lundvall 1992b). However, the cumulativeness and path-dependency of innovation increase the risks for lock-in into technological and institutional cul-de-sacs.

National System of Innovation is based on the system approach and Lundvall (1992a, p 2) states that "a system is constituted by a number of elements and by the relationships between these elements". Lundvall underlines that the National System of Innovation is a dynamic social system as it comprises positive feedback and reproduction.

With knowledge, and its intangible characteristics, placed in the center of the theory the National System of Innovation is well positioned in what is referred to as the network or knowledge economy.

National System of Innovation regards innovation as a process and a ubiquitous phenomenon. Lundvall (1992a, p 4) underscores that National System of Innovation is open and heterogeneous, implying that processes of innovation could be local as well as national or even international. McKelvey (1997, p 201) sees National System of Innovation as a network embracing individual and collective processes of searching, learning and selection among different innovation opportunities, including technical and economic dimensions.

Lundvall (1994, p 5) proposes that the National System of Innovation could either be given a narrow or a broad definition. The narrow National System of Innovation focuses on how R&D-departments of firms interact with universities and technological institutes, while the broad National System of Innovation includes all parts and aspects of the economic structure and the institutional set-up affecting learning as well as searching and exploring. Freeman (1992a, p 181) suggests that the narrow National System of Innovation could be seen as a network comprising exchange relationships between different actors.

The National System of Innovation is based on the old Schumpeter's notion of innovation and entrepreneurship, which is discussed in the section about entrepreneurship, as being a result of work carried out in R&D laboratories. It is therefore logical that National System of Innovation plays down individual firms and regards innovation and entrepreneurship as a collective and continuous process. The firm level, according to McKelvey (1997, p 204), is too narrow to explain the interorganisational nature of innovation. Notwithstanding, firms are included in the analysis because they contain both collective and individual aspects, and they carry out a coordinative role in the search and learning activities in innovation (McKelvey 1997, p 205). Moreover, Lundvall (1992a, p 9) underpins that National System of Innovation does not only concern R&D and technical activities, since learning takes place in connection with routine activities in production, distribution and consumption.

National System of Innovation states that innovation reflects learning and that learning is based on routine activities, which is the reason why innovation has to be based in the current economic structure. This endogenously created change means that technical and economical development will take place in areas where a firm or a national economy is already involved. However, Lundvall (1992a, p 11) emphasises that economic agents and organisations also invest time and resources in expanding their knowledge by searching and exploring, enabling them to create new input to the National System of Innovation.

Innovation is uncertain and disruptive in character and the economic impact of innovation is highly unpredictable. The National System of Innovation approach is neither accidental nor deterministic, because the economic structure and the institutional set-up do not totally dictate the direction of the process of innovation on account of the fact that "a strong element of randomness will always remain" (Lundvall 1992a, p 12). Even though cumulativeness and path-dependence characterise innovations, National System of Innovation emphasises that radical technological innovations are rarely foreseen, neither as pure technical breakthroughs nor as economic innovations with a great economic impact.

The rationale for pursuing analysis with the National Systems of Innovation approach, according to Lundvall (1992a p 12, 1992c, p 45), is to understand and explain why technology develops in a certain direction and at a certain rate, and that markets are organised differently in various national systems and that participants are influenced by the different institutional set-ups. Furthermore, national characteristics play a significant role for the capacity to produce, acquire, adopt and use technology (Dalum, Johnson, and Lundvall 1992, p 296).

National differences

Historically, according to Freeman (1995, p 19), there have been major differences between how countries have organised and sustained the development, introduction, improvement and diffusion of new products and processes. This makes nation states, national economies and National Systems of Innovation equally essential domains of economic and political analysis.

Freeman (1992a, p 174) underscores the importance of taking the changing institutional climate into consideration in accomplishing a complete account of socio-economic development. It makes it feasible for innovative entrepreneurs to recruit certain types of professional managers and engineers and to combine their contributions in novel ways and thereby contribute to successful innovative enterprises. The systemic changes in technology and the changes in techno-economic paradigm, according to Freeman (1992a, p 183), tend to provoke correspondingly significant changes in institutions.

The idea of nation states playing a key role in innovation is presented, as stated, by Nelson and Rosenberg:

> *"There clearly is a new spirit of what might be called "technonationalism" in the air, combining a strong belief that the technological capabilities of a nation's firms are a key source of their competitive prowess, with a belief that these capabilities are in a sense national, and can be built by national action"* *(Nelson and Rosenberg 1993, p 3).*

National and regional systems of innovation, according to Freeman (1995, p 5), remain an essential domain of economic analysis, as the networks of relationships are necessary for any firm to innovate. Freeman (1995, p 15) presents an decisive argument for using the National System of Innovation approach as "local and national variations in circumstances may often lead to different paths of development and to increased diversity rather than to standardisation and convergence". Moreover, Freeman (1995, p 17) claims that radical innovations are immensely influenced by institutional variety and localised learning. Nelson and Rosenberg (1993, p 17) state that technological communities have become transnational at the same time that the idea of national innovation systems have been accepted. It is therefore not surprising that Nelson (1993, p 517) sees a number of difficulties with the concept of a national innovation system

Effect of localisation

The idea of using the nation state as the unit of analysis makes it feasible to analyse economic activity aggregated above the firm level. Geographical

limitations do not have to be equal with national boarders because it could be regions, for example, and there is an extensive literature regarding regional clusters. Regional clusters are referred to as a group of firms active in the same industry, or in closely related industries that are in close geographic proximity to each other (Enright 1998, p 315). The idea of regional clusters is far from new, because it goes at least back to Marshall.

> *"An industry concentrated in certain localities is commonly, though perhaps not quite accurately, described as a localized industry."*
> *(Marshall 1890, p 222)*

The localisation has subsequently played a decisive role for the organisation of the economy. Marshall regards physical conditions such as the climate, the soil, easy access to mines and quarries among the various causes that have led to the localisation of industries.

> *"This elementary localization of industry gradually prepared the way for many of the modern developments of division of labor in the mechanical arts and in the task of business management"*
> *Marshall (1890, p 223)*

Marshall (1890, p 225) emphasises that "a localized industry gains a great advantage from the fact that it offers a constant market for skill". "Every cheapening of the means of communication, every new facility for the free interchange of ideas between distant places alters the action of the forces which tend to localize industries" (Marshall 1890, p 227).

The significance of the localisation for economic development has recently been discussed to explain the success of Silicon Valley versus the decline of Route 128 on the East Coast of the US where the first generation computer industry was based. As Marshall points out, this is an example of regional agglomeration of firms active within an industry. The proximity and market for skills and frequent communication plays a decisive role for the development. In explaining the success of Silicon Valley Saxenian states that:

> *"In an age of volatile technologies and markets, however, the horizontal coordination provided by interfirm networks enable firms to retain the focus and flexibility needed for continuous innovation."* *(Saxenian 1994, p 162)*

Saxenian (1994, p 162) emphasises the importance of interdependence between firms and that managers and policy makers have to realise that it is

not sufficient to regard firms as separate and self-sufficient entities, because innovation is a collective process as well as an individual one.

When discussing innovations and regional aspects and high tech industry it is also relevant to address the question concerning the relative size of firms. Acs and Audretsch (1990) emphasise that

> *"Large firms tend to have the relative innovative advantage in industries which are capital-intensive, concentrated, highly unionized, and produce a differentiated good"*

But in the same time Acs and Audretsch underscore that small firms tend to have a relative advantage in industries that are highly innovative. In high tech industry like mobile telephony smaller entrepreneurial firms have the potential to take advantage of the current development by fast adjustment, provided they have the capability to adjust to continuous changes.

Co-evolution

Even though I have not explicitly discussed the linear model of innovation, basically stating that development goes from invention – innovation – to diffusion in strict sequential order, it is questioned by a growing number of authors. This calls for new ways of regarding innovation, and one idea that has caught a growing interest is the idea around co-evolution.

One author who has placed the notion of co-evolution in the center of the analysis is McKelvey (1994). She see the evolution of the economy as based on innovations that are the outcome of social processes contributed by many individuals and organisations. McKelvey apprehends technological innovation as a co-evolutionary process where innovative activities are simultaneously pursued within different environments, such as the public, the basic scientific and the economic. Agents pursuing innovative activities in different environments interact, and thereby stimulate and mutually shape each other's frames of references and the innovative activity (McKelvey 1994, p 6).

Moreover, Nelson (1994b, p 240) finds the co-evolution of technology and institutions as a fascinating subject, and underscores that it certainly influences the competitiveness of nations. Dosi (1988, p 234) states that innovative opportunities and economic exploitation coevolve in ways that are at least partly endogenous to the process of discovery, development and production. Nelson (1994a, p 133) emphasises that technology, industrial organisation and institutions coevolve in directions that lead to sustained economic development.

Hultén (1999) takes a slightly different view on co-evolution by emphasising the externalities that are produced by technologies and institutions, as they have a bearing on the evolution of more than one industry. The point is that the development path of an industry or a technology is influenced by the development taking place elsewhere in the economy. This means that changes which seem to be independent to a particular technology may affect its development. Hultén (1999) states that "co-evolution of industries is about dynamic externalities that interlock industries in an evolutionary process of entities that mutually adapt." This means that the technological development within a certain area is interdependent with economic, technical and political developments generated by other technologies.

Summing up on innovations

By introducing innovation theories I come one step further in understanding that economic development, as innovation, is a central construct. In this regard Schumpeter's notion of new combinations is essential for my view of innovations. The categorisation of innovation gives an indication of the magnitude of innovations. However, as has been pointed out previously the effect of innovations on a technological system could be extensive even though the innovation is incremental. National Systems of Innovation is closely linked with the concept of system and innovation. As this study concentrates on Sweden it is relevant to address the geographical question, however. While National System of Innovation looks at the economy as a whole and analyses the innovativeness of nations, I study a certain area, i.e. mobile telephony. However, some of the ideas found in National System of Innovation are useful for this study. This is, for example, the emphasis on knowledge, which means that development is guided by knowledge creation and the coordinative role played by firms in the development. While technological system regards specific technologies, National System of Innovation takes a geographical boundary as its starting point. Similar ideas of regional agglomeration are found in theories on regional clusters, and on regional advantage where collaboration between firms is placed into the center of the analysis. As will be evident from the subsequent case, there have certainly been examples of spillover effects and a stream of people moving between different firms in the Sweden's mobile telephone industry. This is at the center of Marshall's notion that access to skill is of vital importance for the economic development. As the linear model of innovation is questioned it is not surprising that the notion of co-evolution has emerged. This means that the innovative development is interactive and concurrent.

I have now laid the foundation for analysing the development of mobile telephony. However, the vehicle for change is still missing which makes it relevant to introduce the concept of entrepreneurship.

4.5 Entrepreneurship theory and research

Entrepreneurship is a multi- and inter-disciplinary field, rooted in the social sciences. It would be no exaggeration to say that an immense amount of literature exists within the field of entrepreneurship, covering a broad spectrum of perspectives such as psychology, business administration, small business research, economics, finance, and public policy. A research area specialising in entrepreneurship related to small and medium size firms has emerged, for example.

The subsequent theoretical survey shows the broad range of entrepreneurship theories, and how various theoretical standpoints lead to different definitions of entrepreneurship. The scope of the various entrepreneurship theories means that entrepreneurship is conceived variously from being an individual act to its opposite, that it is a question of collective actions and a result of structural forces.

It could be seen as a dichotomy, which is in line with Kelly (1978) who states that classical innovation theories are spread around two clusters: deterministic and individualistic theories. In the deterministic theory innovations occur when the circumstances are right and the theory emphasises the role of social and other factors (military and economic) in development of technological changes. The individualistic theory underpins the importance of individuals (great men or heroes) and plays down external influences. These two poles are often interpreted as mutually exclusive:

> *"...regard the course of science and technology as a continuing process of cumulative growth, with discoveries tending to come in their due time, or as the work of men of genius who, with their ancillaries, bring about basic advances in science? In the ordinary way, these are put as alternatives: either the social theory of discovery or the "heroic" theory."* (Merton 1973, p 352)

The theoretical discussion is obviously affected by the purpose of this study, which is to analyse the development of a technological system with all its entrepreneurs and innovations, rather than to carry out a theoretical discourse on entrepreneurship. I develop an analytical framework by mapping the various theoretical standpoints, and present three sources of entrepreneur-

ship. The framework is affected by the fact that I focus on major changes, innovations that have shaped the development rather than every-day changes.

To avoid confusion of ideas with the concept of entrepreneurship I would like to stress the distinction between who is accomplishing the entrepreneurial function, what should be referred to as the entrepreneur and what the entrepreneurship consist of, what kind of entrepreneurial activity is accomplished.

It is beyond the scope of this study to do a comprehensive survey of the entire entrepreneurship research area. Neither is it necessary since a number of authors have already made contributions to cover the various entrepreneurship theories (see for example Casson, (1990); Sexton and Smilor (1986); Bull, Thomas and Willard (1995); and Hérbert and Link (1982).

Different approaches to entrepreneurship

As stated, there are certainly numerous contributions to the definition of entrepreneurship, and many scholars have aspired to come up with the ultimate definition. However, since it has never been accomplished I will utilise different theoretical contributions to formulate a conceptual framework.

One leading scholar within economics and entrepreneurship is Casson (1990, p xiv) and he distinguishes between four approaches to entrepreneurship in economic theory:

1) The first focuses on the factor distribution of income, and seeks to identify a factor for which profit is the reward, leading authors being R. Cantillon, F. Knight, W. Baumol.
2) The second emphasises the market process and takes its starting point in a critique of the static Walrasian concept of perfect competition. This is usually referred to as the Austrian school with authors such as von Mises, F von Hayek, and I. Kirzner.
3) The third is the heroic Schumpeterian vision of the entrepreneur as an innovator, whose "creative destruction" regulates growth and fluctuation in the economy.
4) The forth concerns the relation between the entrepreneur and the firm, and the focus is on the entrepreneur as decision-maker, motivation and perception of the environment. Special attention is given to small and newly founded firms, and key issues are strategy formulation, building market share, and managing growth through diversification. Examples of authors are J.S. Mill, and A. Marshall.

Given the focus of the present study, Schumpeter's notion of the innovator is appropriate for the kind of entrepreneur I seek.

As I previously stated, a number of scholars have pursued research in an endeavour to formulate the ultimate definition of entrepreneurship. Carsrud, Olm, and Eddy (1996, p 367) stress that the absence of a commonly accepted definition of entrepreneurship is a serious shortcoming that misdirects the research within the field, as too much energy is laid on concept building, contributing to a lack of a coherent body of research. A solution to this problem is proposed by Bull and Willard, who suggest that we should:

> *"Adopt Schumpeter-based concepts as it should mitigate further misdirection of effort and allow researchers to focus on the task at hand, i.e. explaining and predicting the occurrence of entrepreneurial events/phenomena."* (Bull and Willard 1995, p 2)

I fully agree with this suggestion and I also use Schumpeter as a basic reference in the theoretical framework. However, as Schumpeter's notion of entrepreneurship has developed over time, I also apply other theoretical contributions as they enable me to broaden the framework. First, I increase the complexity by introducing three sources of entrepreneurship. Then, in the concluding part, I wind it up and discuss the agglomeration of entrepreneurship in a technological system by introducing a model that I call the "entrepreneurial spiral". This enables me to discuss the evolution of entrepreneurship over time.

Schumpeter's theory of entrepreneurship

Hérbert and Link (1982, p 74) state that Schumpeter was the first scholar to develop an elaborated theory of the entrepreneur as an innovator. According to Hérbert and Link (1982, p 76), Schumpeter could be regarded as an integrating figure in the history of entrepreneurial thought because he succeeded to integrate the dynamics of the technology and business enterprise.

The significant idea in Schumpeter's approach is that entrepreneurs have the function to carry out new combinations. The entrepreneur thereby reforms or revolutionises the pattern of production and distribution by exploiting an invention.

For Schumpeter (1949) entrepreneurship consists in "doing things that are not generally done in the ordinary course of business routine, it is essentially a phenomenon that comes under a wider aspect of leadership". Even though Schumpeter (1947, p 151) states that the entrepreneurial

function concerns the doing of new things or the doing of things that are already being done but in a new way, he also underscores that it does not necessarily have to be spectacular or of historic importance.

Schumpeter (1947, p 150) distinguishes between adaptive and creative responses. With adaptive response Schumpeter refers to adjustment and adaptation according to traditional theory on changes, more people, quantity, expansion through existing practice, while creative response is whenever the economy or an industry or some firms in an industry do something outside of the range of existing practices leading to a new social and economic situation.

The peculiar personality and motivation of a particular class of economic agent called the entrepreneur is the mainspring of endogenous economic change, according to the Schumpeter approach. Only the most gifted entrepreneurs are assumed to be the pioneers capable of overcoming the hurdles facing an entirely new venture. The motives for entrepreneurial conduct, according to Schumpeter, is will to conquer, proving oneself superior to others, the joy of creating, otherwise simply exercising one's energy and ingenuity.

The interaction between entrepreneurial activities and technology, according to Schumpeter (1947), is a vehicle for economic development. Schumpeter portrays economic development as a perennial gale of restructuring and expansion and an innovative recombination of the resources, carried out by entrepreneurs.

Witt (1995) underpins that Schumpeter's main argument is that economic change is systematically produced from within the economy, and that this endogenously caused change makes up the evolutionary element in his approach.

Hérbert and Link argue that the Schumpeterian entrepreneur is a construct, much like Weber's charismatic leader, which is introduced to disrupt the self-perpetuating equilibrium. This is confirmed by Schumpeter (1949) who underscores that the entrepreneur should not be interpreted as being the equivalent of a single physical person as much as a function, and that every social environment has its own ways of filling the entrepreneurial function. It could for example be filled co-operatively (Schumpeter 1949).

Schumpeter altered his standpoint regarding that which fulfils the entrepreneurial function since there is a significant difference between the early and late Schumpeter, referred to as Schumpeter I and Schumpeter II. This is well covered in the extensive literature about Schumpeter's entrepreneurship theory (see for example Lundgren 1991, Scherer and Perlman 1992, Elam 1993, Sundbo 1998). In the late period, referred to as Schumpeter II, the entrepreneurial function is overtaken by large organisations where

innovation could be effectively programmed and co-ordinated. Schumpeter (1976) argues explicitly that the pioneering promoter loses out against the teams of trained specialists of the large corporations and becomes increasingly obsolete. Innovative activities become a form of bureau and committee work.

It could be stated that innovation is increasingly going on within large firms as an essentially collective endeavour, independent of single individuals. With the establishment of R&D departments in large corporations, the generation of new knowledge became endogenous to the innovation endeavour. A consequence of this, as Schumpeter stated, is that economic development becomes automated and decreasingly a matter of leadership and individual initiative. Nevertheless, Elam (1993, p 129) argues convincingly that Schumpeter is not actually making the entrepreneur invalid, rather that the entrepreneurial function in Schumpeter II is transformed in conjunction with the development of the economy and that the motive for the entrepreneurship is changing.

Even though Schumpeter originally came from Austria he is not part of the Austrian school of entrepreneurship because their standpoint is quite different. While Schumpeter emphasises the function of entrepreneurship as disturbing an equilibrium situation through entrepreneurship and new combinations, the basic idea of the Austrian theory, expressed by Kirzner, is that entrepreneurship is the process of moving the economy towards equilibrium.

Austrian theory of entrepreneurship

According to Casson (1990), the Austrian theory is based on a repudiation of objectivity in social science, all knowledge being regarded as provisional and subjective. Moreover, the Austrian theory is founded on methodological individualism which states that all attempts to explain social macro phenomena, like institutions and social structures, should be rejected if they are not expressed in or possibly refer to facts about individuals, like decisions, motives, acts and attitudes.

The basic idea in Kirzner's (1973, p 17) notion of entrepreneurship is that the market process essentially is entrepreneurial. For Kirzner (1973, p 81) entrepreneurship is about to "perceive new opportunities which others have not yet noticed" and an ability to see where new products have become unexpectedly valuable to consumers. Moreover, Kirzner (1979, p 115) see entrepreneurship as the grasping of opportunities that somehow have escaped notice, and that the entrepreneur "fulfill the potential for economic development that a society already possesses". The basic motive for entre-

preneurs is pure profit opportunities (Kirzner, 1979, p 175).

Kirzner criticises neoclassical theory as it does not state how equilibrium is accomplished from an initial state of disequilibrium, and that it leaves no room for purposeful human action. In Kirzner's theory market participants learn about what other market participants are likely to do and capture possibilities that already are available, and it is through this discovery process that entrepreneurs move economic markets in the direction towards equilibrium. The market is in Kirzner's (1973, p 9) view made up of interacting decisions of consumers, entrepreneur-producers, and resource owners. His position is that "systematic changes in the interconnected network of market decisions constitutes the market process" (Kirzner 1973, p 10).

von Mises postulates that knowledge is never complete or perfect – why markets constantly are in a state of disequilibrium. Human action according to von Mises (1963) is founded on subjective knowledge of the environment and human action is one of the forces that creates change in the economic system. Therefore, knowledge about people, local conditions and particular circumstances are equally important for economic success as scientific fact. Entrepreneurs, according to von Mises, are the first to understand that there is a discrepancy between what currently is done and what ought to be done.

The Austrian school emphasises knowledge and learning as a fundamental process in the economy. The difference between the Austrian and Schumpeter viewpoints, according to Lundvall (1992b), is that the Austrians have not integrated Schumpeter's innovating entrepreneur in their theory, giving their learning process a one-way bias towards a constantly moving and never realised equilibrium. This is a plausible argument not to include Kirzner in the analytical framework for the analysis of the mobile telephone system. However, I use the idea of individuals as a unit of analysis and in the concluding analysis I return to the idea of market processes and how the definition of the market is continuously reframed when I introduce a model I call the "entrepreneurial spiral".

The distinction between entrepreneurship and entrepreneurs

Although the previous discussion gives a good understanding of entrepreneurship I think it is relevant to elaborate on the issue further and introduce some additional authors. In the subsequent analysis I emphasise the distinction between entrepreneurship and entrepreneur.

Let me start with entrepreneurship. Dahmén sees entrepreneurship as a significant force in the economic development, as entrepreneurs generate and react on business opportunities. In transformation processes it is a

constant conflict between new and old things – in which entrepreneurial activities play a decisive role – and transformation pressure could be either positive or negative (Dahmén 1989, p 110). The greater transformation an innovation gives birth to, the greater the economic significance. Expressed in a slightly different way, Johanisson (1996) regards entrepreneurship as linked to separate individuals, to people's perception and ability to act in interaction with other people. Entrepreneurship, according to Johanisson, could be seen as a radical organiser, implying that entrepreneurship not only creates business and new consumption patterns but also contributes to the formation of the institutional platform in society. A central concept in entrepreneurship is change or, as Bull and Willard (1995, p 4) state, discontinuity through which value not previously available to society is created. A central question is how this is achieved and Thomas and Willard (1995) acknowledge that entrepreneurship is not deterministic, but rather the result of a confluence of different factors such as opportunity, perception, preparation, and risk-taking. Expressed in general term De Jong (1989, p 287) defines entrepreneurship as the creation of added value or surplus value. Entrepreneurship, according to Baumol (1995), could be seen as the creation and cessation of business entities and as a vehicle for economic innovation in different settings that adds value to the society as well as to the entrepreneur.

To sum up, this overview gives an understanding of entrepreneurship and how it contributes to the forward movement of the economy. Concurrently, it is necessary to focus on the various categories of agents that could perform the entrepreneurial function.

The entrepreneur is commonly seen as an individual and Casson (1993, p 31) defines the entrepreneur as "someone who specialises in taking judgemental decisions [judgemental decisions are decisions for which no obviously correct procedure exists] about the co-ordination of scarce resources". Moreover, Casson (1990, p xviii) emphasises that it is a mistake to suppose that there can only be one entrepreneur per firm, and to regard the operations of the firm as merely an extension of the personality of its founder. Baumol (1995) states that the entrepreneur detects previously unrecognised opportunities and implements them, thus becoming the strategist of the business. Baumol distinguishes between two types of entrepreneur: 1) Firm-organising entrepreneur, someone who creates and then, perhaps, organises and operates a new business firm, whether or not there is anything innovative in these acts. 2) Innovating entrepreneur, someone who transforms inventions and ideas into economically viable entities, whether or not that someone creates or operates a firm in the course of so doing.

Individual entrepreneur

The entrepreneur is commonly seen as being the equivalent of one individual, and this standpoint on entrepreneurship is prevalent in the popular management literature and business press where the entrepreneur is ascribed superior qualities, like being able to control the destiny of large corporations. When this is taken to its extreme, it gets closer to a kind of glorification which is widely criticised as it is creating a unrealistic picture of what individuals can do on their own.

In spite of the focus on business leaders it is commonly accepted in the literature that all that fulfils the entrepreneurial function, including employees of a firm, could be called entrepreneurs. This is because everyone qualifies as an entrepreneur when they actually carry out new combinations, while they lose that character as soon as they have built up their business or move to administrative tasks. Witt (1995) questions whether Schumpeter is overdoing the personalization of the entrepreneur, and that it resembles an elite theory since the Schumpeterian entrepreneurs are anything but average, and that he tends to overrate the role of spectacular innovations and underrate small-scale innovative activities. Hill (1995) pursues the same line of thinking and claims that the academic research and the popular press have over emphasised the individual entrepreneur. Nevertheless, Hill underscores that he is not implying that development will occur without entrepreneurs.

In this context it is also relevant to raise the question of the difference between entrepreneurship and management. Utterback (1994, p 84) sees this as when firms lose their dynamic character, individuals with management skills gradually increase their power on the behalf of those with entrepreneurial ability.

Entrepreneurial teams – collective entrepreneurship

As an reaction towards the focus on individual entrepreneurs Vyakarnam, Jacobs and Handelberg (1997) presents the idea that entrepreneurial teams, consisting of a combination of people with different personalities, characteristics, knowledge and skills, are more likely to accomplish the entrepreneurial function. Similar ideas are presented by Gartner (1995, p 67) who underpins that the entrepreneurial function has not necessarily to reside in one person but in many, and that successful ventures are often established by teams rather than by single individuals. Gartner underscore that observers have a tendency to underestimate the influence of external factors and overestimate the influence of internal or personal factors when making judgements about the behaviour of individuals. The increasing complexity of research and

innovative activities, which initiated the foundation of formal organisations, such as firm's R&D laboratories departments, government laboratories, universities, effectively balance the significance of individual innovators (Dosi 1988, p 223).

An explicit collective approach towards entrepreneurship could be found in the strand of National System of Innovation, which claims that entrepreneurship are carried out or produced collectively, however Lundvall (1992a) stresses that there is an element of randomness in the venturing process. Related ideas are presented by Van De Ven (1993) who emphasises that historical studies clearly show that most innovations are collective achievements. They are efforts of many actors working over an extended period of time, often in parallel and independent of locations. He refutes the idea of random events or a specific actor's genius and applies a social system perspective on entrepreneurship. Furthermore, Van de Ven emphasises that entrepreneurship is not only for the private sector as it is also relevant for the public sector.

4.6 Three sources of entrepreneurship

The theoretical survey illustrates the broad range of entrepreneurship and innovation theories. Let me first define entrepreneurship.

My starting point corresponds with Schumpeter's notion that entrepreneurship is a function that could be carried out by a number of different actors, or group of actors. Given that I see entrepreneurship as a function there is an agent who fulfil the capacity as an entrepreneur which makes it essential to determine what constitutes entrepreneurship. However, I will first discuss which agents perform entrepreneurship and then define what constitutes entrepreneurship.

The literature covered contains many theories for defining the entrepreneur, ranging from the individual to the collective endeavour. What can I say about the various theories? In an attempt to systematise the various theories I formulate three categories or sources of entrepreneurship, which I present in the following:

1) the individual as entrepreneur,
2) the company as entrepreneur, and
3) the network as entrepreneur.

It could be maintained that these three sources of entrepreneurship are mutually exclusive but even so my conviction is that it is feasible to place them side by side. In my view, it is a way to apply various entrepreneurial theories and use them as different categories of actors in an analysis of a

case study. In the following, I explain and expound upon the three sources of entrepreneurship and complement my earlier examples of theories, starting with the individual as entrepreneur.

The individual as entrepreneur

The concept of the individual entrepreneur is founded on the idea that one individual can influence economic events. J. Hughes (1986) rejects the assumption that historical force and structures are the factors that trigger economic development. He argues that there are no masses – only individuals – and that those individuals force economic development.

In economic theory, the entrepreneur has been perceived as an individual, not as a member of a group, team, department or organisation. Baumol (1990) sees the entrepreneur as the Napoleon of the economy, dictating its direction and its strength. This is in line with the early Schumpeter who averred that the individuals who are capable of moving against the existing order of economic life are the real entrepreneurs.

Another kind of individually centred entrepreneurial theory has arisen around the research of small and medium sized business, where the individuals who are the owners or founders are the entrepreneurs. Dandridge and Johannisson (1996) argue that genuine entrepreneurs create their own organising context, basically by way of a resourceful egocentric network including major customers, research centres and politicians.

According to this line of thinking, it is individuals who trigger innovations, even when those innovations have to be fitted into an existing organisation to work effectively. The underlying theory is that in most cases only one or two individuals recognise a new possibility when they see it and are able to cope with the resistance and difficulties when going beyond the boundaries of established practice.

I have previously mentioned the prevalence of the individual entrepreneur in the business literature, popular press and how this slant has influenced the popular conception of entrepreneurship. It is an established way of regarding entrepreneurship and it is straightforward, therefore, to conceptualise the individual as a unit of analysis.

The company as entrepreneur

Schumpeter argued that the individual entrepreneur looses out against the team approach and the trained specialists employed by the large companies, enabling the function of entrepreneurship to be carried out by the company,

as such. Whether entrepreneurship turns into being a form of bureau and committee work, something like an incessant, routine-like, industrial innovativeness could be questioned. The main point is that innovation is increasingly going on within companies largely independent of individuals. Economic development is becoming automated and is decreasingly a matter of leadership and individual initiative. With the setting up of R&D departments in large companies, the generation of new knowledge becomes an internal activity.

A company does not have to be small or newly set up, since both big and small companies could employ entrepreneurship. Moreover, entrepreneurship is not limited to private sector companies as it could certainly also take place within public organisations.

A sign that a company is being entrepreneurial, according to Schumpeter, is that it has the ability to respond creatively, to do something different from normal routines.

Hjort and Johannisson (1994) argue that the cast for the entrepreneurial organisation includes all echelons of the organisation. The role of the top management is to epitomise entrepreneurial values and to sponsor the creation of arenas where corporate entrepreneurs can nurture their own networks.

Hjort and Johannisson regard corporate entrepreneurs in a social-constructivist perspective, and they are seen as innovative network organisers of internal (corporate) and external resources. The entrepreneur is guided by an ever evolving vision in the rationalisation of actions taken and in the guidance of present action. Vyakarnam, Jacobs and Handelberg (1997) contribute to the understanding of how entrepreneurial teams, which often lead fast growth firms, are created and their role. A team, a combination of people with different personality characteristics, knowledge and skills, is more likely to be reliable in creating successful enterprise processes.

The entrepreneurial firm is a concept derived around small and medium size firms. This source of entrepreneurship means that the firm is the unit of analysis. Given that this category comes after the first one: the individual as entrepreneur, it is certainly a broad category ranging from a small team to a large multinational firm. The fact that the firm is an accepted concept is to its benefit and is why it is relevant to use it in the analytical framework.

The network as entrepreneur

The starting point in the industrial network approach provides models and conceptualisations for understanding the totality of relationships among

firms engaged in production, distribution and use of goods and services (e.g. Axelsson and Easton 1992). A basic idea in Johanson and Mattsson's (1992) view of the network approach is that inventions and innovations occur in networks – not within but between companies – and in order to make an innovation successful, the network has to be mobilised. This is in line with Snehota (1990) who argues that entrepreneurship can only be performed by networking, connecting to other actors and thereby gaining access to resources not previously available. Snehota (1990) sees entrepreneurship in the Austrian perspective as a way to initiate and accomplish exchange relationships in a mutually beneficial exchange not previously acknowledged by the market participants.

The network approach also stresses the underlying technological interdependencies, linking changes in the network governance structure to changes in the technological, activity and resource structures. This is forwarded by Håkansson and Snehota (1995) who state that resource development appears to a large extent to take place between companies rather than within companies, and that the development and performance of companies could be explained by their ability to develop relationships.

As presented above, Van de Ven's (1993) social system approach on entrepreneurship could be labelled as network entrepreneurship, as it comprises a collective type of entrepreneurship. The assumption is that any given firm is only able to perform a limited set of roles, being therefore dependent upon many other actors to accomplish all the functions needed for an industry to prosper.

Elam (1993, p 129) outlines a perspective on innovation, presenting it as an essentially collective endeavour in advanced economies where the entrepreneurial function could be exercised by a growing variety of people working alone or in close co-operation with others. This is line with National System of Innovation, which regards entrepreneurship as a collective process, making it plausible to refer to it as the network as an entrepreneur.

Hirschman (1958, p 17) underscores the importance of the co-operative function, such as to engineer agreement among all interested parties, such as the invention of the process, the partners, the capitalists, the suppliers of parts and services. The notion of collective invention presented by Allen (1983) builds on free exchange of information about new techniques and plant designs among firms in an industry. For instance the American and British steel industries relied on collective invention for their development of new technology. Collective invention tends to generate new techniques that are adapted to the localities that generate them, as these new techniques lead to lower costs when utilised primarily by firms who face relative input prices similar to those which prevail in the locality where they are invented.

Antonelli (1992, p 21) launched the concept network firms which emphasises the relevance of externalities in knowledge and technology and the collective nature of the innovation process. Innovation, according to Antonelli, is the result of networking strategies of firms, appropriate factors of the technological environment. Network firms, according to Antonelli, are groups or loose-linkages of firms that cooperate strategically in order to share know-how, technical capabilities and learning opportunities. Antonelli (1992, p 21) states that network firms can be viewed as "cooperative institutions designed to increase the appropriability of the benefits of technological innovation and to reduce the public good character of knowledge". This means that the effects of technological innovations predominately are utilised by network firms.

To sum up on entrepreneurship

The way I have chosen to handle the broad spectrum of entrepreneurship theories is to categorise three sources of entrepreneurship. This study explores whether it is possible to combine heroic theory, in the type of individual entrepreneurs, and social theory, in the form of companies and networks as entrepreneurs, in an analysis of a technological system.

I have now traversed these three areas: systems, innovation and entrepreneurship and it is now timely to elaborate on the analytical tool that will be used in the subsequent case study.

Formulation of an analytical tool

I take the notion of technological system as the unit of analysis in this study. The technological system for mobile telephony consists of different functions performed by various organisations such as network operators, system and telephone suppliers, distributors, standardisers, regulators and end-users. Mobile telephony is both a service and a product market. First there is the mobile telephone network which consists of radio base stations, mobile switches, mobile telephones, and a number of communication and information system. As it connects the end-user to the network, it is crucial to the network operators. Then there are the operators, with the appropriate knowledge to put these technical parts together or who engage external partners to do so. This means that suppliers of equipment have a market on which to sell their products. If any of the required sub-systems are missing the system is incomplete. One technical component that is often out of step with the remaining system equipment is the mobile telephone itself.

Although easily perceived solely as a technical project, mobile telephony

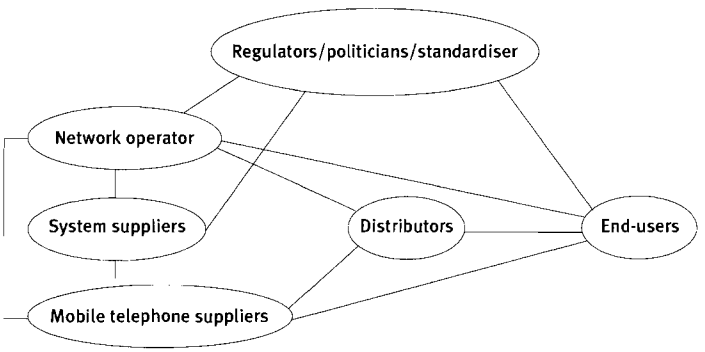
is not vigorous without a functioning distribution and marketing involvement. Nor is mobile telephony solely a product market, because the service that network operators provide and end-users utilise gives it specific characteristics.

I focus on complementarities and interdependencies between the different actors and their underlying technologies and sub-systems in line with Dahmén (1989), who underpins the importance of complementarities between technological, economical and other factors.

Why is it appropriate to use a technological system approach? This study was initiated by an interest in exploring how the network operator market for mobile telephony had developed. This induced an interest in suppliers of mobile systems and mobile telephones. It was therefore natural to view it as a system, facilitated by the incorporation of standardisers, distributors and end-users into the framework. Moreover, mobile telephony is a network technology, an infrastructural system. This is why it is easy to argue for the benefit of using a framework of a technological system.

The following picture shows the various participants included in the technological system, mobile telephony:

Figure 1 / **Participants in the technological system**



Although not shown in Figure 1 above, the relevance of financial actors in the technological system should not be forgotten. Financial resources have unquestionably been vital for the development, in the capitalisation of firms and for network extensions and the like, and there are several examples of occasions where access to capital played a decisive role in the development of mobile telephony in Sweden. Let me present four examples:

1) The deregulation of the market for mobile telephones in 1971 was forced upon Swedish Telecom as it could not raise a sufficient amount of capital in the short time available to invest in mobile telephones.
2) External financing facilitated Ericsson's expansion on the mobile telephony market in the US.
3) Access to capital has been vital for the Kinnevik Group's expansion within the field of mobile telephony.
4) The same is valid for Europolitan, which was forced to finance the negative cash flow in the build up stage.

The education system, embracing universities and research institutes, could also have been included as part of the technological system as well. The directions of education programs certainly influence how prepared the students are to take up positions within the mobile telephony industry. The technical universities, such as the Royal Institute of Technology in Stockholm, Chalmers University of Technology, and Lund Institute of Technology have educated people involved in mobile telephony, and their profile and research levels have formed the workforce for the industry. Moreover, research have been conducted at the technical universities which have relevance for the mobile telephony system. However I have not incorporated this particular aspects as research was concurrently carried out at the various mobile telephone firms. The available education programs at technical universities are certainly influenced by the development of the industry and its needs. The significance of the education programs could be illustrated by an example from Japan. Japan's relative weakness within mobile telephony has been explained by the fact that they did not educate a sufficient number of radio engineers as they thought that fibre optics was the future, while mobile telephony was seen as becoming just a minor application.

As I am forced to restrict the size of the technological system defined I do not include the aspects I have presented above into the framework in this study. Moreover, I must desist from assimilating all details in the empirical account. The focus is on the development of the entire system rather than on all details of all the firms and individuals involved.

A definition of entrepreneurship

Entrepreneurship is commonly interpreted as being mainly relevant to private business firms. I would like to underline that entrepreneurship is not restricted to firms, because public entities and those engaged in them could also carry out entrepreneurship. In this study Swedish Telecom, which is a public entity and Telia, as an incorporated company, play a vital role in

promoting innovativeness in the development of mobile telephony in Sweden. Moreover, standard-setting bodies could equally well perform the entrepreneurial function in the sense that they create something and thereby fulfil the criterion for entrepreneurship.

The theoretical discussion of entrepreneurship is influenced by the purpose of the analysis. The aim with this study is to analyse major changes in the development of mobile telephony in Sweden.

In order to establish a definition of entrepreneurship for my use, I refer to Schumpeter's (1955) classification of five different types of new 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 any industry, and
5) the opening of a new market.

Even though the latter of Schumpeter's new combinations concern market related innovations I find it appropriate to add Hultén and Mattsson's two categories (see Hultén and Mattsson 1994):

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

To facilitate the analysis where it concerns the type of innovation fulfilled, I group the seven innovation types into three categories:

1) technique related innovations,
2) organising related innovations and
3) market related innovations.

This enables me to create an entrepreneurial matrix that I use throughout the analysis of the three phases.

Table 5 / **Entrepreneurial matrix**

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			

For each phase I use the entrepreneurial matrix to fill in the entrepreneurship which I identify. An individual, company or network must have executed one of the innovation types to be labelled an entrepreneur. An individual can then be classified as an individual entrepreneur at the same time as his/her company has served the function of an entrepreneur. When I identify an individual 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 every case. 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.

4.7 Three sources of entrepreneurship identified

In the subsequent case I present a number of individuals, firms and networks of firms to whose entrepreneurial activities the Swedish mobile telephony industry owes its origins. By singling out individuals, I emphasise that what people achieve for the subsequent development of the technological system is of utmost significance. In spite of the emphasis placed on individuals, I would make the point that there is a limit to what individuals can achieve on their own, which is where companies or networks of firms come in. Firms certainly operate with bigger resources and therefore may be able to carry out entrepreneurial activities beyond the range of individuals. Moreover, when firms cooperate with other firms, they form networks to be able to handle the development of major projects.

My primary interest lies in actual activities carried out by the agents that I categorise as entrepreneurs. I do not deliberately seek out the underlying motives behind entrepreneurial action nor do I look for the personality traits which typically identify the entrepreneur. Actual activities are not restricted to physical activities because strategy formation, organisational changes and even visions could likewise be considered as entrepreneurial activities.

Even though I am not able to categorise the activities of the end-users into the entrepreneurial matrix the main user categories are put into the technological system for each phase

Theoretical constructs

To conclude this chapter I would like to summarise the theoretical constructs that this study is based on and which I have discussed above. To begin with, the concept of systems gives me a framework within which to place the case. More specifically this concept is referred to as a technological system.

This idea originates in Dahmén's notion of development block, but as this notion concerns the development of an industry, all interest is naturally placed on the supply side. In order to bring this system into balance I introduce the customers and end-users into the analysis.

Innovation is the second pillar supporting this study. Innovation, in the words of Schumpeter, is the new combinations that are introduced and utilised and thereby take the development further. By combining system and innovation I discuss National System of Innovation which gives a framework for analysing innovativeness. Building on ideas from Marshall, the idea on regional agglomeration has a decisive effect on the economic activity. Finally, the idea of co-evolution offers a complementary view on innovative activity as a process going on concurrently and interdependently.

The third pillar that this study rests on is entrepreneurship. This is the vehicle for the development and by combining various entrepreneurship theories I am able to formulate three sources of entrepreneurship.

Entrepreneurial spiral

I have mentioned that an "entrepreneurial spiral" will be developed in the concluding chapter, the idea being that the entrepreneurial activities are creating connections and the basis for entrepreneurship is continuously changing. The basic idea is that entrepreneurs identify and solve structural tensions and thereby contribute to pushing the spiral. The entrepreneurial spiral could be described as a process that aims to grasp the aspect of cumulativeness and learning and place entrepreneurial activities into a dynamic context. It is further elaborated in the concluding chapter.

Next step

It is now time to introduce the case of the development of mobile telephony in Sweden. As I described in chapter 1, the case is divided into three phases. This is a way of making the empirical material easier to present and of facilitating the analysis of the entrepreneurial activities achieved in each phase.

In the following three chapters I will present the development of the Swedish mobile telephone system from 1950 up until 1998. The account is divided into three phases: the local, the national/Nordic and the international. For each phase I present participants for each category in the technological system. I identify entrepreneurship according to the model of three sources of entrepreneurs: the individual, the firm and the network. Moreover, I present the kind of innovation type encountered which I place into a technological system and show how the entrepreneurship fits into it.

5. The local phase 1950-70

5.1 The introduction of the first car phone system

When Swedish Telecom opened Mobile Telephone System A (MTA) for commercial traffic in April 1956, it was the first automatic mobile telephone system in the world to allow subscribers to make or receive calls in the car without the assistance of a telephone operator. However, Sweden at that time was far from alone in developing a mobile telephone system. But unlike most other countries, Swedish Telecom decided to develop a system that was fully automated from the outset. Manual mobile telephone systems, on the other hand, were independently developed in a number of countries in the late 1940s and early 1950s. For instance a mobile telephone network opened in St. Louis, USA 1945, the Netherlands started a mobile network 1948, Switzerland opened a system in 1949, Denmark started a network in Copenhagen 1950, and in 1951 a system was opened in Hamburg, Germany.

5.2 Network operator

Having witnessed the rapid development of radio and air communication in the 1940s, Håkan Sterky, Director General of Swedish Telecom, could see the potential for developing the business of mobile telephony. In the late 1940s, Sterky commissioned Ragnar Berglund and Sture Lauhrén, both working at Swedish Telecom, to develop a fully automated mobile telephone system. Together with Ivar Ahlgren from Svenska Radioaktiebolaget (SRA) and representatives from LM Ericsson, Berglund and Lauhrén prepared a test system in 1950.

Ragnar Berglund designed the radio technical part of the MTA system, while the teletechnical part of the system was based on an innovation developed by Lauhrén, which was patent pending in a number of countries. However, Swedish Telecom was reluctant to pay any significant attention to Lauhrén's

patent since, in the management's view, it was based on what was general knowledge for that period. The patent dispute between Lauhrén and Swedish Telecom was not solved until the mid 1960s, when Lauhrén received SKr 25,000 from his employer. Interestingly enough, Swedish Telecom made a reference to two patents of which one was from 1935, concerning a car telephone with a two-way radio circuit between a car and a permanent station. A minor system of this type was running outside Stockholm in 1950.[4] True, Swedish Telecom considered the device a general solution, but much too expensive, since a separate waveband with radio station equipment was required for every car[5]

Ragnar Berglund and Sture Lauhrén worked part-time with the mobile telephone system development along side their other duties at Swedish Telecom. Sture Lauhrén left the area of mobile telephony with the completion of MTA while Ragnar Berglund continued his work within radio communication and established the radio laboratory at Swedish Telecom. Sture Lauhrén confesses to have had no idea what he was laying the foundation for. In retrospect, how could he have conceived that mobile telephony would become a wide spread phenomenon, with Sweden having a leading mobile telephone industry.[6]

Modest investment

Mobile Telephone System A was complete in 1952-53, after three years work, at an approximate cost of SKr 300,000.[7] The system consisted of modified technologies. The MTA system, operating in Stockholm with 20 telephones, was tested until the mid 1950s, when the production was enlarged to include four channels and 75 mobile telephones.[8]

Swedish Telecom considered the investment in mobile telephony as a satisfactory alternative to private radio networks since the radio frequency was used more effectively. According to Ragnar Berglund, it was always the intention that Swedish Telecom should operate the mobile telephone network since this facilitated connection to the public telephone network.[9]

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4 Patent number 73169. Patent number 100481: valid from 1935, published 1940 and expired 1944.

5 Sven Nordström, Swedish Telecom, "Utredning angående automatiska biltelefonsystem, användbara såsom alternativ till Lauhréns biltelefonuppfinningar", 27 March 1954. Interview Carl-Gösta Åsdal, former chief executive Swedish Telecom Radio, 16 April 1991.

6 Interview Sture Lauhrén, 15 April, 1994.

7 Sture Lauhrén, "Svensk helautomatisk biltelefon startklar", Populär Radio, nr 4 1952.

8 Swedish Telecom, Land mobile radio, report published by a work group for mobile telephony, August 1967.

9 Ragnar Berglund, "Mobil radio med särskild inriktning på biltelefon", adress given at a conference with Svenska Elektroingenjörsföreningen 7 September, 1951.

The total investment, in the mobile system and mobile telephones was about SKr 1 million. The largest share of the investment in the first system concerned mobile telephones as the following table indicates.

Table 6 / **Investment in MTA in SKr at 1998 year's prices (137 mobile telephones)**

	1957	In 1998 years prices
Mobile telephones	863 000	7 962 396
System	324 000	2 989 358
Total	1 187 000	10 951 755

There were, in fact, plans for a nation-wide mobile telephone network as early as in the mid 1950s. The instigators of the first mobile telephone systems regarded it as technically possible to build a nation-wide network. Yet they regarded it as being too much of an investment to become a reality, and there was a long way to go before the plans could be implemented. At this stage of development, mobile telephony and the motor car were virtually synonymous. Swedish Telecom considered a nation-wide network built only in connection with traffic along the main roads as unrealistic. It preferred the alternative of installing radio base stations, in larger communities along the main roads where a demand could be identified, which could serve the nation-wide network at the same time. Swedish Telecom estimated the number of potential customers in larger communities, not counting Göteborg, Malmö and Stockholm, at no more than 30. Initially, the intention was to deploy the MTA system along the main roads between Stockholm, Göteborg and Malmö. But the number series was limited to 1,000 numbers and an extension was looked upon as far too expensive.

Development of a second system

In the late 1950s, Ragnar Berglund, as well as others at Swedish Telecom, argued in their analyses that it was better to invest in a new system, with low initial cost as well as relatively cheap mobile telephones, than to extend the MTA system. Because the first system suffered, according to Berglund, from a number of shortcomings: the telephones were unwieldy; setting-up time was long; the system was complicated to use, and the mobile telephones were expensive. Berglund estimated that the MTA system required investment in equipment at a cost of SKr 30,000 at the telephone stations and quite expensive mobile telephones.

Berglund began work on a new system which resulted in a new mobile telephone system, Mobile Telephone System B (MTB), built on a patent developed by himself, and facilitated by the development of the transistor.[10] There were some three to four persons involved in this development work.[11]

The MTB system was in comparison to the MTA system cheaper in network structure; the system could connect directly to the telephone system, and the switching was faster and the mobile telephones less expensive.[12] The MTB system, which included two mobile telephones, was tested as from 1957 and the test proved satisfactory.[13] As from 1961, the test system included 13 mobile telephones. Some of these were used by the security police during Nikita Krushchev's official visit in Stockholm 1964 and the Director General of Swedish Telecom had an Ericofon, a "Cobra-model" with an illuminated dial – adjusted to the mobile operation – installed in his official limousine.

In 1965, four channel radio base stations were set up in Stockholm and Göteborg, handling 150 mobile telephones. The network expanded in 1967/68 in Stockholm, Göteborg and Malmö through the extension to six channels, increasing the capacity to 500 subscribers.[14]

The estimated cost for expanding the MTB system, which had six channels serving 500 subscribers came to SKr 3 million. The operation was fairly limited in size, in spite of the network expansion. Swedish Telecom did not regard mobile telephony as becoming a "big business" [15], but it did expect the business to show a minor profit when subscribers exceeded a hundred. Swedish Telecom estimated annual revenue at SKr 150,000, meaning that the subscribers on average paid SKr 1,375 annually in mobile telephone fees. Neither MTA nor MTB was profitable for Swedish Telecom, according to Olle Gerdes, who was engaged in mobile telephony at Swedish Telecom from the 1950s.[16] The following table exhibits the annual turnover and revenue per subscriber for mobile telephony 1956-71.

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10 Patent number 173 730. Swedish Telecom, Land mobile radio, report published by a work group for mobile telephony, August 1967.

11 Interview Olle Gerdes, former Swedish Telecom Radio, 13 February 1991.

12 Swedish Telecom, Thomas Övergaard, Memorandum to District meeting, internal information material, 27 February 1957. Swedish Telecom, Land mobile radio, report published by a work group for mobile telephony, August 1967.

13 Swedish Telecom, deputy director Thomas Övergaard, memorandum to the manager for the Radio Unit, 15 June 1957.

14 Swedish Telecom, Land mobile radio, report published by a work group for mobile telephony, August 1967.

15 Thomas Övergaard's choice of words in internal memorandum.

16 Interview Olle Gerdes, former Swedish Telecom 13 February, 1991. Olle Gerdes, "Från trådlös telegraf till mobiltelefoni", Tekniska Musets årsbok Daedauls, 1991.

Table 7 / **Swedish Telecom's annual turnover for the mobile telephone service, and revenue per subscriber 1956-71 in SKr at 1998 year's prices.**

Year	Total revenue	Revenue per subscriber
1956	1 166 212	44 854
1957	2 635 541	36 605
1958	2 762 689	28 481
1959	3 221 647	27 073
1960	3 450 679	25 187
1961	3 082 500	22 500
1962	3 102 274	24 818
1963	2 808 257	20 957
1964	2 532 804	18 902
1965	2 451 434	19 303
1966	4 724 176	24 864
1967	4 260 557	19 909
1968	5 297 576	20 613
1969	10 546 469	28 581
1970	10 362 863	20 809
1971	8 156 289	15 961

Source: Swedish Telecom, official statistics

Though MTB could only handle six calls simultaneously in Stockholm, it was comparatively more useful from a subscriber's point of view than American Telephone & Telegraph's system in New York in the 1960s, which was not able to handle more than 12 calls at the same time for the whole of Manhattan.[17]

MTA was phased out in 1969, the subscribers being transferred over to the MTB system.

Private operators

Although competition is thought of as a recent phenomenon, private network operators have been established in the Swedish market since the mid-1960s. A predecessor among the private operators was Wikanders Ur & Optik in Jönköping, which operated a private network from 1965, when it established one base station located in Jönköping with one channel

[17] Tom Forester, High-Tech Society, MIT Press, Cambridge MA, 1987.

in the 70 MHz band. A year after its start Wikander changed its name to Telelarm Mobiltelefon AB.[18] In 1968, Telelarm applied to Swedish Telecom for permission to connect its base station to the public telephone network and for allocation of additional frequencies in the major Swedish cities. Telelarm received the requested permission in late 1968, and was allowed to connect its network to the public network at 12 locations. However, the company was forced to lease equipment from Swedish Telecom.[19]

5.3 System suppliers

The equipment used in the MTA system, consisting of radio equipment and mobile telephones, was manufactured by SRA, while the relay equipment was manufactured in Swedish Telecom's workshops.

AB Nordisk Teleproduktion supplied the mobile radio equipment for MTB. It was transistorised with the exception of the transmitter's driver stage and final stage, which meant that the consumption of current from the car battery could be reduced considerably. Nordic Teleproduction's aim was to concentrate on mobile radio systems, and the company was the Swedish representative for Motorola and the British company Pye. The company was introduced to mobile telephony when it developed a mobile radio system for the retail chain Konsum and worked with Swedish Telecom.[20] Åke Lundqvist, who later became the executive director of Ericsson Radio, began his career at Nordisk Teleproduktion at the end of the 1950s, and participated in the development of mobile telephones and transmitters for the MTB system. The company supplied a trial system to MTB, which was manufactured by AGA in Gävle.

Technique of the different systems

The MTA system was built on a relay technique. 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 set-up 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 transmitter's power factor was 15-25 W and

[18] Magnus Karlsson, The Liberalization of Telecommunications in Sweden, Linköping: Linköping University, 1998, p 226. Based on Communication from Swedish Telecom to Wikanders Ur & Optik, 28 December, 1964, communication from Telelarm to Swedish Telecom, 15 March, 1965.

[19] Magnus Karlsson, The Liberalization of Telecommunications in Sweden, Linköping: Linköping University, 1998, p 226. Swedish Telecom, 10 November, 1981 p.1, communication from Swedish Telecom to Telelarm, 4 November, 1968.

[20] Interview Åke Lundqvist, Ericsson, 22 February, 1994.

the radio base station transmitter's 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.[21] A radio base station was placed on the water tower at Lidingö, 90 meters high, which gave the system a range of 30-40 kilometres.

MTB used duplex, and operated in the 80 MHz-band. The system had an automatic speech expedition 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 individual subscriber's relay with a subscriber's card unique to that subscriber. This implied that the system could only be used locally unless the subscriber had a subscriber's card based at several base stations.[22] The mobile transmitter's output power was 15-25 W, and the radio base station transmitter's 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.

5.4 Mobile telephone suppliers

Swedish Telecom purchased the first MTA telephones from Svenska Radioaktiebolaget (SRA), and then leased them out to the subscribers. The telephones plus the transmitter equipment were bulky and heavy, weighing 40 kilos, and used so much current that the car battery could hardly operate the equipment.[23] The telephones also needed much repair and maintenance.

SRA and AGA delivered the MTB mobile telephones.[24] They were cheaper, smaller, lighter and consumed less energy than the MTA telephones. SRA also launched a second generation of MTB telephones, with wholly transistorised transmitters. The telephones were made of black Bakelite with a dial, and the whole equipment weighed around nine kilos.

5.5 Distributors

During the 1950s, the distribution function was quite rudimentary, as there were no independent distributors and Swedish Telecom did not market the mobile telephone service in any particular way. Those who were interested

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21 Swedish Telecom, Land mobile radio, report published by a work group for mobile telephony, August 1967.

22 Ibid.

23 Sture Lauhrén, "Svensk helautomatisk biltelefon startklar", Populär Radio, nr 4 1952.

24 SRA-News number 4, February 1968.

wrote to the company inquiring as to the chances of obtaining a subscription. According to the person responsible at Swedish Telecom, there were in fact numbers of inquiries from interested parties.

The marketing of MTB from 1966 was initially modest and consisted mainly of advertisements in the telephone directory and at Swedish Telecom's sales offices, in principal the only distribution channel.

5.6 End-users

> *"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 potential."* [25]

Those who developed the first system were convinced that there was a demand for mobile telephony among larger companies, transport companies, doctors and businessmen in major cities. Swedish Telecom carried out a market survey in 1954 which showed the interest in mobile telephony among larger companies.[26] From the very outset, mobile telephony was foreseen as becoming an exclusive, high tariff service, as the following table show, since Swedish Telecom worked on the principle that the mobile telephone service should cover its own costs. It considered it as unlikely that mobile telephony would become attractive to all.[27]

Table 8 / **Connection and annual charge 1956 and 1967 in SKr at 1998 year's prices**

	Connection fee	Annual charge
MTA (1956)	18 482	15 842
MTB (1967)	17 393	10 436

Source: Swedish Telecom

Nevertheless, Swedish Telecom aspired to make mobile telephony available to a number of different categories by deciding on suitable levels of the tariffs. The ambition was to offer a variety of services to the public. Swedish Telecom was aware from the start that mobile telephony opened up new possibilities for service firms to improve the service to their customers. Notwithstanding its potential benefits, it was only the larger companies and transport companies who could afford the significant costs of making use of the mobile telephone service.

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[25] Handelstidningen, 26 November 1953.

[26] Swedish Telecom, Thomas Övergaard, Memorandum to District meeting, internal information material, 27 February 1957.

[27] Handelstidningen, 26 November 1953.

Mobile telephone users were typically:

1) Banks: Svenska Handelsbanken, Stockholms Enskilda Bank, Skandinaviska Banken, Sveriges Kreditbank,
2) Doctors, hospital management, veterinary surgeons,
3) Transport companies: taxis, Freys Express, boats, breakdown lorries,
4) Directors, managers, engineers, service technicians,
5) Public institutions: AB Radiotjänst, customs authorities,
6) Small companies: locksmiths, photographers, reporters.

The bank application is interesting since it facilitated a new means of offering bank services. In the mid 1950s, there were no bank offices established in the new suburbs outside Stockholm, which meant that bank buses equipped with mobile telephones could move among the suburbs of Stockholm acting as bank offices, opening for an hour at each location. Sveriges Kreditbank, for instance, possessed a mobile telephone, which, according to the bank management, played an important role in their business. The telephones worked more or less satisfactorily when they were newly adjusted – often better in the mornings than in the afternoons.[28]

A number of doctors tried out the novelty of mobile telephony. For instance, Dr Stig Valentin of the Stockholm Medical Association thought a car phone was marvellous, allowing him to get in touch with his patients quickly, and Stockholm's Medical Association installed mobile telephones in four emergency cars. With the installation of such telephones, home visits could be conducted more efficiently and effectively.[29] However, the system was not fully reliable and periodically all four telephones were out of order at the same time. This forced the emergency doctors to install radio communication in their cars as well and on occasion to even redirect the operation via the rescue corps. Another problem remaining was the fact that many households were without a telephone.

Mobile telephones meant major changes for the taxi companies:

"Premiere for telephone dial in four Göteborg 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 located in the trunk, "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.[30]

Taxi drivers could now be directed by telephone to those needing taxis, thereby achieving a saving in valuable time and gasoline and so also an improve-

[28] Letter to the Swedish Telecom Radio unit in Stockholm from Sveriges Kreditbank, 28 August 1954.

[29] Letter to the Manager for Swedish Telecom Radio Unit from Stockholm Medical Association, emergency committee Stig Valentin, 2 February 1960. Interview Stig Valentin, 4 October 1991.

[30] Handelstidningen 20 September 1956.

ment in efficiency. In another case, the customs director in Göteborg spoke of success when testing a mobile telephone.[31]

Subscribers were offered favourable terms to switch over to NMT when the MTB system was phased out in 1983.[32]

Table 9 / **Details about MTA and MTB**

Sector	MTA	MTB
Developer of system technologies	Swedish Telecom	Swedish Telecom
Developer of switches	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	1950-56	1956-65
Opening	1956	1965
Costs	SKr 300,000	SKr 200,000
Termination	1969	1983

5.7 Entrepreneurship in the local phase

In this phase the network operator Swedish Telecom is the main figure, having initiated the development of the first system and having decided to develop an automatic system of its own 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 considerable fees associated with using a mobile telephone service. Banks and the medical profession were prominent among those using the first system. As mentioned, the bank application, in particular, is interesting since it represents a service innovation.

In accordance with the analytical framework, I identify the following three different sources of entrepreneurship evident in the local phase.

The individual as entrepreneur

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

[31] Letter from Swedish Telecom Radio Unit, Thomas Övergaard, 27 December 1956.

[32] Swedish Telecom, information material.

system. It is therefore plausible that Sture Lauhrén and Ragnar Berglund qualify, as individuals, as entrepreneurs.

The company as entrepreneur

By investing in mobile telephony, a new type of service previously not offered, Swedish Telecom introduced a new market and therefore qualifies, as a company, as an entrepreneur.

The network as entrepreneur

Swedish Telecom, SRA and LM Ericsson participated in the production of the first systems. These companies worked together in the development resulting in a new product, qualifying them, as the network, as entrepreneur.

5.8 Summarising entrepreneurship in the local phase

The following table summarises the entrepreneurial activities I have identified in the local phase. In the framework of the network operator's activity, a technique and market related entrepreneurship is carried out by individuals and companies. The connection to system and telephone suppliers is carried out by a technical entrepreneurship within the framework of an industrial network.

Table 10 / **Entrepreneurship in the local phase**

	Individual	Company	Network
1) A new product	S Lauhrén, R Berglund		Swedish Telecom-Ericsson-SRA
2) A new production process			
3) A new input			
4) A new organisation of industry			
5) A new market		Swedish Telecom	
6) A new type of marketing			
7) A new distribution channel			

In relation to the technological system

The limited number of entrepreneurial activities in the local phase reflects the modest approach to mobile telephony, at least up until the late 1960s.

While the entrepreneurship was limited, it was of major significance regarding future developments.

Given the entrepreneurship I have identified and placed into the technological system the following picture is formed.

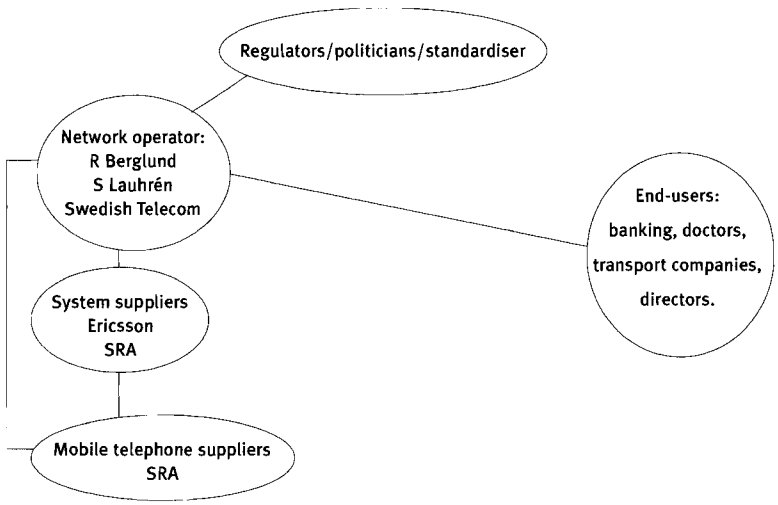

Figure 2 / **The technological system in the local phase**

As mobile telephony filled a new role for the users as been previously stated it laid the foundation for the mobile telephone market stimulating the future development, which will be explored in the next chapter.

6. The National/Nordic phase 1967–95

6.1 General overview

In the late 1960's, development plans emerged for an expansion of the mobile telephone operations. A report on the future development of land mobile radio communication published by Swedish Telecom in 1967 can be seen as the step from the local to the national/Nordic phase.[33] There were 450 mobile telephone subscribers in Sweden at the time. In this phase, Sweden emerges as a mobile telephone country, building on the entrepreneurship carried out in the local phase.

6.2 Network operator

The Land Mobile Radio Survey 1967

In August 1967, Carl-Gösta Åsdal, chief engineer at Swedish Telecom Radio, submitted a report regarding the future of mobile telecommunications in Sweden. The report proposed that Swedish Telecom should supply a nationwide mobile telephone network and paging networks. Although the report was positive towards the future prospects for mobile telephony, the service was looked upon as likely to be limited in terms of size and potentially not very profitable.

The investigation suggested that Swedish Telecom should develop a fully automated national mobile telephone system, and that MTB, the second Swedish mobile system, should be expanded on a regional level, pending the advent of a national system. Moreover, Swedish Telecom should initiate and conduct the development and the design of the system, since the

33 Swedish Telecom, Land mobile radio, report published by a work group for mobile telephony, August 1967.

manufacturing of mobile telephone switches and other products was not expected to reach such volumes that the industry would be willing to invest sufficient capital.[34]

The conclusive reason behind Åsdal's proposition to establish a national system was the positive experience from the first two mobile telephone systems, MTA and MTB, which had demonstrated a major interest in the services from trade and industry. The report regarded it as indisputable that the mobile telephone service should be provided by Swedish Telecom, since the service was integrated with the public telephone network. It was also part of Swedish Telecom's responsibility, as determined by the Swedish parliament, to offer telecommunication services for the entire country at affordable prices. The public telephone network was looked upon as an entire system, with signaling and all other equipment connected to it, which was Swedish Telecom's responsibility.

It was certainly feasible that end-users could own and maintain their own mobile telephones but there would be a severe problem, according to the report, if end-users owned the telephones and Swedish Telecom was in charge of maintenance. Åsdal considered Swedish Telecom to be the owners best suited to possess the mobile telephones which could then be leased out to subscribers. The mobile telephones were expected to be of standard types, obtainable from any telephone supplier after a few modifications.

Despite the fact that most of the mobile telephone systems in the world at that time were manual, Åsdal forecast that the future was headed towards fully automated systems. But none of the existing, fully automated mobile telephone systems in the world, like the Improved Mobile Telephone System (IMTS) in the US, were suitable for expansion nationally. Neither was it regarded as realistic to prepare expansion of a manual system. It was recommended that the sale of subscriptions to the new system and the lease of mobile telephones should take place through Swedish Telecom's general sales organisation.[35]

One result of Åsdal's investigation was that Swedish Telecom's radio laboratory began development work, 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. Berglund and Mäkitalo 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

34 Ibid.

35 Ibid.

operate a sophisticated mobile telephone system with advanced features such as roaming and handover. This standpoint was confirmed by Åsdal, who actively supported the development work at the radio laboratory.[36] Åsdal investigated the possibility of building a national system and increasing the number of subscribers. However, he concluded that it would be better for Swedish Telecom to work with the other Nordic telecommunication administrations in order to develop a common standard.

Development of a Nordic system

The other Nordic administrations were also active in the field of mobile telephony and were discussing the possible introduction of fully automated mobile systems. It was therefore not difficult for Åsdal to launch the idea of a joint Nordic mobile telephone system at the Nordic telecommunications conference in 1969. Åsdal saw the advantages of a common system in Scandinavia - a market of 23 million inhabitants, large enough for the industry to consider it profitable to develop systems and mobile telephones. Roaming between the Nordic countries was not a decisive argument but more of a positive side effect.

The Nordic administrations decided at the 1969 conference to reach a common system solution, which was why the working group set up was named the Nordic Mobile Telephone Group, the NMT-Group.[37] The Group would meet up to seven times a year. Meetings could last up to five days and more than 100 meetings in all were held.[38]

The NMT-Group had its first meeting in 1969. Its assignment was to develop a fully automated common Nordic mobile telephone system. The development began at the beginning of 1970, and the group was working on principles for signalling between mobile telephone switches, radio base stations and mobile telephones. However, the NMT-Group's first assignment was to develop a manual system, ready to be used immediately, and to work out a frequency plan.[39] The group should also investigate the prerequisites for a standardised signaling system for selective calling.[40]

36 Interview Carl-Gösta Åsdal, former manager Swedish Telecom Radio 16 April 1991, and interview Östen Mäkitalo Telia Research, 24 February, 1993.

37 Memorandum Swedish Telecom, Introduction of a national automatic mobile telephone network MTC, July 1975.

38 NMT Group, Hans Myhre, documentation 1993.

39 In the frequency band 453-455 MHz and 463-465 MHz.

40 NMT-Group, Minutes meeting number 1, 14-15 January 1970.

Development of a manual system

The reason why the NMT-Group had to work on a manual system was that it was anticipated that it would take quite a long time to develop an automated system, and that it was considered equally important to be able to offer a national mobile telephone service immediately.

Swedish Telecom was well aware that manual mobile telephone systems required many personnel and were expensive to run. But since the development of the automated system looked like taking a long time, it became an urgent priority to speed up the national mobile telephone service. Swedish Telecom was anxious to meet a growing demand for mobile telephony, a number of private operators concurrently showing interest in establishing mobile networks throughout Sweden. At this point, Swedish Telecom had 500 subscribers, while the various operators of private networks had 215 subscribers. This resulted in Swedish Telecom's decision to launch a transitional manual service. Åsdal played a decisive role in this process.[41]

In 1971, the Nordic telecommunication conference approved the plans of a manual system, and decided on new rules which allowed the cross-border use of mobile telephones in Scandinavia. MTD-networks were also established in Denmark and Norway.

Many people regarded a manual system as a retrograde step, but there was a belief, mainly advocated by Östen Mäkitalo at Swedish Telecom, that it was necessary to await technological improvements in micro electronics before building a sophisticated system, at least until the micro electronics industry in the late 1970's could provide computing capacity at considerably lower prices.

Mäkitalo's appointed group at Swedish Telecom's radio laboratory, consisting of about 15 persons, was responsible for the development of the manual system. According to Mäkitalo it was straightforward to install the system since they could make use of existing technology which did not require any particular development work to compile a system and allocate 80 radio channels in Sweden.[42]

The opening of a manual system – MTD

The Mobile Telephone System D (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.[43] The deployment of MTD began in the Lake

41 Interview Åke Lundqvist, Ericsson, 22 February 1994.

42 Interview Östen Mäkitalo, Telia Research, 24 February 1993.

43 Håkan Bokstam, "Televerket landsomfattande mobiltelefonsystem", Tele 1/1972.

Mälar Valley region and continued gradually throughout the country.

The system's radio parts were interconnected with the public telephone network at the service centres. The system had 80 channels, and when fully extended, 110 radio base stations. The system lay in the 460 MHz band. Aerials to radio base stations were located on TV and radio masts, which gave an effective range. MTD did not provide roaming or handover. No particular mobile telephone switches were required since it was a manual system, but Svenska Radioaktiebolaget (SRA) supplied selected system components.

The influx of subscribers was around 2300 annually, 200 000 calls were exchanged every month and the operating revenue was about SKr 20 million.[44]

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; a signal was given instead. An optical signal meant that a lamp was turned on at the receiver. [45] As far as calls from the mobile telephone were concerned, the operator responded to tone signalling by activating the calling channel. The exchange indicated the relevant base station so that the operator could expedite the call.

Profitability was satisfactory when the number of subscribers stood at around 10,000 but the costs increased immensely when the number came up to around 20,000 since at that level more than 400 telephone operators were needed, accounting for about 60-70 per cent of the network's total cost.

According to Anders Lundblad at Swedish Telecom Radio, MTD was a learning period for the operator, suppliers and subscribers, which was decisive for NMT's success. To facilitate the rapid expansion of NMT 450 in the early 1980s, frequencies were transferred from the MTD-system. MTD was phased out in 1987.[46]

NMT development from 1972

As from mid 1972, a number of working groups were established to address different aspects regarding the development of the Nordic system. In 1972, the NMT-Group commissioned the Danish company Storno [47], the domi-

44 Carl-Gösta Åsdal, "Televerket radioverksamhet, Landmobil radio", Tele 2-3 1977.

45 Håkan Bokstam, "Televerket landsomfattande mobiltelefonsystem", Tele 1/ 1972.

46 Interview Anders Lundblad, Swedish Telecom Radio, 23 August 1991.

47 Motorola acquired Storno in 1985.

nating radio company in Scandinavia at that time, to perform a signaling study and to carry out research on three different signaling methods. The study formed the basis for decisions and resulted in the group deciding on binary signaling.

Åke Lundqvist, SRA, in 1971 had expressed to Östen Mäkitalo that it was necessary to select tone signalling (computer or digital signalling) instead of the five tone signalling, according to a CCIR standard, proposed by Storno. The principal reason for Lundqvist taking that position was that five-tone signalling was primarily aimed at mobile radio and that it restricted the number of subscribers to 100,000.[48] Lundqvist, who had a vision about wireless telephones as early as in 1968, considered the limit uncalled for.[49] It was Östen Mäkitalo's opinion that NMT would have been a considerably inferior standard if Lundqvist's ideas had not been taken into consideration.[50] Storno investigated possible signalling speed for the system. This gave the group the grounds for deciding on 1200 bit/s.

In 1973, the Nordic telecommunications conference approved of the NMT-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 Nordic countries.[51] The NMT-Group stressed that the mobile telephone system should be looked upon as an integrated part of the public telephone network.[52]

In 1975, the NMT-Group examined the different costs between 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 SKr 2.5 million, including costs for development and programming, for a fully automated system. But in addition there were expedition costs of SKr 3 million per annum for a manual system while, at the same time, the mobile telephones cost an extra SKr 15 million in a fully automated system.[53]

The NMT-Group introduced a proposition, in time for the Nordic telecommunications conference in 1975, for a fully automated mobile telephone system. The system was so designed that subscribers would be treated in a similar way as in the public telephone network. The system's requirements were:

48 Interview Åke Lundqvist, Ericsson, 22 February 1994.

49 Ibid.

50 Interview Östen Mäkitalo, Telia Research, 23 February 1993.

51 NMT-Group, memorandum to the Nordic Telecommunication conference 1973.

52 Ibid.

53 NMT-Group, memorandum to the Nordic Telecommunication conference 1975.

1) automatic switching and charging – to and from the mobile telephone,
2) it should be possible to call any permanent 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 automatically give access to roaming and automatic switch between base stations (handover).

Doubtful suppliers

Even if the principles are self-explanatory today, not everyone believed that they could materialise. Representatives from Motorola, for example, visited Lundqvist at SRA in 1975 and suggested a joint approach to the NMT-Group to pursuade them to abolish the requirements for roaming.[54]

Mäkitalo involved

Östen Mäkitalo was involved in the NMT-Group from 1975. He had worked on the Mobile Telephone System C until the mid 1970s which, in practice, was the Swedish contribution to the Nordic standard. Mäkitalo consequently factored in new technology, which met with severe criticism from his colleagues. It was referred to as "Östen's curve" for technical development. Mäkitalo applied his own Moore's Law, established by Gordon Moore, one of the two founders of Intel Corporation who postulated in 1968 "in about every 18 months, performance is doubled, and prices halved for micro-processors." [55] It is also in line with what Giovanni Dosi has developed, a theory on technological trajectory which is "the activity of technological progress along the economic and technological trade-offs defined by a paradigm".[56]

Mobile telephony is certainly dependent upon several underlying technologies. Besides various radio technologies, the development of micro processes from the early 1970s has been of decisive importance for the development of the NMT standard.

Mäkitalo was convinced that the micro processors were necessary for the system to supply handover, where calls could be transferred between radio

54 Interview Åke Lundqvist, Ericsson, 22 February 1994.

55 Interview Östen Mäkitalo, Telia Research, 23 February 1993. Intel Technology Briefing, webmaster@www.intel.com.

56 G. Dosi, "The Nature of the Innovation Process", in *Technical Change and Economic Theory*, edited by G. Dosi et.al. London: Printer Publisher, 1988, p 225.

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.

NMT – 10-15 people working in Stockholm

A group of 10-15 people at the Swedish Telecom radio laboratory in Stockholm as well as two or three persons in Norway were in charge of the production of NMT. A number of committees studied various parts of the detailed description. The NMT-Group wanted to find a cost effective and flexible system, which was not too demanding of computer assistance. The mobile telephones required program memory of only a couple of kilobytes.[57]

The system's detailed description was completed in 1975, but was further developed until 1977-78.[58] A necessary requirement was that the system should be able to handle 180 channels. Many of the suppliers were reluctant and doubtful whether this was possible.[59]

It was necessary to conduct a pilot test, 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. The developers considered that one of the administrations should handle the test system, in preference to the industry, so as to utilise the knowledge that the NMT-Group had built-up and so as to maintain control over the standard.[60] The NMT-Group considered the Swedish administration, with Swedish Telecom's radio laboratory, best suited for the test. The pilot system, with comprehensive tests of all switches, radio base stations and mobile telephones ran for two and a half years and was completed in early 1978. Swedish Telecom used ten converted MTD-telephones with software developed by Swedish Telecom. The cost was SKr 1.2 million, which was shared between the administrations according the number of fixed telephones in the respective countries.[61] The cost was split in the following way: Sweden 52 per cent, Denmark 20 per cent, Norway 14 per cent and Finland 14 per cent.[62]

57 Interview Östen Mäkitalo, Telia Research, 23 February 1993.

58 NMT-Group, Nordic Mobile Telephone System Description, NMT Doc. 1 1977, Revised February 1978.

59 Interview Åke Lundqvist, Ericsson, 22 February 1994.

60 NMT-Group, memorandum to the Nordic Telecommunication conference 1975

61 According to the budget 1800 working days SKr 400-500, and purchase of material SKr 310,000.

62 NMT-Group, memorandum to the Nordic Telecommunication conference 1975.

End-users own the equipment

The NMT-Group suggested that the subscribers should purchase or lease the mobile telephones from radio suppliers, after the telephones had been accepted according to type. This proposition was supported by the Nordic Telecommunications conference.[63] No administrations were then forced to invest in either mobile telephones, distribution or service networks. The end-users could freely choose equipment and could then receive better service when travelling to another Nordic country.[64] Swedish Telecom required a type approval from either the radio laboratory, or the Nordic administrations, so that the mobile telephones could be used in the Swedish network.

Difference US – Sweden cellular

Östen Mäkitalo, manager of the radio laboratory, visited the famous Bell Lab at American Telephone & Telegraph (AT&T) during the 1970s, and was able to ascertain that the radio laboratory was doing equally well as Bell Lab's when it came to the development of automated mobile systems. According to Mäkitalo, the Americans were concentrating on geographic delimited systems; as opposed to the Nordic system that concentrated on the concept of:

1) creating a large surface reach;
2) locating a subscriber no matter where;
3) using the frequencies effectively, and
4) keeping the calls to a more effective radio base station by an automatic switch.[65]

The reason for mobile telephony being delayed in the US was that the responsible authority for frequency allocation, the Federal Communications Commission (FCC) ran into procedural problems with allocation of licences for network operators.[66]

Östen 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 him, it was difficult to convince his Swedish and Nordic colleagues about the necessity of a small cell technique, since 180

63 Ibid.

64 Swedish Telecom, Memorandum July 1975, Introduction of a national automatic mobile telephony, MTC.

65 Interview Östen Mäkitalo, Telia Research, 23 February 1993.

66 M. von Platen, *Boken om Stenbeck*, Stockholm: Dagens Industris Förlag, 1993. M. Paetsch, *Mobile Communications in the US and Europe: Regulation, Technology, and Markets*, Norwood, MA: Artech House, 1993.

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 efficiency by introducing a small cell technique. Mäkitalo had discovered that the subscribers only moved a couple of kilometres at normal speed during a mobile call lasting approximately two minutes. 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 was a considerable improvement in economising on frequencies. Still, it was necessary to have access to processing capacity to look after how the frequencies were used. True, small cell techniques did bring the need for additional radio base stations, but the higher capacity would compensate the extra investment.[67]

Nordic Mobile Telephone – NMT

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 a year after the start, the number of subscribers had increased to more than 35,000 in Scandinavia, and traffic growth exceeded projections by a comfortable margin. As from October 1982, roaming began to work 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 in order 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 made to extend NMT to the 900 MHz band.[68]

The specifications for the new standard, NMT 900, were completed in 1985. It originated in NMT 450, but was in a higher frequency band and had more channels, as well as a few new components such as noise limiter

67 Östen Mäkitalo, Frekvensekonomi i mobilradiosystem, Tele 4/1975.

68 NMT-Group, memorandum 12 January 1983.

and compander. The system was designed as a small cell system, which gave higher capacity, suitable for handportable or pocket telephones, which had not been permitted in the NMT 450 system, 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 nation.

During 1984/85 it was discussed whether it would be possible for Swedish Telecom to purchase a fully developed system, such as the American AMPS, or the British TACS, which would give end-users 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. Åke Lundqvist at Ericsson Radio tried, without success, to convince Swedish Telecom to select a standard that was already developed. But Carl-Gösta Åsdal, responsible at Swedish Telecom Radio, responded that in such case they should purchase equipment from an American company.[69] Lars Ramqvist, Ericsson Radio's managing director, also tried 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 launching was sluggish at first due to the new system that did not offer subscribers anything new in comparison with NMT 450. Not until the launching of handportable telephones, and the network expansion outside urban regions, did the market grow. The increasing number of subscribers also motivated an expansion of the network in the whole of Sweden.

Ericsson did not believe in a public mobile telephone network and was working on a closed radio system. In the co-operation between Ericsson and Swedish Telecom, Ericsson often played a minor role.[70] Swedish Telecom co-operated to some extent with the Danish Storno during the early period in mobile telephony development.[71]

Effects of underestimation

The continuous under estimation of the demand for the mobile telephone service led to the operator, Swedish Telecom, having a problem in keeping up with the high demand and in sufficiently expanding the network, and

69 Interview Åke Lundqvist, Ericsson, 22 February 1994.

70 Interview Östen Mäkitalo, Telia Research, 23 February 1993.

71 Interview Carl-Gösta Åsdal, former executive Swedish Telecom Radio, 16 April 1991.

suppliers had problems producing sufficient numbers of system equipment and mobile telephones. These shortcomings forced Swedish Telecom to be more market oriented and improve its service ability. It was also a clear signal to the business community of the growth potential of mobile telephony.

Expansion of NMT internationally

On an international level there were three analogue mobile telephone standards competing in the 1980's, the Nordic NMT, the American system, AMPS, and the British system, TACS. Beside these standards some national European standards existed, for example the German C-Net and a French system.

According to Bo Magnusson, it was obvious from the beginning that NMT had to expand beyond the Nordic markets, so that industrial enterprises would become interested in further development of mobile systems and telephones. Swedish Telecom therefore discussed the advantages of NMT in various contexts, to convince operators abroad to invest in the NMT-system.[72]

NMT 450 was one of the alternatives when the Department of Trade and Industry and the two network operators in the United Kingdom were going through the process of deciding which available standard to chose. Other alternatives were a Japanese standard from Nippon Telephone & Telegraph (NTT), the German system C450, a system developed by Alcatel and Philips called MATS-E and the US standard AMPS.

The Japanese system was considered to be technically acceptable but was only supplied by one company (NTT) and therefore not an alternative. The same was the case for the German C450 system, which was considered as elegant but very expensive and only available from Siemens. The MATS-E system developed by Alcatel and Philips was technically attractive but unproven, as no operator had yet installed it. NMT 450 was considered as not providing sufficient capacity for the center of London and suffered from a relatively slow signaling speed which was why it was not a competitive alternative. (NMT 900 was not available at this stage.) The AMPS standard was tested and met the general requirements. It was available from several suppliers and operated at a frequency band only 70 MHz below the 900 MHz band, which was why it was considered to be the best alternative to be used in the UK. The two appointed operators and the Department of Trade and Industry in 1983 decided to modify the American standard Advanced Mobile Phone System (AMPS) and name it Total Access Communication System (TACS).[73]

A difference between NMT and TACS is that NMT has an open interface

72 Interview Bo Magnusson, Swedish Telecom International, 20 September, 1991.

73 Garry. A. Garrard, *Cellular Communications: Worldwide Market Development*, Norwood, MA: Artech House 1998, p 98.

between base stations and mobile telephone switches which enables supplier independence. Although not chosen by the UK authorities, the NMT standard succeeded in getting established in a number of other countries. As NMT was not patented it was open to any supplier interested in building systems or in mobile telephones. This contributed to the continuous growth in the installed base of subscribers, pressing down prices on system and telephones.[74]

Competitors in the network operators' market

A number of companies operated mobile telephone networks in Sweden up until 1981, when Swedish Telecom got its first major competitor in Comvik. The majority of these companies were local or regional operators, but some covered relatively large parts of the country, and thereby competed directly with Swedish Telecom. Most of them were smaller companies with mobile telephony as a sideline, but there were some having it as a principal line of business. According to Swedish Telecom, the common problem among the private operators was of financial character, which Swedish Telecom had to solve by keeping the companies alive, in order to avoid the subscribers from being affected.[75]

Another private operator, Biltelecentralen AB, applied for frequencies to establish a mobile network with a capacity of up to 1000 subscribers. According to practice, Swedish Telecom reserved only one channel for a new operator and gradually increased the number when the network expanded. Nordiska Biltelefonväxeln, managed by Arne Byström and which operated a network in Göteborg and Stockholm, was established when a few smaller operators merged in 1971.

In 1970, Telelarm received permission to operate in the 400 MHz band, at which time it had 151 subscribers, which had grown two years later to 800. The subscribers were offered specific secretarial services such as looking after orders and booking tickets.[76]

In 1971, a total of 13 operators offered mobile services and together they had 45 private base stations. The three largest operators were Telelarm AB, AB Svenska Sambandscentralen, and Nordiska Radiocentralen. The mobile terminals were leased or privately owned and each customer needed a permit from Swedish Telecom to operate a radio transmitter. [77]

74 Interview Jan Sverup, Ericsson Radio, 7 May 1991.

75 Swedish Telecom, Comment General Director, 14 October 1981.

76 Magnus Karlsson, *The Liberalization of Telecommunications in Sweden*, Linköpings: Linköpings University, 1998. p 228, based on Communication from Telelarm to Swedish Telecom, 7 January, 1970, 10 November, 1972.

77 Magnus Karlsson, *The Liberalization of Telecommunications in Sweden*, Linköpings: Linköpings University, 1998, p 228, based on Swedish Telecom, 10 November, 1981 p.4, Telestyrelsen, 9 December, 1970 §6 SM 101.

In 1972, Nordiska Biltelefonväxeln AB (NOBAB) and Telelarm Mobiltelefon AB were the two major private operators. Both firms had considerable difficulty in complying with Swedish Telecom's directives and policy, comprised of various requirements on the networks in the mid 1970s.

Swedish Telecom presented a new and restrictive policy in November 1979 with the aim of a) protecting the public network from interference, b) limiting the number of private networks in order to provide a rational solution for less profitable areas, c) maintaining frequency economy and d) creating a more pleasant environment by limiting the number of antennas and radio installations. Swedish Telecom's standpoint was that mobile telephone networks with manual connection to the public network could be established in areas where Swedish Telecom's network was yet not extended. Automatic mobile telephone traffic was not permitted according to the directive. Swedish Telecom charged a fee of SKr 240 annually for each mobile subscriber to the private networks. The purpose of this fee was to contribute to the financing of network deployment in sparsely populated areas of the country.[78]

Svensk Kommunikationskonsult AB, the general agent for Salora mobile telephones, acquired Telelarm in 1979, and changed the company's name to Företagstelefon AB. Lennart Lindström, with a background from the Nordiska Radiocentralen AB in Stockholm and experienced in mobile telephony, managed the company. When Salora, which supplied mobile telephones to Swedish Telecom's MTD system as well as Företagstelefon's system, terminated the agency and set up a business in Sweden, Företagstelefon suffered enormously and almost went bankrupt. However, it recovered and in mid-1980 the company purchased Nordiska Biltelefonväxeln AB giving access to an additional number of frequencies and an installed base of 1,900 subscribers. By then, Företagstelefon was the only private mobile telephone operator in Sweden.[79]

Företagstelefon prepared for a new mobile telephone system and in October 1980, the Company applied for a licence to operate a fully automated mobile telephone system with mobile telephone switches supplied by Rydax Inc and to interconnect to the public network.[80]

Swedish Telecom rejected their application. Företagstelefon's managing director Bo Hammarstedt appealed against the decision to the Director

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78 Magnus Karlsson, *The Liberalization of Telecommunications in Sweden*, Linköpings University, 1998, p 229, based on Swedish Telecom directive, 28 February, 1974, 6 April, 1976, 20 November, 1979, 5 September, 1980.

79 Communication from Företagstelefon to Swedish Telecom, 1 September, 1980, Interview Lars-Erik Almberg, Frequency Management Swedish Telecom Radio, 7 September 1990, Lars-Erik Almberg Swedish Telecom Radio, memorandum, Development phases of network operators up until Comvik AB, 10 November 1981.

80 Communication from Företagstelefon to Swedish Telecom, 13 October, 1980.

General of Swedish Telecom. A series of exchanges took place between the two parties. Swedish Telecom consistently refused to give permission for an automatic exchange. The company for its part emphasised the necessity of taking advantage of more advanced technology and to improve the efficiency of the operation. Swedish Telecom argued that mobile telephone equipment concerned equipment for voice communication over the public network, which according to the telecommunication policy set by the Swedish Parliament and Swedish Telecom's Directive should be included in the monopoly area. Furthermore, Swedish Telecom underscored a number of factors such as government policy, frequency economy, the planned deployment of NMT, national goodwill and the insecurity it could cause the Swedish industry, supporting the standpoint not to let Företagstelefon have the permission to connect automatic switches. However, the Director General of Swedish Telecom announced that he was willing to allow Företagstelefon to connect its system to the public telephone network, providing that the mobile network was operated manually.[81]

In March 1981, Företagstelefon applied for a type approval to operate their radio switches manually, which was approved by Swedish Telecom at the end of May. The two parties decided to co-operate and Swedish Telecom should assist Företagstelefon to improve its manual system. The switches should be modified and approved for manual connection, frequencies in the 450 MHz band should be allocated, a method for transferring certain customer categories from the MTD system should be discussed and Företagstelefon should be able to establish an integrated secretary service within the NMT system.[82]

Företagstelefon implemented the new switches during the summer of 1981 and was then almost the only private competitor to Swedish Telecom because there were only two other small operators remaining. When Företagstelefon took over the activities from NOBAB, one of its associated companies, NOBAB Biltelefonväxeln i Västra Sverige AB was not included in the transfer, only the frequencies. The company operated a network in Göteborg but had no frequency permit. The same was the case for Biltelefonväxeln i Södra Sverige AB.[83]

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81 Communication from Swedish Telecom to Företagstelefon, 21 November, 1980, Directive 5 September, 1980, Communication from Företagstelefon to Swedish Telecom, 11 November, 1980, 12 December, 1980.

82 Communication from Företagstelefon to Swedish Telecom, 24 March, 1981, Communication from Swedish Telecom to Företagstelefon, 26 May, 1981, Swedish Telecom report, 3 June, 1981, Magnus Karlsson, *The Liberalization of Telecommunications in Sweden*, Linköpings University, 1998, p 232.

83 Magnus Karlsson, *The Liberalization of Telecommunications in Sweden*, Linköpings University, 1998, p 238 based on Communication from Swedish Telecom to the Government, 15 March, 1982, 11 June, 1982, government decision, 25 March, 1982 NO 10, communication from Biltelefonväxeln i Västra Sverige to the Government, 3 June, 1982, 14 June, 1982, Government decision, 30 June, 1982 No 9, and 30 June, 1982 No 10.

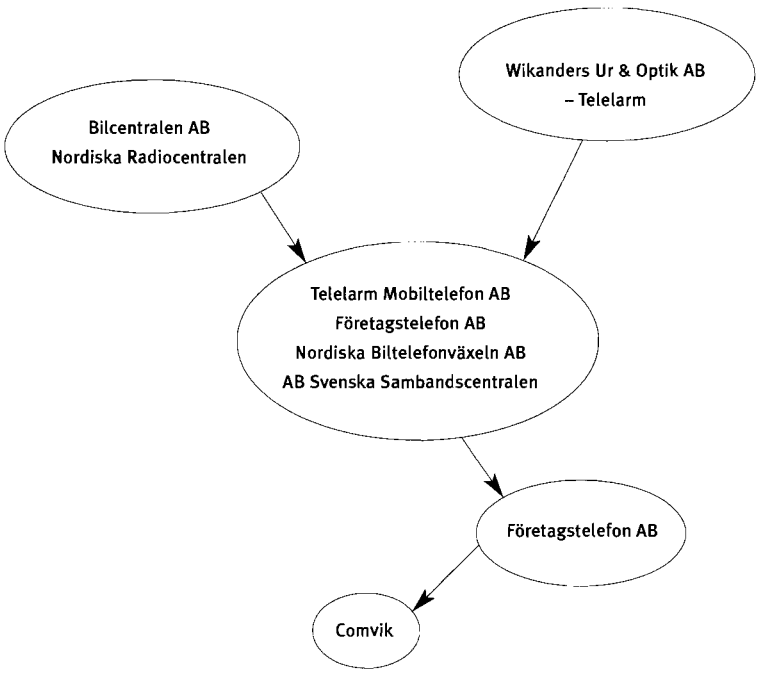

Figure 3 / **Private operators from Wikander to Comvik**

Kinnevik becomes a mobile telephone network operator

In September 1981, Industriförvaltnings AB Kinnevik acquired Företagstelefon and reorganised it into Comvik. The company then had a network with frequencies spread over different frequency bands and had the ambition to consolidate a network in the 460 MHz band.[84] Soon afterwards the company introduced its mobile telephone system, which consisted of six Rydax mobile telephone switches from E.F. Johnson in the US. Concurrently the older systems were phased out.

The main owner of Kinnevik, Jan Stenbeck, was engaged in mobile telephony projects in the US through his American company Millicom Inc., which he founded in March 1979 together with Shelby Bryan. They had a vision that mobile communication was to become a potential future market.

84 Industriförvaltnings AB Kinnevik Annual Report 1989.

Millicom's business concept was to take advantage of the deregulation within telecommunications by applying for licences, as well as to operate mobile telephone networks together with local partners and investors internationally.[85] Before Millicom was founded, Stenbeck with partners had acquired Millitop, a company involved in military communication. But the allocation of operators' licences in the US was turning out to be a lengthy process, which made Stenbeck move his attention to Swedish mobile telephony. The interest in the Swedish mobile telephone market also resulted from the fact that Jan Stenbeck had been taking responsibility for the family company Industriförvaltnings AB Kinnevik since 1977. It was originally planned that his older brother should manage the Company but he died in 1976 a year before his father.[86]

In the late 1970s, mobile telephony was tested at three locations in the US. Millicom succeeded to get one of the three development authorisations to establish a test system in Raleigh-Durham in North Carolina. The two other systems were set up by Illinois Bell, which was AT&T's operating company in Chicago, and American Radio Telephone Service, a subsidiary of Motorola. Millicom's objective was to evaluate the market for new handportable telephones which could then be a radical innovation since all phones at the that time were quite large and could only be mounted in vehicles.[87]

The plan was that Millicom together with E.F Johnson and Racal and other partners should develop a handportable mobile telephone in the US. Moreover, ITT should develop switches and Thomson radio base stations. Therefore, Racal sent a team of engineers to the US to carry out the necessary development, and their plan was to modify the phone for UK use and manufacture it at their Seaton plant in Devon.88 However, the project did not result in development of any new products and was dismantled after a year.[89]

Nevertheless, an outcome of the project was that Millicom succeeded in concluding a deal with Racal, helping them to submit a successful bid for a UK mobile telephone network licence and establish the network operator Racal-Vodafone.[90] It was Gerald A Whent, responsible for radio communication at Racal, and Jan Stenbeck who laid the foundation for the venture. Together

85 Millicom Annual Report 1985.

86 J. Meurling and R. Jeans, *The Mobile Phone Book*, London: Communications Week International, 1994. M. von Platen, *Boken om Stenbeck*. Stockholm: Dagens Industri Förlag, 1993.

87 Garry. A. Garrard, *Cellular Communications: Worldwide Market Development*, Norwood, MA: Artech House 1998.

88 Ibid. p 97.

89 Millicom Annual Report 1985 and 1986.

90 Garry. A. Garrard, *Cellular Communications: Worldwide Market Development*. Norwood, MA: Artech House 1998, p 32.

with Racal Electronics they formed a joint venture Racal-Millicom in which Millicom had a 15 per cent equity and Hambros Advanced Technology Trust 5 per cent. The Racal-Millicom company owned the network operator Vodafone.

In December 1982, the Department of Trade and Industry (DTI) in the UK allocated one licence to Cellnet, formed by British Telecom (BT) and the private company Securior, and the second licence to Racal-Vodafone. A decisive factor in Racal-Vodafone receiving the second licence was that the company had an aggressive and well-developed market plan.

In 1986, Racal bought out Millicom and Hambros from Racal-Millicom Ltd in a deal that valued the company at £ 80 million. It gave Millicom shares in Racal Telecom and US$ 30 million in cash as a transfer of its 10 per cent pre-tax profit royalty for profits for the subsequent 15 years.[91] Millicom gradually sold its holdings to finance investments in mobile telephone networks in developing countries.[92] This meant that Kinnevik, which partly owned Millicom, had an extensive international mobile network operation as well as a mobile telephone business in Sweden.

Comvik launches its network

Comvik continued the plans Företagstelefon had outlined for the modernisation of its network. In September 1981, Swedish Telecom discovered that Comvik violated the permit by using an automatic exchange which was why Swedish Telecom reacted strongly. According to Swedish Telecom, there was an apparent risk of serious interference to the public telephone network, since it was unclear how the signalling was worked out.[93] Swedish Telecom threatened to disconnect Comvik's system from the public telephone network.[94]

Comvik appealed against the disconnection to the Director General of Swedish Telecom, and claimed that the company's 15-year-old mobile telephone business was threatened.[95] 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 net".[96]

Swedish Telecom argued that an exemption from the monopoly would set a precedent, resulting in more companies wishing to operate private

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91 Millicom Annual Report 1985 and 1986.

92 Garry. A. Garrard, *Cellular Communications: Worldwide Market Development*, Norwood, MA: Artech House 1998. Interview Håkan Ledin, Millicom International, 12 March, 1991.

93 Interview Carl-Gösta Åsdal, Swedish Telecom Radio, 16 April 1991.

94 Communication from Swedish Telecom's Radio Control station to Swedish Telecom's Radio Division 25 September 1981.

96 Communication from Swedish Telecom to Comvik 21 November 1981.

mobile networks. Thereby there was a clear risk of not being able to expand the new NMT system in remote regions 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.[97] At this time, Comvik attracted about 30 per cent of the new mobile telephone subscribers.

The significance of this case and the reluctance to open the market for competition is underscored by a communication from LM Ericsson to the Government. Björn Svedberg, Chief Executive Officer, LM Ericsson supported Swedish Telecom's restrictive policy and argued that Swedish Telecom should be able to establish a national network without competition from a private network operator. It could challenge NMT's expansion since it was anticipated that the private operator primarily would expand in profitable urban areas. Svedberg emphasised that a rapid deployment of NMT throughout Sweden was a prerequisite for NMT's as well as Ericsson's success on international mobile telephone markets, thereby securing employment in Sweden.[98]

Even though Swedish Telecom had the vast majority of mobile telephone subscribers, the company did not attract all the new customers since the private operators signed up every fourth or fifth new subscriber, as the following table indicates.

Table 11 / **Swedish Telecom's share of the network market 1979-83**

	Swedish Telecom's share in per cent of the total number of mobile telephone subscribers	Swedish Telecom's share in per cent of new mobile telephone subscribers
1979	89	67
1980	90	75
1981	92	76
1982	91	89
1983	91	92

Not surprisingly, the trade union supported Swedish Telecom's position and argued that mobile telephony unquestionable should be included in the monopoly. According to the trade union, Comvik had no aspirations towards

97 Communication from Swedish Telecom to Comvik 10 October 1981, Communication from Swedish Telecom to the Government 14 October 1981.

98 Magnus Karlsson, *The Liberalization of Telecommunications in Sweden*, Linköping: Linköping University, 1998, p 235. Based on Communication from LM Ericsson to the Government, 3 November, 1981, communication from Statsanställdas förbund et. al to the Government, 12 November, 1981.

achieving national coverage and neither did it contribute to the labour market as it imported all its equipment from the US.[99]

Comvik appealed to the Swedish Government and asked for a licence to connect its automatic system to the public telephone network, arguing that it was specialised in customer related services. Comvik also claimed that a rejection of their request would make customers suffer economically, left holding worthless mobile telephones that had cost almost SKr 10,000 each. The company would have to terminate its business and employees would lose their jobs.[100]

Comvik gave assurance that 50 per cent of the network's mobile telephones would be manufactured in Sweden, which would mean excellent export opportunities for industries. Comvik emphasised that it was not going to change its business since the company and its predecessors had been operating a licence for 15 years. So, according to Comvik, the case could not be considered as setting a precedent. Besides, Swedish Telecom would have no problem in competing with Comvik, since the NMT system was technically considerably more sophisticated.[101]

In December 1981, the Government decided to grant Comvik the licence. However, it was referred to as an exemption. The Government did not question whether mobile telephony was protected by Swedish Telecom's monopoly, since it had to do with voice communication over the public network, but argued that specific circumstances applied and that it was one way to increase the competition in the market. It was also in accordance with the ideology of the liberal and center government in power in Sweden at the time. The Government, however, regarded Comvik's activities as relatively small. There were approximately 2,000 subscribers, and the company anticipated that they 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 it already had at its disposal.

Gradual expansion

After the first expansion of the network for SKr 24 million Comvik's network covered the mid and south of Sweden, but the network was not cellular from the start. Comvik leased and sold telephones under their own logotype, E.F Johnson supplied the first one. From 1983 Comvik also offered a model from Technophone. Comvik commissioned Nils Mårtensson's newly founded

99 Ibid.

100 Communication from Comvik to the Government, 6 October 1981.

101 Communication from Comvik to the Government, 6 October, 1981, 26 October 1981.

company Technophone, with two employees at the time, to develop it.

In 1982, Comvik's market organisation with sales staff expanded. During 1982, the company invested SKr 53 million in the network. In early 1983, the network was almost nation-wide with 140 radio base stations, rented telephone lines, six automatic switches and six staffed centrals. Comvik used aggressive ways of marketing; methods quite foreign to Swedish Telecom.

In 1984, when Comvik asked for another twelve frequencies, the Director General of Swedish Telecom denied this, and Comvik appealed to the Government. Swedish Telecom responded on the appeal in September 1984.[102]

In April 1985, Chief Executive Officer Daniel Johannesson, Industriförvaltnings AB Kinnevik, Comvik's owner, 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 12 frequencies.[103] In June 1985, the Government decided to allocate another eight frequencies to Comvik; it then had 34 frequencies at its disposal.[104]

Comvik in 1985 dropped the plans to construct a complete new system. According to the management, the company would have built a TACS system if it had been allocated sufficient with frequencies.[105] 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 in allocating Comvik 120 frequencies in the 900 MHz band.[106]

The original system was improved, and during 1986, roaming was introduced between switches. In Stockholm the system was reconstructed into a small cell system, which meant that the call capacity was tripled. The coverage was improved, particularly in northern Sweden.

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 it had 50 frequencies at its disposal.[107]

According to Torbjörn Johnson Radiosystem, who sold radio base stations to the Comvik when it introduced small cell structure, the company had difficulty in keeping up with the technical development and offered too few and much too inadequate mobile telephone models.[108] But Comvik explained

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102 Communication from Comvik to Swedish Telecom, 22 March, 1984, Communication from Swedish Telecom to Comvik, 22 May, 1984, Communication from Swedish Telecom to the Government 25 September, 1984.

103 Communication from Industriförvaltnings AB Kinnevik to the Government, 16 April, 1985.

104 Government Decision, 27 June, 1985, II 1153/84.

105 Interview Thomas Julin, Comvik GSM AB, 11 April 1991.

106 Communication from Comvik to the Government, 18 April 1986.

107 Government Decision, 12 June, 1987, II 678/86.

108 Interview Torbjörn Johnson, Ericsson Access (Radiosystem), 23 February 1993.

that its weak position in the market had to do with the action taken by Swedish Telecom in not allocating a sufficient number of frequencies, as well as the unsatisfactory connection to the fixed telephone network.

For a period of two years Comvik tried to purchase AXE-switches from Ericsson, but Swedish Telecom who held the exclusive rights for the Swedish market refused to sell any equipment to Comvik. The company pursued the issue to the Market Court, but just before the case was due to come up for hearing Comvik decided to drop the case.

Comvik dismantled its analogue network in 1996, transferring the remaining subscribers to the digital network that Comviq had been operated since 1992.

6.3 System suppliers

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

Co-operation between the industry and the NMT-Group

During the development of NMT, the industry was continuously sharing the specifications and proposing changes. This gave the NMT-Group an opportunity to find technically and economically realistic solutions while the suppliers could effect improvements to radio base stations, switches and mobile telephones. When the NMT-Group held its first information meeting at the end of 1971, some 40 companies expressed their interest in developing equipment to the Nordic standard. In this period, the NMT-Group met representatives from a large number of Swedish as well as international companies, such as Tekade, ITT, Martin Marietta, Motorola, AP Radiotelefon, Sonab, SRA, Storno, and Ericsson. Several Japanese companies, such as Mitsubishi and NEC, also showed interest, and according to Mäkitalo, were prepared to factor in the new technical development.[109]

In 1977, the NMT-Group invited tenders from a number of companies. In competition with many others, like Fujitsu, Hitachi, Motorola and

[109] Interview Östen Mäkitalo, Telia Research, 23 February 1993.

especially NEC, LM Ericsson obtained the order with its AXE switches, adjusted for mobile telephony. In September 1978, the telephone administrations in Denmark, Norway and Sweden ordered mobile telephone switches from Ericsson.

At first, Ericsson's intention was to offer the AKE-13 exchange, which had been developed during the 1960s, and which had a computer controlled cross bar switch system. But Swedish Telecom did not consider the system to be fully sophisticated which was why it prescribed Ericsson to supply the AXE switch instead. The digital AXE switch was developed at Ellemtel Utvecklings AB, which was Ericsson's and Swedish Telecom's common development, in itself a fascinating story.[110] Mobile telephony was not regarded by Ericsson as being a particularly interesting application, particularly as AXE was originally not meant for mobile telephony.[111] According to Anders Lundblad, Swedish Telecom Radio, the AXE exchange was not a requirement for NMT, but a good choice considering further expansion.

Ericsson adopts mobile telephony

Ericsson in the 1970s had a rather guarded approach towards the concept of a public mobile telephone system, as such, since the company's aims were more in line with mobile radio systems used by emergency services for example and in the transport sector.[112] But orders from the Nordic telecommunication administrations, as well as from Saudi Arabia, demonstrated mobile telephony's market potential. Accordingly, Ericsson secured a place in the domestic market and obtained access to a mobile telephone network to exhibit to potential customers.

Since Ericsson had established relationships with telecommunication administrations around the world, and the AXE switch turned out to be a success, the company could gain a competitive advantage.[113] Ericsson was soon the dominating enterprise in mobile telephony, a position it succeeded in retaining even when the world market expanded. Ericsson was aware from the outset that the AXE switches could more than cope with the modest subscriber growth projected. When the influx of subscribers grew considerably, the switches could easily handle the growth and generated a positive revenue stream for the mobile telephone network operators.

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[110] See J. Meurling and R. Jeans, *A Switch in Time*, USA: Telephony, 1985, and B-A Vedin, *Teknisk Revolt*, Stockholm: Atlantis, 1992.

[111] B-A Vedin, *Teknisk Revolt*, Stockholm: Atlantis, 1992.

[112] Interview Bengt Dahlman, Ericsson (Magnetic) 3 September 1991.

[113] Interview Jan Sverup, Ericsson Radio Systems, 7 May 1991.

Ericsson's long history in radio communication

Ericsson's commitment to the radio sector goes back 80 years, to 1919, when Svenska Radioaktiebolaget (SRA) was founded by Telephone Company LM Ericsson, Gasackumulator AB (AGA), Allmänna Svenska Elektriska AB (ASEA), as well as three financial institutions, with the aim of developing and manufacturing equipment within radiotelegraphy and telephony. The company was directed by Dr. Maurtis Vos, who had been the manager of Telefunken's laboratory for developments in Berlin.[114]

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 a partner in SRA. In 1927 Ericsson bought out the rest of the Swedish owners and then controlled 57 per cent of the company. In 1965, Ericsson increased its share to 71 per cent by purchasing a part of Marconi's share holding.

SRA supplied a wide range of products within radio, serving both the private as well as the military market. Among the products were transmission equipment for radio, gramophones, TV-sets called Radiola, police radio systems, paging systems, and 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 concentrated, as from then, on communication radios and radio equipment serving the defence.

Expansion through acquisitions AGA – Sonab

As far back as the early 1960s SRA aspired towards purchasing AGA's mobile radio business which manufactured communication systems, marketing them to public and private organisations, but SRA's aspirations did not meet with success. AGA Mobilradio AB, which at the time had 475 employees and revenue of SKr 30 million, was acquired by Sonab instead.[115] AGA had a significant share of the mobile radio equipment market which at this period was growing at the rate of 15 per cent annually in Sweden and Finland. Moreover, the company sold to the other Nordic countries and North America. AGA sold its mobile radio business as the management considered that mobile radio demanded greater sale and service organisation compared with the company's other products, and that an international expansion would lay claim to considerable resources.[116]

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114 Ingvar Bevenius, "History of Ericsson Radio Systems AB", memorandum 31 January 1994.

115 AGA Annual Report 1972.

116 AGA Klipp nr 6 1974.

Sonab AB was founded in 1966 to market loudspeakers developed by Stig Carlsson, so called Carlsson speakers, and was part of a state holding company, Statsföretag AB. The company started to concentrate in the early 1970s on industrial electronics and communication systems with mobile telephony and paging as a priority. Sonab soon became a leader in mobile telephones on the Nordic market and was the leading supplier of radio communication in Sweden, apart from SRA, with the acquisition of AGA Mobilradio AB. The company expanded strongly but the venture on communication equipment demanded large development resources, which led to financial problems.

In January 1978, SRA[117] acquired Sonab with 400 employees and manufacturing and sales departments in a number of countries. SRA then obtained access to new products, such as mobile telephones and components to radio base stations, as well as significant 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 that had the competence in the sector of mobile radio and the mobile telephony knowledge that Ericsson needed.[118]

In 1981, SRA acquired the Dutch firm Nira which manufactured pagers.

System supplier

SRA was unsuccessful in obtaining any orders relating to radio base stations for the MTD-system in the 1970s, since its products were not sophisticated enough. In 1979, SRA introduced an automatic mobile telephone network based on the NMT standard comprising the AXE switch and with radio base stations from Sonab. The company delivered such a system to Saudi Arabia in 1981, an order worth SKr 50 million.

A mobile telephone network supplied to the Buffalo Telephone Company in 1983 and worth SKr 25 million was the first mobile telephone system to be installed by Ericsson in the US. Ericsson received financing from the Swedish Investment Bank to fulfil that order.[119]

A conclusive reason for SRA investing in mobile telephony notwithstanding a certain lack of interest from the management at Ericsson was that Marconi partly owned the company up to 1982. It was not until 1982/83 that SRA become a wholly owned subsidiary of LM Ericsson, to then be

117 In 1978 Svenska Radio AB changed its name to SRA Communications AB.

118 Interview Åke Lundqvist, Ericsson, 22 February 1994.

119 Dagens Nyheter 15 July 1995.

reorganised into Ericsson Radio Systems. A deciding factor in Ericsson acquisition of Marconi's shares was the fact that the British company was owned by CSE General Electric, a direct competitor within the area of public telephony.[120]

The sale of systems

Prior to 1982, LM Ericsson and SRA tendered for different contracts where it concerned mobile telephone systems: LM Ericsson offered mobile telephone switches while SRA offered radio base stations, i.e. system integration was the buyers' function. But from 1982 onwards, Ericsson's objective was to sell integrated systems. A contract awarded by the telecommunication administration in the Netherlands for the expansion of an NMT network there triggered this change in policy. LM Ericsson, as usual, offered the switches and SRA the radio base stations but the Dutch telecommunication administration was only interested in buying switches from Ericsson, and intended to buy radio base stations from Motorola. Ericsson's reaction was positive initially, but Åke Lundqvist, Managing Director of SRA, objected. He managed to stop the deal and to force Ericsson not to supply the switches unless the Ericsson Group supplied the radio base stations as well. Lundqvist was convinced that if Motorola got access to the AXE switches, Ericsson's position would weaken considerably. In the final event, the Dutch telecommunication administration decided to purchase the equipment from Ericsson/SRA, but stipulated that the network should consist of the small cell technique. Ericsson's experts advised it would take two to three years to develop such a technique. Lundqvist, through an American friend, turned to Chandos Rypinski, an American expert in cell structure, who not only played an important role in the expansion of the Dutch system but also in Ericsson getting established in the US.[121]

Vodafone selected Ericsson as supplier to its mobile network in the UK. It went for the AXE switch as it was well proven and met all likely requirements. The Ericsson system required somewhat more development than Motorola's since no TACS version was immediately available, even although the AXE switch was in use for NMT 450 in the Nordic region. Ericsson delivered the system to Vodafone in late 1984.[122]

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120 Interview Åke Lundqvist, Ericsson, 22 February 1994.

121 Ibid.

122 Garry A. Garrard, *Cellular Communications: Worldwide Market Development*, Norwood, MA: Artech House 1998, p 97.

In order to strengthen its radio base station products, Ericsson purchased Magnetic in 1983, which had 140 employees at the time and revenue of SKr 140 million, 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.[123] Through this acquisition, Ericsson doubled its market share in radio base stations to 40 per cent of the world market. The purchase of Radiosystem gave Ericsson greater capacity in production, as well as access to more research and development facilities. According to Lundqvist, Ericsson's chairman of the board, Hans Werthén, did not at first approve of the Radiosystem acquisition but it turned out to be a very profitable affair in the long run.[124] Whertén agreed that it was strategically correct to acquire Radiosystem but realised that Ericsson lacked the necessary capital. It was far from easy to arrange the financing and, after an attempt to raise the capital in New York failed, Investeringsbanken in Stockholm agreed to provide the financing.[125]

Magnetic – manufacturers of MTD transmitters

Magnetic, a small company in the 1960s with only a hundred employees, manufactured a diversity 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 to the manual mobile telephone system, MTD, Magnetic received the entire 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.[126] The economic development for Magnetic is presented in the following table.

123 Interview Åke Lundqvist, Ericsson, 22 February 1994.

124 Ibid.

125 Marika Ehrenkrona, *Passion för teknik, om drivkrafter inom Ericsson Radio Access*, Stockholm: Ekerlids Förlag, 1998. p 77.

126 Interview Torbjörn Johnson, Ericsson Access (Radiosystem), 23 February 1993.

Table 12 / **Magnetic AB economic development 1974-83**

Year	Annual turnover in million SKr	Profit after financial items in million SKr	Number of employees
1974/75	25.5	0.3	136
1975/76	29.7	0.2	137
1976/77	42.2	4.1	136
1977/78	51.8	0.9	135
1978/79	32.2	2.1	130
1979/80	58.6	1.6	118
1980/81	55.8	1.3	101
1981/82	66.9	1.6	95
1982/83	58.1	6.2	95

Source: Magnetic Annual report 1974-83

Under Johnson's management, Magnetic developed NMT radio base stations. After a dispute with the owner, Johnson left the company and established Radiosystem. Johnson had a royalty agreement with the owner which was not kept, so when Magnetic received an order in 1978 worth SKr 30 million for products developed by Johnson – without him being compensated – he gave in his notice.[127]

Radiosystem increased its value by SKr 465 million in ten years

Torbjörn Johnson, with SKr 5,000 in start up capital, established Radiosystem in 1978, together with two colleagues from Magnetic: Tommy Moberg, expert on amplifiers, and Leif Kågström, specialised in filter.[128] Johnson was convinced that mobile telephony was to become the thing of the future, and that those products Radiosystem planned to develop – which would be based on the products that Johnson had developed at Magnetic – had a great market potential. [129]

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 combiners for mobile telephone systems. Radiosystem supplied equipment to a number of

127 Ibid.

128 Initially, the name of the firm was Radiosystem Utvecklings AB, and in 1983 it was changed to Radiosystem Sweden AB.

129 Interview Torbjörn Johnson, Ericsson Access (Radiosystem), 23 February 1993.

standards: NMT 450, NMT 900, RC 2000, Comvik system and Mobitex; and was a pioneer in surface mounting, which made the manufacturing cheaper. The company also designed a robot wire. Radiosystem engaged around 30 subcontractors and 500 component suppliers.

Radiosystem was a subcontractor to Ericsson when that company supplied an NMT network to Saudi Arabia in 1981. After much deliberation, Swedish Telecom Radio decided to let Radiosystem supply combiners for the radio base stations related to the first deployment of NMT 450. The company obtained the order because of the low prices quoted.[130] Radiosystem later became one of the major manufacturers of radio base stations for the NMT system.

At the beginning the company had four employees; after one year seven, and then it expanded quickly. There were 25 people working with developments from the mid 1980s, of which about 12 persons worked with the development of a GSM-prototype.[131] Among those contributing with capital were 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. An external financier, Anders Tuvenhjelm, became a part owner in 1983. The company was listed on the Stockholm Stock Exchange in 1986. The economic development for the company is illustrated in the following table.

Table 13 / **Radiosystem's economic development 1978-88**

Year	Annual turnover in million SKr	Profit after financial items in million SKr	Number of employees
1978/79	0.4	0.03	4
1979/80	2.0	0.1	8
1980/81	3.7	0.4	13
1981/82	16.3	1.8	23
1982/83	30.9	4.9	33
1983/84	51.6	16.0	37
1984/85	45.0	8.5	43
1985/86	41.5	8.8	50
1986/87	92.7	15.4	86
1987/88	147.1	19.6	115

Source: Radiosystem Annual Report 1978-99

[130] Interview Anders Lundblad, Swedish Telecom Radio, 23 August 1990.

[131] Radiosystem Annual Report 1986.

After establishing in the Nordic countries Radiosystem expanded primarily into Europe. According to Johnson, Radiosystem's success was due to 1) rapid prototyping, 2) rapid product development, and 3) excellent products.[132]

Johnson argued that the transmitter output powers for the mobile telephones to NMT were unnecessarily high and should have been set 50 per cent lower. The telephones could have been considerably cheaper and more safe, as the risk for negative side effects, such as skin disease, could be minimised. The output power on handportable telephones for NMT was set to 1 watt compared to 0.6 watt for AMPS and TACS. In GSM the effect according to the specifications was 2.5-watt, which Johnson regarded as being far too high, because it could have been feasible with 0.1 watt.[133]

In 1988, Ericsson made an offer worth SKr 465 million for Radiosystem which by this time was listed on the Stockholm stock exchange.[134] The majority owners, Torbjörn Johnson, Managing Director and Anders Tuvenhjelm, Chairman of the Board, accepted the offer. Johnson justified his approval by stating that Radiosystem would have the opportunity to work with a diversified range of products, and that the company could benefit from Ericsson's special competence and capacity in manufacturing.[135] Radiosystem's turnover for the financial year 1987/88 was SKr 147 million with a profit of SKr 20 million. The company had 147 employees.

After the sale, Johnson continued working for Radiosystem, renamed Ericsson Radio Access in 1992. As part of the deal, Johnson was precluded from starting a new venture in this industry within five years. In early 1995, Johnson left the company and started up a new venture with the name Radio Design AB. Under the slogan "Excellency in Radio Systems Concepts" the company sought to attract young well educated persons interested in working for a company with the declared aim to going from SKr 0-100 million in sales in four years. Radio Design AB is presented in the international phase.

Allgon – from car aerials to mobile telephony

At the beginning of the 1980s, Ulf Saldell, technical manager at Allgon, discovered disparity between Swedish Telecom's forecasts and the actual influx of subscribers. He regarded it as a sign of mobile telephony's great market potential, which would consequently result in a huge demand for mobile telephone aerials.[136]

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132 Interview Torbjörn Johnson, Ericsson Access (Radiosystem), 23 February 1993.

133 Ibid.

134 The offer was worth SKr 141,50 per A share and SKr 120 kronor per B share.

135 Radiosystem Annual Report 1988.

136 Interview Ulf Saldell, Allgon AB, 26 March 1993.

Allgon was established in 1947 and had the business idea of developing and selling radio aerials for cars. The product range was later diversified to include aerials for broadcasting and the expanding TV-network. In the 1960s, military radio equipment became an important business for Allgon, and the defence became its main customer during the 1960-70s. But the company also supplied antennas and radio equipment to the civilian market. In the late 1960s, the Kämpe family bought Allgon. The previous owners had owned the company since it was founded. Jonas Kämpe took over management from his father at the end of the 1970s.

Ulf Saldell, expert in 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 per cent of the production to the private market instead of to the national defence, as was the case during the 1970s. Allgon's management identified two attractive activities for the future: 1) parabolic aerials and 2) mobile telephony equipment. The management decided on mobile telephony since it was considered to be the business of the future with larger margins than from the sale of parabolic aerials, which to a large extent would be a consumer market. Saldell, observing that Swedish Telecom's forecasts were always surpassed in the early 1980s, favoured mobile telephony for its considerable market potential.[137] From 1982 onwards, Allgon invested in aerials and various components for radio base stations and mobile telephones. The economic development for Allgon is presented in the following table.

Table 14 / **Allgon's economic development 1984-98**

Year	Annual turnover in million SKr	Profit after financial items in million SKr	Number of employees
1984	53,3	-0,5	110
1985	54,8	1,1	117
1986	83,9	4,4	131
1987	85	14,3	126
1988	119,8	20,9	136
1989	157	16,1	170
1990	209,8	16,8	234
1991	208,2	5,6	227
1992	216,2	7,1	232
1993	481	52,4	378
1994	916,2	91,7	615
1995	1174,5	73,9	672
1996	1369	108,6	714
1997	1639	131,7	809
1998	1725	140,6	901

Source: Allgon Annual Report 1984-98

137 Ibid.

Allgon's manufacturing is mainly located in Åkersberga, north of Stockholm, together with its head office and department for developments. The company uses some 100 subcontractors in Sweden and abroad for the manufacture of components. Allgon's highly specialised business forced it to establish abroad and export earnings increased from 1983-84. Establishing abroad took the form of the acquisition and foundation of local sales companies. But the internationalisation was far from straightforward; it took five years, for example, to establish a profitable sales organisation in the US.

Network operators, manufacturers of mobile telephones and systems, vehicle manufacturers and distributors rank among Allgon's customers. 97 per cent of all sales are achieved outside Sweden. Nokia, for instance, predominantly uses aerials from Allgon for its mobile telephones. Allgon holds 10-15 per cent of the market for combiners and 40 per cent of the world market for aerials to mobile telephones. The cost for research and development has increased steeply in step with the expansion, and now accounts for around 13 per cent of revenue.[138]

6.4 Mobile telephones

A historic settlement – the opening of a mobile telephone market

As mentioned earlier, the Land Mobile Radio Survey Commission of 1967 proposed that Swedish Telecom should own the mobile telephones and lease them to the subscribers. This was the established model to organise telecommunication services, and was also used for the first two mobile telephone systems, the telephones being considered an integrated part of the system. The NMT-Group also suggested this model for the new manual system in January 1970. However, it required a considerable investment on the part of Swedish Telecom over and above the SKr 20 million per year which had to be invested in the network expansion. The necessary investment for the procurement of mobile telephones was estimated at SKr 40 million. Swedish Telecom considered it unfeasible to obtain sufficient capital to purchase mobile telephones through the state budget and time was also limited. Instead Swedish Telecom began discussing the possibility of breaking with the established convention – that telecommunication operators should control all parts of the telephone system – and liberalising the market. Suppliers could then market the phones directly to end-users, thereby also promoting the mobile telephone service. This move was also inspired by experiences from Denmark and Norway, where the mobile telephone national

[138] Allgon Annual Report 1998.

operators had opened the market for mobile telephones.[139]

In 1971, Swedish Telecom took the big step towards a liberalised telephone market in which mobile telephone suppliers could market their products directly to end-users. Subscribers had to purchase or lease the telephones from a retailer or distributor selling mobile telephones.[140] This step changed the definition of the mobile telephone system as it created a separate market for mobile telephones, handing over the responsibility for the mobile telephone to the users, and thereby facilitating the emergence of independent distributors. However, the mobile telephones had to be Swedish Telecom-approved before they could be used. This was a new policy for Swedish Telecom and one which became important for the further development.

The range of products increased and among the suppliers of mobile telephones to MTD were AP, Handic, Mitsubishi (Gadelius), Salora, Storno, Sonab and Svenska Radioaktiebolaget (SRA). Competition between suppliers intensified and the marketing of the mobile telephone service stimulated, since mobile telephone suppliers – through sales – also contributed to the promotion of the mobile telephone service.[141]

The entire 80 radio frequencies in the MTD system needed to be utilised for a mobile telephone to function throughout the length and breadth of Sweden . However, to start with the mobile telephones were only able to connect up to about 20 frequencies. In 1974, SRA launched a mobile telephone weighing only 3 kilos, equipped with frequency synthesis, which meant that it could use all frequencies in the network.[142] Sonab introduced a mobile telephone with a radio base station ranging 40 kilometres, with which a portable telephone could be used.

When the MTD system was phased out Swedish Telecom offered subscribers SKr 2000 discount on the NMT telephones, provided the MTD telephone was handed into Swedish Telecom.[143]

The liberalisation of the mobile telephone market meant that Swedish Telecom was denied the possibility of assigning to Teli, Swedish Telecom's mechanical shop, the development and manufacture of proprietary mobile telephones. Swedish Telecom considered that Teli lacked the appropriate competence and preferred to have external suppliers. Swedish Telecom thought it sufficient with type approvals to have control over which mobile telephones were used.[144]

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139 Magnus Karlsson, *The Liberalization of Telecommunications in Sweden*, Linköping: Linköping University, 1998, p 223. Based on Telestyrelsen, 28 April, 1970 SM 94, 2 May, 1979 §3 SM 7 p 4.

140 Håkan Bokstam, "Televerket landsomfattande mobiltelefonsystem", Tele 1/1972.

141 Carl-Gösta Åsdal, "Televerket radioverksamhet, Landmobil radio", Tele 2-3 1977.

142 SRA CN-505.

143 Interview Bo Magnusson, Swedish Telecom International, 20 September 1991.

144 Interview Carl-Gösta Åsdal, former Swedish Telecom Radio, 16 April 1991.

Technophone

Comvik commissioned Technophone to develop a mobile telephone, which was introduced in 1983.

Nils Mårtensson founded Technophone, which was a spin off from a company Mårtensson had started in France in 1978, together with a number of British investors and a venture capital firm in 1983 when the Department of Trade and Industry decided to license two mobile telephone operators in the United Kingdom. Nils Mårtensson, civil engineer, worked for SRA in the 1960s and 70s, where he was involved in the development of NMT. He left SRA in 1976. Mårtensson owned 40 per cent of Technophone and was Managing Director.

Technophone succeeded in establishing itself on the market as a leading supplier of handportable mobile telephones. It was technologically advanced and supplied mobile telephones to a number of different mobile telephone standards around the world. The company made a profit of £2.5 million on a turnover of £49.1 million in the financial year ending March 31, 1990.[145] Technophone had 750 employees.

In the beginning of 1991 Nokia acquired Technophone paying SKr 370 million, giving Mårtensson a profit on SKr 150 million.[146]

AGA and Sonab

In the 1960s and 70s, AGA Mobilradio was a leading supplier of mobile radio equipment in Sweden, and had 475 employees and an annual turnover of SKr 30 million. The company supplied mobile telephones to the first two systems and to the MTD-system. In 1974, Sonab acquired AGA Mobilradio, and then became one of the largest suppliers of radio communication equipment on the Swedish market.

Spectronic – sub-contractor at first

Per Siversson established Spectronic in 1972. Its operation includes development, design, manufacturing and marketing of products within telecommunications, specialising in handportable mobile telephones.[147] Per Siversson, as Executive Director, remained the main owner of Spectronic, with 90 per cent of the equity, the remainder of the shares being split

145 Mobile Communications, 14 February 1991, issue number 73.

146 Dagens Nyheter 12 February 1991.

147 Until 1989 the firm was named Specialelektronik i Helsingborg SEHAB AB, then it was changed to Spectronic AB. During 1993/94 Spectronic AB founded three subsidaries: Spectronic Communications AB (marketing), Spectronic Production AB (production) and Spectronic Research AB (development). Annual Report Spectronic AB 1993/94.

between a number of employees. Some financial support for research and development came from Utvecklingsfonden i Malmöhus län and from the Swedish National Board for Industrial and Technical Development (NUTEK).

In the mid 1980s, Spectronic began developing its own handportable mobile telephone, partly based on the company's process microphone Masterphone, which was launched in the autumn of 1989. At the same time, Spectronic started co-operating with Siemens, where Spectronic developed and manufactured an NMT telephone for the German company. Spectronic supplied 20,000 NMT telephones, called Marathon, to Siemens up to 1992, when Siemens terminated the contract. The co-operation had meant a great deal when it came to Spectronic's annual turnover and profitability, intensified by the positive reception accorded the handportable telephone TS 220. The mobile telephone functioned as a cordless data terminal, which could be attached to a telefax and used as a pager.

During the latter part of 1992, Spectronic launched a small powerful handportable mobile telephone for NMT 450. In early 1993, the company launched a handportable mobile telephone with an enclosed data terminal for NMT 900. The computer telephone made it possible for Spectronic to initiate a number of projects in co-operation with private as well as public users in different countries. The economic development for the company is presented in the following table.

Table 15 / **Spectronic's economic development 1985-98**

Year	Annual turnover in million SKr	Profit after financial items in million SKr	Number of employees
1985/86	7.5	0.9	12
1986/87	13.7	1.1	13
1987/88	14.7	1.7	17
1988/89	15.1	2.8	20
1989/90	30.3	3.1	29
1990/91	118.7	62.2	40
1991/92	136.8	71.6	46
1992/93	61.0	40.2	44
1993/94	60.2	16.6	40
1994/95	54	11	44
1995/96	73.4	17.8	56
1996/97	55.2	8.2	50
1997/98	10.2	10.3	42

Source: Spectronic Annual Report 1985-98

A large part of the company's production has been exported to Europe and Southeast Asia. Some mobile telephones are sold with different trademarks, which has been the case with Clarion, Facit and Telecom Finland as they have all co-operated with Spectronic. The company originally planned to launch a GSM telephone at the beginning of 1997, but instead the company with its 42 employees, most of them civil engineers, has been working since mid 1997 on a multimedia mobile telephone which will be launched in the latter part of 1999. This has meant the suspension of the production of mobile telephones, i.e. some 200 people previously involved as subcontractors manufacturing various components, Spectronic's own manufacture of the telephone's printed circuit and its automatic assembly are temporarily at a standstill.

The market for mobile telephones

Several of the companies that develop and manufacture mobile telephones owe their origins to the mobile radio business or to military radio. The mobile telephone market, which until the late 1980s consisted of mounted and portable mobile telephones, was fragmented during the 1980s, as the following table shows. There were about 20 approved mobile telephone suppliers in Sweden competing for end-users, among them being Bosch, Cetelco, Dancall, Ericsson, Mitsubishi, Mobira, Motorola, NEC, Panasonic, Siemens, Simonsen, and Storno.

During the 1990s, Ericsson, Motorola and Nokia have dominated with over 80 per cent of the market. However, Motorola has gradually lost ground, enabling Ericsson and Nokia to expand.

Even though the market has moved towards increased concentration some smaller suppliers manufacturing special mobile telephones for particular usage have succeeded to getting established. Among these are Spectronic and Benefon, a Finnish company concentrated on handportable mobile telephones for NMT 450.

Table 16 / **Mobile telephone suppliers**

1971-81	1981-86	1986-91	1991-98
Six main suppliers: AP, Handic, Mitsubishi, Salora, SRA, and Storno.	Twelve suppliers: Bosch, Cetelco, Dancall, Ericsson, Mitsubishi, Mobira, Motorola, NEC, Panasonic, Siemens, Simonsen, and Storno.	Seven main suppliers: Ericsson, Motorola, Nokia-Mobira, Panasonic, Philips, Technophone, and Mitsubishi	Three major suppliers: Ericsson, Motorola and Nokia.

The development of mobile telephones has produced a steady stream of cheaper, smaller, lighter and more sophisticated units. When NMT was introduced, mobile telephones were exclusively mounted. Then came transportable mobile telephones, weighing three to four kilos. The number has gradually increased since the first handportables were launched in 1987 and nowadays hardly any mounted phones are sold.

6.5 Distribution

The main interest within mobile telephony has primarily been directed towards the technology and the products, while distribution has received considerably less attention. The distribution function was not assigned any significance when Swedish Telecom opened the market for mobile telephones in 1971. It was considered as something that one took care of oneself as distributors and retailers could handle the contact with the end-users in any way they wished.

The mobile telephone business has undergone major changes since the market opened. The biggest major change is that specialists have gradually lost their dominating position, at the same time as the customer structure has become more diversified and technical development has produced new types of mobile telephones. Five distribution channels have emerged [148]:

1) mobile telephone specialists,
2) car dealers,
3) retailers in office supplies,
4) radio and TV shops, and
5) network operator shops.

The following table illustrates the development of different retail categories within the mobile telephone business.

Table 17 / **Mobile telephone retailers**

1971-81	1981-86	1986-91	1991-94
Mobile telephone specialists	Mobile telephone specialists, Car dealers	Mobile telephone specialists, Car dealers, Office equipment retailers	Mobile telephone specialists, Car dealers, Office equipment retailers, Radio & TV-shops, Telia shops

[148] Based on Anderson and Mölleryd (1994).

An indication of the number of retailers can be found in the number of test and demonstration permits issued. For retailers to sell mobile telephones it was mandatory up until 1993 to have a test and demonstration permit originally issued by Swedish Telecom, and then the Swedish National Post and Telecom Agency. The numbers increased from 292 in 1980 to 3,423 in 1992. Network operators and mobile telephone suppliers estimated that around 1,000 of the 3,423 firms were selling just a few mobile telephones per year.

1971- 81 specialist retailers

The first firms to sell mobile telephones were retailers specialising in communication equipment and mobile radio. They were predominately small, local or regional firms. The specialist dominated the trade and offered combined sales and service outlets. They handled the contacts with the end-users, which primarily were small and medium sized companies. Contacts were often based on personal relations between the salesman/service technician and the customer.

1980s – automotive dealers, office shops

In the early 1980s, automotive dealers entered the retailing business besides the mobile telephone specialists, which dominated with around 85 per cent of the total sales in the mid 1980s.

With the launch of handportable mobile telephones in the latter part of the 1980s national chains of office supply shops, including two major wholesalers, began to market mobile telephones as a side business. Scribona/Esselte, Sweden's largest office equipment wholesaler with a nationwide network of retail outlets, started the sale of mobile telephones in the late 1980s.

Mobile telephone manufacturers also made attempts to integrate vertically into retailing. Ericsson Radio and Nokia-Mobira operated their own shops in the late 1980s. Ericsson opened up a minor chain of city-based, exclusive sales and service outlets, so called Hot-Line shops, while Nokia-Mobira developed an equivalent Mobira Center concept. However, it was not particularly successful which was why Ericsson decided to dismantled its Hot-Line shops within a year, turning retail personnel into sales representatives responsible for contacts with independent retailers. Nokia-Mobira had a similar experience. Neither did the suppliers find it profitable to insist on exclusive arrangements with retailers.

Comvik provided branded Comvik telephones and subscriptions through direct contacts between regional, city-based Comvik representatives in

Stockholm, Göteborg and Malmö and their organisational buyers.

Until the early 1990s, the retail trade was dominated by small traders. A large number of shops were located in industrial areas as that was where the end-users could be found and where mobile telephones were mounted in the car. The big influx of subscribers during the 1980s led to a great number of small traders opening up shops and establishing themselves in the business. However, many soon experienced financial problems and were forced to dismantle their businesses. Despite the turbulence in the trade it was certainly feasible for enterprising traders with just one shop to form retail 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 being channelled to the distributors.

Geab – from car showroom to retail chain

Bob Erixon worked up Geab AB in ten years to become a retail chain with some 20 outlets.[149] Erixon started selling mobile telephones in 1984 in the car showroom owned by his father, Gillis Erixon. In order to stimulate business, Bob Erixon offered customers leasing contracts as mobile telephones at that time were quite expensive. Erixon opened the first Geab shop in Stockholm in 1985.[150] Over a number of years that shop was responsible for the biggest sale of NMT subscriptions in Sweden, more than 1,000 subscribers being signed up annually.[151]

After establishing its second shop in central Stockholm in 1989, Geab began expanding during the recession in the early 1990s. The company acquired competing retailers showing poor profitability and established centrally located shops financed by internally generated profits. A so-called Teleshop was opened in Gallerian in Stockholm in March 1990 and in June of the same year Geab took over a shop in Sollentuna. The company ventured outside of Stockholm for the first time in 1992 by establishing in Göteborg and Växjö. The shop in Göteborg was acquired from a competing Stockholm firm, which had not been profitable. During 1993, Geab opened several shops in Stockholm and Malmö. Geab purchased a chain, Telejack, with three outlets in Stockholm in 1994, which meant that the company then had 18 outlets. In addition to selling mobile telephones, Geab sold telephones for the fixed network, smaller switchboards for offices and computers.

149 GEAB stands for Gillis Erixon AB.

150 Interview Stefan Olsson, GEAB, 11 March 1994.

151 Interview Sören Hemmingsson, Telia Mobitel, 16 March 1994.

6.6 End-users

During the 1970s, the mobile telephone users were predominately small and medium sized companies, such as artisans, taxi companies, transport companies, local trucking firms and the like. With the introduction of NMT 450, mobile telephony gradually spread to new user groups such as building and construction firms, repair service firms and wholesale traders.

From the mid 1980s mobile telephony started to spread beyond the core users. It could be, for instance, that companies decided to equip sales and service personnel with mobile telephones. The industry rationalisation, which required higher labour efforts in combination with further mobility, was seen as a contribution to the increasing interest in mobile telephony. The introduction of handportable mobile telephones for NMT 900 opened the mobile telephone for the young urban professionals.

The following table illustrates which categories used mobile telephones in the latter part of the 1980s.

Table 18 / **Mobile subscribers: Lines of business**

Lines of business	Per cent
Freight transport by road	17
Building and construction	14
Repair services	12
Departments of communications	7
Electrical manufacturers	6
Business services	5
Retail trade	4
Car trade	3
Building services	3
Metal industry	3
Machinery	3
Wholesale trade	3
Others	20

Source: Swedish Telecom Radio 1987

The first attempt to market mobile telephony explicitly to consumers was initiated by Swedish Telecom Radio in 1991 when the operator launched the subscription form NMT Red, which was Europe's first low-use tariff. The operator succeeded to sign up some 65,000 private customers during the first one and half years.

6.7 Entrepreneurship in the national/Nordic phase

During this phase Sweden becomes the leading country in mobile telephony and takes the decisive step in developing the mobile telephone industry centred around the development and introduction of NMT. The network operator Swedish Telecom faces competition for the first time during this phase. From the account I identify the entrepreneurial activities presented below, divided into the three different sources of entrepreneurship.

The individual as entrepreneur

Carl-Gösta Åsdal's commitment to mobile telephony had its origins in the work done during the investigation into the future of land mobile radio. He directed Swedish Telecom's investment in mobile telephony and contributed to the creation of a new industry organisation and a diversification of market products. However, Åsdal was far from being the only individual who could be classified as 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 development within microelectronics, and anticipated the manufacturing of a new input to the new system. He played a significant role in organising the development at Swedish Telecom as well as organising the production of different standards (new product).

Åke Lundqvist, at one time an important person for SRA and its investment in mobile telephony, exerted a strong influence on Ericsson Radio Systems, since he expanded the market and created a new organisation of industry. Lundqvist contributed enormously in marketing mobile telephony as a product crucial to the Ericsson Group in the late 1970s, at a time when mobile communication only accounted for a fraction of Ericsson's total turnover. Moreover, Lundqvist argued in favour of SRA/Ericsson Radio purchasing companies with the specific competence Ericsson needed. Among his most significant contributions was his success in persuading Ericsson to apply the AXE switch to mobile telephony (new input), and in launching the idea that Ericsson should supply complete mobile telephone systems rather than various parts only (creating a new organisation of industry).

Torbjörn Johnson founded the company Radiosystem, later to be acquired by Ericsson, to develop his fundamental ideas around a filter in radio base stations (new products; a new production process).

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

Jan Stenbeck, was instrumental for Kinnevik's involvement in mobile telephony with the foundation of Comvik, which meant a new organisation of industry.

The distribution function was undeveloped when Swedish Telecom opened the market for mobile telephones in 1971. Retailers had to manage customer relations on their own and Bob Erixon was one of those who established a distribution company in the 1980s, and whose company Geab became a retail chain out of a few shops. Erixon established connections between operators, mobile telephone suppliers and business and private customers, by developing a new distribution channel and by new marketing methods.

The company as entrepreneur

Through Comvik establishing itself 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 Swedish Government had not planned to introduce competition since Swedish Telecom had a monopoly. It came instead as a result of Comvik pressing Swedish Telecom and the Government, helped by a large number of petitions and sophisticated legal procedures. Later on, the private operator conducted a number of campaigns to obtain additional frequencies. Comvik's establishment entailed a new industrial organisation and market expansion, as well as a new approach to marketing by the company.

Allgon presents yet another model of a company investing in mobile telephony by turning its attention to the market potential, and improving 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, it formed a new industrial organisation and a new market. The introduction of NMT in Sweden by Swedish Telecom Radio created a new market. And when handportables were allowed the market expanded considerably.

The network as entrepreneur

One activity that could be considered as performed by the network as entrepreneur is the development of NMT, where the Nordic telecommunication administrations jointly developed a standard. The NMT in itself was a new product, and the Nordic co-operation implies a market expansion.

The co-operation between Ericsson and Swedish Telecom is yet another example of entrepreneurship carried out by the network as entrepreneur. It resulted in new products, which were developed in connection with many different activities, such as AXE and NMT.

The three sources of entrepreneurship

To summarise, the following table lists the different entrepreneurs I have identified and classified into the three different sources of entrepreneurship.

Table 19 / **Entrepreneurship in the national/Nordic phase**

	Individual	Company	Network
1) A new product	T Johnson Ö Mäkitalo, P Siversson	Allgon	Ericsson Radio – Swedish Telecom NMT-Group
2) A new production process	T Johnson		
3) A new input	Å Lundqvist Ö Mäkitalo		
4) A new organisation of industry	Å Lundqvist C-G Åsdal J Stenbeck	Comvik Swedish Telecom Radio	NMT-Group
5) A new market	Å Lundqvist C-G Åsdal	Comvik Swedish Telecom Radio	
6) A new type of marketing	B Erixon	Comvik	
7) A new distribution channel	B Erixon		

Entrepreneurship placed in the technological system

The entrepreneurship in the national/Nordic 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 fulfilment of an organising entrepreneurship, as well as a breakthrough for a market oriented entrepreneurship.

The activities in this phase are largely dependent upon the entrepreneurship accomplished by the standardiser. It involves the NMT-Group as well as the co-operation between the Nordic telecommunication administrations, which operate a technique and a market oriented entrepreneurship.

Just as in the local phase, the network operator is in the center of the course of events. Mäkitalo's individual entrepreneurship contributes 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

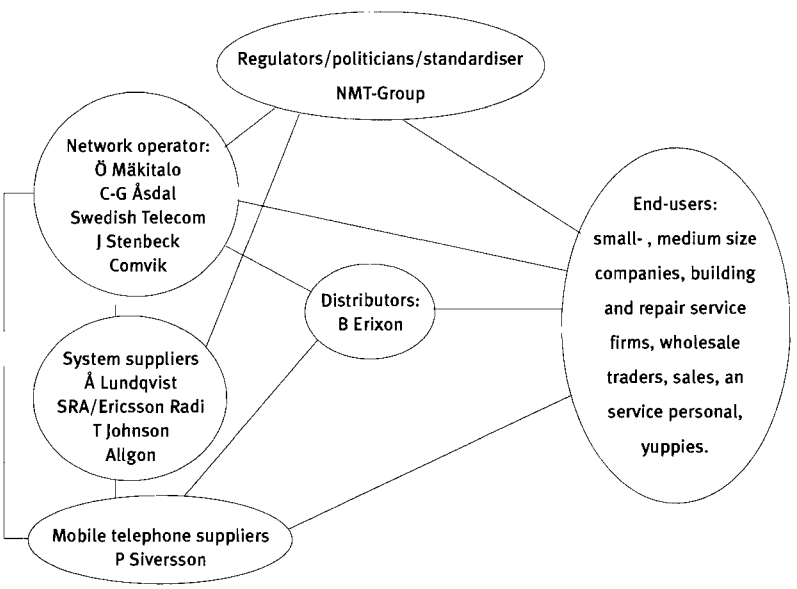
between Ericsson and Swedish Telecom Radio. Åsdal, at Swedish Telecom Radio, was another individual entrepreneur who contributed to the establishment of a new industrial organisation by opening the market for mobile telephones in 1971. The network operator function was also influenced by Comvik's entrepreneurship, which resulted in a market expansion.

Lundqvist's contributions with a technical, organisational and market oriented entrepreneurship played a significant role in the system supplier SRA/Ericsson Radio's breakthrough in mobile telephony. Allgon, the system supplier, operated a technique-oriented entrepreneurship and developed new products. Radiosystem's success was due to Johnson's technique oriented entrepreneurship. As for Spectronic, the mobile telephone supplier, it was Per Siversson who performed a conclusive entrepreneurship.

The distributor function was developed during this phase through a market-oriented entrepreneurship carried out by Bob Erixon at Geab.

If I place that entrepreneurship in the technological system, the following picture emerges:

Figure 4 / **The technological system in the national/Nordic phase**



The formation of the technological system gives the starting point for the international phase, which will be presented in the next chapter.

7. International phase 1992-98

7.1 Regulators/politicians/standardiser

GSM development

The market for mobile telephony in Europe was fragmented and undeveloped in the 1980s, with numbers of incompatible analogue mobile telephone standards in operation, with no particular market leader.
It was not feasible to use mobile telephones when travelling throughout Europe or internationally. However there were some exceptions such as the Nordic region where the NMT system permitted use of the same mobile telephone throughout the whole region.

The infrastructure equipment and the mobile telephones themselves were quite expensive and the products limited in variety in the majority of the European countries, apart from the United Kingdom and the Nordic countries.

In the 1980s, the Commission of the European Communities actively promoted the development of a pan-European mobile telephone standard. It was anticipated that it would contribute to a positive economic development in Europe, primarily in two respects. Firstly, inter-country and inter-personal communication would improve, generating positive effects on business life. It would be possible, for instance, to use GSM telephones when travelling throughout Europe. Secondly, by creating a single market for mobile telephone systems as well as mobile telephones it would strengthen the European telecommunication industry, something that was considered to be essential. The Commission also considered it as essential to introduce competition into the sector and separate the regulatory duties from the operational activities in the telecommunications administrations.

First step in 1982

As early as in 1970, the NMT-Group discussed a future European mobile telephone system, although the group anticipated difficulties in reaching an agreement regarding the standard. The NMT-Group realised 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 the possibility of achieving a limited level of compatibility between different European standards.[152]

A first step towards a mutual European system was taken in 1982, when the Conference on European Posts and Telecommunications (CEPT), consisting of national telecommunication administrations from 26 member states, decided to assemble a group called Groupe Spéciale Mobile (GSM) – in the early 1990s the name was changed to Global System for Mobile Telecommunications – which was commissioned to develop a mobile telephone standard. The Nordic countries were instrumental in promoting this initiative.

Frequencies between 862 MHz and 960 MHz had been reserved at the World Administrative Radio Conference of the International Telecommunications Union (ITU) in 1978.[153] Subsequently the conference of European Posts and Telecommunications Administrations decided to allocate this frequency band to mobile telephony.

The inaugural meeting of GSM took place in Stockholm in December 1982, where representatives from eleven countries met under the chairmanship of Thomas Haug from Swedish Telecom. Thomas Haug had also chaired the NMT-Group from 1976. The GSM-Group was to design a number of interfaces in the mobile telephone system, to facilitate communication between switches and radio base stations, human beings and machines.[154]

The GSM-Group met regularly, and the standardisation work expanded gradually, involving more and more people. In 1985, the detailed specifications were approved and communicated throughout the industry, facilitating the development of the various technical components and systems. Östen Mäkitalo, in charge of the radio laboratory at Swedish Telecom Radio, participated in the standardisation of GSM until 1988. He drew up a blueprint for a digital mobile standard as early as 1982 which, according to Mäkitalo, corresponded fairly well with the final result.[155]

It was already assumed from outset that the GSM system would be based on digital transmission, even though it was not officially decided until 1987. According to Mäkitalo, a digital GSM had several advantages such as:

1) improved speech quality,
2) improved combined services,
3) higher capacity, and
4) extended security through encryption.[156]

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152 NMT-Group, minutes meeting number 5, 20-22 January 1971.

153 Garry A Garrard, *Cellular Communications: Worldwide Market Development*, Norwood, MA: Artech House, 1998, p 63.

154 Interview Thomas Haug, Swedish Telecom, 11 September 1990.

155 Interview Östen Mäkitalo, Telia Research, 23 February 1993.

156 ibid

During 1985-86, the GSM-Group explored different alternatives for handling the radio transmission. A wideband solution was first discussed, but Swedish Telecom decided at an early stage to concentrate on narrowband Time Division Multiple Access (TDMA), which divides the frequency spectrum into a number of time slots. At first, Ericsson tried the Frequency Division Multiple Access (FDMA) technique, which divides the frequency spectrum into a number of frequencies, before the company decided on TDMA.

France and West Germany were in favour of wideband TDMA, and their respective national operators had invested about $ 50 million in development work and, together with a handful of firms, developed a prototype for wideband transmission. Moreover, Italy and the United Kingdom joined France and Germany in this venture.[157]

In 1986, a decisive test for the selection of radio transmission technique was performed in Paris by Center National d'Etudes Télécommunications (CNET), supervised by the GSM-Group. Altogether, eight prototypes were tested: four resulting from the Franco-German alliance and four originating from the Nordic region: one from Swedish Telecom, one from Ericsson, one from Nokia, and one from Trondhiems Technical University in Norway. The results of the test were presented at a plenary session held by CEPT in Madeira in February 1987. It was straightforward to decide that the system should be based on TDMA. However, it was more intricate to determine whether GSM should use wide- or narrow band TDMA. Finally, it was decided that GSM should be based on narrow band TDMA – which the Nordic systems were based on – as this enabled faster hand-offs, smaller cells, down to 100 meter radius, and was compatible with existing spectrum planning. The main argument against the wide band solution was that it demanded considerably larger investments in densely populated areas.[158]
In 1987, the Commission of the European Communities made several decisions, in the form of directives, related to the pan-European standard. The plan for the introduction and establishment of a digital cellular system throughout Europe was taken in recommendation 87/371/EEC. And Directive 87/372/EEC required national frequency regulators to co-ordinate the allocation of 2 x 9 MHz of spectrum in the frequency band reserved for mobile telephony. The directive also stated that the allocated frequency band should be made available for GSM in accordance with demand, implying that analogue systems, such as NMT 900, should be dismantled from the year 2000.[159]

As the projections for the future growth of mobile telephony in the latter

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157 Garry A Garrard, *Cellular Communications: Worldwide Market Development*, Norwood, MA: Artech house, 1998, p 129.

158 Ibid. Interview Åke Lundqvist, Ericsson, 22 February 1994.

159 Garry A Garrard, *Cellular Communications: Worldwide Market Development*. Norwood, MA: Artech house, 1998.

part of the 1980s were modest and analogue networks were concurrently expanded throughout Europe, it was considered necessary by the Commission that the European network operators made a commitment to implement GSM-networks. This would create a sufficient market to convince the industry to make vast investments in research and development for the pan-European GSM standard. In May 1987, ministers from France, Italy, the United Kingdom and West Germany called for an agreement between network operators in Europe to be formalised in a Memorandum of Understanding (MoU). The MoU stated that the signatories were committed to introduce GSM networks by January 1, 1991, later put back to July 1, 1991. The MoU was signed in Copenhagen on September 7, 1987 by operators and regulators from thirteen countries: Belgium, Denmark, Finland, France, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, the United Kingdom, and West Germany. In line with European Commission's ambition to liberalise the telecommunications market a number of directives was initiated under article 90 of the Treaty of Rome. The first of these, issued on May 16, 1988, concerned competition in markets for telecommunications equipment and ensured liberalisation of the equipment market including mobile telephones.[160] The second, usually referred as the service directive, was issued in 1990 and ensured the separation of the telecommunications operation and regulation. These initiatives played an important role in shaping the development of mobile telephony.

With the ambition of liberalising the mobile telephony market, it was not consistent to develop GSM within the CEPT organisation, as it was only opened for national telecommunication administrations. Therefore, the responsibility for the development of the GSM standard was transferred to the newly founded European Telecommunications Standards Institute (ETSI) in 1989. ETSI is open to any organisation based in Europe involved in the telecommunications industry, enabling suppliers and other industry participants to take active part in the standardisation process.

The specifications for the GSM standard, comprising some 5,000 pages, were completed in 1989. After 1989, further development of standardisation was initiated, including supplementary services and speech codecs. By the end of 1990 it was estimated that ten manufacturers had invested 5000 man-years of effort in the development of GSM at a total cost of $ 350 million.[161]

Swedish Telecom was highly involved in the development of GSM, and held positions such as chairman and secretary in the GSM-Group. Comvik

160 88/301/EEC.

161 Garry A Garrard, *Cellular Communicatians: Worldwide Market Development*, Norwood, MA: Artech house 1998, p 129.

participated in the standardisation work from 1988/89.

In the early 1990s, ETSI specified a standard in the 1800 MHz band based on GSM. The only significant difference compared to GSM 900 was that it operated in a higher frequency band, requiring about 4-6 times as many base stations as GSM 900 to create equivalent radio coverage. The development of the standard – called Personal Communication Networks (PCN), Digital Cordless System (DCS) 1800 or simply GSM 1800 – was forced by the United Kingdom as the Department of Trade and Industry (DTI) had appointed three PCN operators in 1989. The intention was to intensify competition in the mobile telephony market and to challenge British Telecom's monopoly in the private consumer market.

In accordance with the directives from the European Commission, each of the European countries licensed two operators to build GSM networks. One of the licences has normally been appointed to the state (or former) owned telecommunication operator, while the other licence has been allocated to a private operator, predominately owned by a consortium. When GSM was introduced it faced stiff competition from analogue networks in some European countries, particularly in the most advanced mobile telephone countries, such as the UK, Sweden and Norway. It was Germany who took the lead in GSM during 1993. However, GSM started to develop on a wide front in Europe from 1994-95.

It is no exaggeration to say that the GSM project has been a tremendous success, probably one of the most successful ventures in the history of European telecommunications. GSM has been a vehicle for introducing competition into the telecommunication sector. In countries where analogue mobile telephony had diffused widely – particularly the Nordic region – GSM would not have succeeded for many years without the introduction of competitive network operators, who had no other service to offer.

GSM has spread all over the world: Europe, Asia, South America and the United States. Today it is the de-facto world standard regarding digital mobile telephony, established in 132 countries and used by over 130 million people. This has strengthened the competitiveness of the European telecommunications industry as the firms that had been involved in the development now have a world market to approach. Particularly, Ericsson and Nokia have succeeded in taking advantage of this development and continuously strengthen their market positions.

7.2 Network operators

In this phase the network operator market not only comprises Swedish Telecom/Telia and Comvik/Comviq but also a third firm which had entered the market. However, let me start with the incumbent operator.

Year	Annual growth in percent
1978	22
1979	14
1980	18
1981	13
1982	22
1983	48
1984	43
1985	43
1986	40
1987	39
1988	43
1989	46
1990	39
1991	23
1992	15
1993	21
1994	49
1995	22
1996	19
1997	13
1998	14

Telia – mobile telephony a growing activity

Swedish Telecom Radio had a turnover of SKr 145 million for 1979 and almost twenty years later the company, now called Telia Mobile, produced a turnover of SKr 8.5 billion for 1998. The company has undergone tremendous development during this period, illustrated by the annual growth of subscribers in the following table, transforming itself from being a sort of civil service department into becoming a highly competitive company.

Table 20 / **Swedish Telecom Radio/Telia Mobile annual growth in number of mobile telephone subscribers 1978-98**

Source: Swedish Telecom, official statistics

Mobile telephony is by far the largest business sector, and accounts for more than 90 per cent of the annual turnover. The company has invested SKr 12.6 billion in their infrastructure since 1981. The economic development for the company is illustrated in the following table.

Table 21 / **Swedish Telecom Radio/Telia Mobile economic development 1977-98**

Year	Annual turnover in million SKr	Investment in million SKr	Profit after financial items in million SKr	Number of employees
1981	212	38		
1982	226	57		
1983	273	65		
1984	406	250		
1985	1461	329	188	2547
1986	2721	641	375	2799
1987	2335	621		2874
1988	2758	824		2843
1989	3522	1085	810	2973
1990	4203	942	927	3104
1991	4771	1213	1226	2920
1992	4355	827	1191	1838
1993	4609	765	1174	1972
1994	5247	712	752	2112
1995	6685	1230	1098	2185
1996	6230			
1997	7894	1593	1242	1761
1998	9680	1486	1491	1959

Source Annual reports Swedish Telecom/Telia 1981-98

In the attempts to attract the consumer market for NMT, Telia Mobile collaborated with suppliers of mobile telephones in its marketing activities. For example Motorola developed a pocket telephone called Personal to match Telia Mobitel's launch of NMT Private, and sales campaigns were co-ordinated.

Telia Mobile develops, creates, and markets radio based communication services to corporations and individuals. The GSM network was opened in November 1992.

In 1995, Telia's market organisation for both fixed and mobile telephony had been divided in five divisions for interactions with five major types of counterparts: large public organisations, large business corporations, small and medium sized companies, the private consumer market and retailer groups.

The increasing competition in the market for network operators drove the company to introduce a large number of different subscription forms, creating a private consumer market and a business market. Moreover, it opened for a race with intensified marketing as well as payments of commission to retailers. During 1997, Telia reduced the number of subscription forms from nine to two: Mobitel Volume and Mobitel Pott. The former is aimed for the business market, offering discounts for volume callers, while the latter is meant for the private consumer market. Telia operates with two trademarks: Telia Mobitel and Department of the Future, DOF.

Telia was the first network operator to introduce a combined GSM 900 and GSM 1800 network, so called dual band, in late 1997, which enhanced the capacity in congested urban areas. This put pressure on the suppliers to develop mobile telephones with dual band functionality.

To a large extent, tariffs have remained unaltered over the years. With the explosive growth of mobile telephony there is a tendency for voice communication to migrate from the fixed to the mobile telephone network.

During mid 1998, Telia launched a prepaid telephone card called Mobitel Refill, which is rechargeable. With the growth of GSM the number of NMT-subscribers has not surprisingly dropped, further escalated by Telia's decision to dismantle the NMT 900 system in the end of year 2000. In order to attract these subscribers Telia has made a commitment to further expand GSM in densely populated areas.

An indication of Telia's strength as a network operator is its extensive presence in mobile network operations around the world. It started with the establishment of NMT abroad. Telia has interests in mobile operations in Brazil, China, Denmark, Ecuador, Estonia, Finland, Hong Kong, Hungary, India, Ireland, Italy, Latvia, Lithuania, Namibia, Norway, Russia, Sir Lanka, Slovenia and Uganda.

The international activities have also proved to be quite profitable, for instance Telia had a minority stake in the Italian mobile network operator

Omnitel which Telia sold in 1998 at a profit of SKr 3.3 billion, seven times the invested capital.

Telia has established itself as a mobile network operator in the adjacent Nordic countries with GSM 1800 networks. The idea is to deploy networks in city areas and establish national roaming with other GSM operators.

Comviq – confident of victory

In late 1987, Comvik, a wholly owned subsidiary of Industriförvaltnings AB Kinnevik, approached the Ministry of Transport and Communication for permission to establish a digital mobile telephone system and to discuss a co-operation regarding the development of GSM.[162] The Frequency Management at Swedish Telecom Radio raised no objections and in November 1988 the Government decided to grant Comvik permission to operate a GSM network. The Government justified its decision by stating that Swedish Telecom's monopoly would terminate in 1990 and that there was no (frequency economical) hindrance to having two GSM network operators.

During 1990, Comvik advertised in the daily press about its ambitions as regards GSM:

> *"During the 1990s, governmentally 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 per cent of the expanding Swedish market for mobile subscriptions."* [163]

The backbone to Comviq's network (the company was first named Comvik GSM AB) is the Swedish National Rail Administration's fibre optic network, Kinnevik having signed a 25-year agreement with the Rail Administration in the early 1990s. A certain amount of the communication between base stations and nodes in the fibre-optic network goes by radio link.

According to the former managing director, Thomas Julin, Sweden was only big enough for two GSM operators, and Comviq 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 its dominating position on the mobile telephone

162 Communication from Comvik to the Government, 14 December 1987.

163 Dagens Nyheter, 17 June 1990.

market concurrently with the increasing importance of GSM, since the company possessed insufficient competence in marketing together with a rigid bureaucracy, which obstructed control as well as private initiatives.[164] The company's installed base of subscribers and the annual growth of subscribers are presented in the following table.

Table 22 / **Comviq's total number of subscribers and annual growth in per cent 1982-98**

Year	Number of subscribers	Annual growth in per cent of subscribers
1982	2800	
1983	4500	61
1984	7500	67
1985	8500	13
1986	10900	28
1987	12700	17
1988	15000	18
1989	17500	17
1990	18000	3
1991	16 300	-9
1992	15 600	-4
1993	32000	105
1994	141000	341
1995	429100	204
1996	466000	9
1997	810000	74
1998	1279000	58

Source: Annual reports Industriförvaltnings AB Kinnevik,

Comviq opened its GSM network in September 1992. Siemens supplied the mobile telephone switches, Motorola the radio equipment and Digital Microwave the radio link equipment. Kinnevik, as well as an international bank consortium led by Westdeutsche Landesbank and including Nordbanken, financed the expansion with up to SKr 1.6 billion. The financiers made it a requirement that Korsnäs, a pulp and paper company within the Kinnevik Group, should be linked to the financing.

Comviq is mostly sales oriented, and its motto is low price products. The company's aim has been to terminate NMT, and to make GSM an obvious choice. During the first year, Comviq concentrated on business customers,

164 Interview Thomas Julin, Comvik GSM, 11 April 1991.

but after low profitability, the company turned instead to private consumers and went for the mass market. The company began searching for places where consumers did their shopping, such as shopping malls for Radio & TV. Comviq first took the initiative to contract 200 retailers for Comviq GSM sales at the beginning of 1992. In 1993, Comviq started to build up relationships with large retail chains of radio & TV shops. 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.[165]

Successively, the contacts with retailers were narrowed down to the 30 most important customers, concentrating on retail chains' central organisations. Comviq, like the other two operators, also established direct contacts with the large corporate customers. Comviq uses retailers, specialist, retail chains and distributors. The operator has a sales force who work directly with companies to make deals for volume traffic.

Comviq has been prepared to pay large commissions, on average SKr 3000 per subscriber, in order to improve sales.[166] This has turned out well since the influx of subscribers has increased immensely since 1994.

Comviq was the first Swedish network operator to launch prepaid mobile cards, starting to sell them in March 1997. The following table shows the number of sold prepaid cards.

Table 23 / **The number of pre paid card for mobile telephony sold 1997-98**

Year	Telia	Europolitan	Comviq	Total
1997		2 000	228 000	230 000
1998	313 000	95 000	615 000	1 023 000

Source: Annual reports Telia, Europolitan and Netcom Systems.

It is an SIM-card loaded with a certain amount of traffic minutes and there is a number connected to the card. Up until the end of 1997 Comviq had sold 297 000 prepaid cards, and up until the end of 1998 over 500 000. The incentive for the operator with prepaid cards is to decrease the amount of administration, cheaper distribution, eliminate losses on account of customers and improve cash flow.

165 Interview Ulf Groth Comvik, 10 May 1994.

166 Ibid.

The economic development regarding Comviq is shown below.

Table 24 / **Comviq's financial development 1982-98 in million SKr**

Year	Revenue	Income before depreciation
1982		
1983	48	-15
1984	64	-17
1985	76	-6
1986	94	-2
1987	106	7
1988	111	-14
1989	115	-23
1990	110	18
1991	112	6
1992	103	-14
1993	107	15
1994	449	-140
1995	1088	-625
1996	1584	430
1997	2095	687
1998	3308	

Source: Annual reports Industriförvaltnings AB Kinnevik,

With the assistance of Banque Invik in Luxembourg, controlled by Kinnevik, Comviq introduced a VISA card, which could be connected to GSM subscriptions. Comviq has regularly used media companies owned by Kinnevik, such as television, radio, and the press, to market its services.

In 1993, Industriförvaltnings AB Kinnevik founded NetCom as a vehicle to own and develop the Group's telecommunication companies. Initially, NetCom was a subsidiary of Kinnevik but during the spring 1996 the shares were distributed to the shareholders in Kinnevik. At this time NetCom was listed on the Stockholm Stock Exchange.

During autumn of 1997 Comviq launched Tele2Mobil, a service attractive for companies. On January 1, 1998 the activities in Tele2, Comviq and Kabelvision were integrated into Tele2 AB. Churn rate dropped from 30 to 20 per cent during 1997.

NordicTel – less and less Swedish

Ulf Johansson and Mats Ljunggren, former executives at Ericsson Radio Systems with experience in mobile telephony, founded NordicTel Holdings AB in early 1989.[167] They were inspired by the steady growth of mobile telephony and the bright prospects for future profitability for mobile network operators. Their business idea included design and operation of mobile telephone networks in Sweden as well as internationally.

Four major Swedish companies: Trellswitch (Custodia), Scandinavia Airlines System, Spectra Physics (Pharos AB), and AB Volvo each invested SKr 9 million in the capitalisation of NordicTel Holdings AB in 1990. According to Ulf Johansson, chairman of NordicTel, the initiators engaged Swedish large-scale enterprises in order to obtain a stable capital base, coupled with the fact that they needed weight behind their application for establishing a GSM-network in Sweden.[168] Mats Ljunggren, Managing Director at NordicTel, believed that the company would succeed because of its joint owners who were good at marketing. The financially strong owners behind the company made Swedish Telecom more scared of NordicTel than of Comviq.[169]

NordicTel's operating licence

In February 1990, NordicTel applied to the Frequency Management for the allocation of frequencies for establishing a nation-wide GSM network.[170]

The Frequency Management rejected their application claiming that Swedish Telecom Radio had expressed a need for additional frequencies for the expansion of NMT 900, and had already, together with Comviq, been allocated GSM frequencies, which meant that competition was a fact in the network operators' market. Furthermore, the Frequency Management argued for extra frequencies for GSM operators, as well as stating that the frequency economy would weaken with a third operator. [171]

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

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167 In the following I use NordicTel for the holding company, that from start was named NordicTel PCN AB, and later changed to NordicTel Holdings AB, and Europolitan for the fully owned network operator that from start was called NordicTel. Now the operating company is named Europolitan AB.

168 Svenska Dagbladet 17 February 1991.

169 Interview Carl-Gösta Åsdal, former manager Swedish Telecom Radio, 16 April 1991.

170 Communication from NordicTel to Swedish Telecom, 16 February 1990.

171 Communication from Swedish Telecom to NordicTel, 27 February 1990.

that NMT 900 used. NordicTel stressed the importance of operating a mobile telephone network in Sweden, which was vital for the company's anticipated international expansion. A rejection would mean encroaching upon trade liberty, according to NordicTel, together with great economic loss and corresponding advantages for the company's competitors.[172]

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.[173] 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 identical conditions for all competitors, the attitude of the participants had to do with how well competition worked and with three operators it would deliberate rules to prevent cartelisation or market division.[174]

Comviq, with its owner Kinnevik, argued against a licence to NordicTel and submitted a number of memorandums to the Government. Comviq agreed with the Frequency Management, stressing that if one was to give licences to more operators, this would mean strong disadvantages to the existing operators. NordicTel argued that if the Government were to allocate further licences, it should mean substantial economic advantages to society. Comviq maintained that the two existing operators would be able to amply meet the demand for mobile telephone services in the Swedish market. Moreover, no other European country had more than two mobile telephone operators, despite the fact that the customer base in many countries was bigger than Sweden's.[175]

The Government decided, on December 13, 1990, to allocate the requested frequencies to NordicTel.[176] Sweden was then the only European

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172 Communication from NordicTel to Government 7 March, 1990. Appeal against decision made by the Frequency Management at Swedish Telecom 7 March 1990, and a memo submitted to the Government presenting additional information concerning NordicTel's application for a permission to operate a digital mobile telephone network 12 April 1990.

173 Petition to the Government, 29 June 1990.

174 Frequency Management, Swedish Telecom, Memorandum to the Government regarding Nordic Tel's appeal, 15 May 1990.

175 Comvik memorandum to the Ministry of Transport and Communication, concerning application for radio permission for mobile telephone systems, 31 October 1990.

176 Government Decision concerning allocation of frequencies to NordicTel, 13 December 1990.

country with three GSM operators. A decisive factor was a statement from Professor Ulf Körner at the Lund Institute of Technology, who explained that there was enough frequency space for yet another GSM operator in Sweden. According to Körner, it was better from a frequency economic perspective with only one operator, who would minimise the number of cut off calls, since all mobile telephones had access to all channels. With two operators there are a greater number of cut off calls than with only one operator. With three operators, the number of cut off calls would increase even further. But the increase would be less than when switching over from two to three operators, than when switching from one to two operators. Besides, if intercommunication were to be permitted between the operators' networks, meaning that one operator can use another operator's channel without the risk of overload, the result would 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 1990s, and it would not be necessary for the frequency management to take any action before the year 2000. The frequencies might then be transferred from NMT to GSM, as well as a reallocation of frequencies between the GSM operators.[177]

Another reason for giving a licence to NordicTel was that the Government wanted to increase competition in the network operators' market. According to the executive at the Ministry of Transport and Communication, NordicTel was allocated frequencies because they were a trustworthy company with major Swedish owner interests and had proved it 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.[178]

According to the Comviq's management, NordicTel obtained a licence to build a third GSM network in Sweden because of the company's successful canvassing of support, which came mainly from Pharos' board of directors with Krister Wickman in the lead, from Camilla Odnoff, the county governor in Blekinge, and from the Karlskrona Trade and Industry Committee with Rune Andersson and Ulf Lindén.[179]

Ownership changes

In the period before NordicTel was introduced on the Stockholm Stock Exchange in 1994, Swedish ownership changed and was gradually reduced.

177 Memorandum to the Government, The number of operators on the Swedish GSM market, 21 November 1990.

178 Interview Jerker Thorngren, Ministry of Transport and Communication, 12 February 1991.

179 Interview Thomas Julin, Comvik GSM AB, 11 April 1991.

In 1991, the Vodafone Group became part owner with 10 per cent of the subsidiary AB NordicTel, which was the operating company Europolitan, while NordicTel Holdings AB held 90 per cent. Shortly afterwards, one of the joint owners, Scandinavian Airline Systems sold its shares to the other joint owners for SKr 9 million. Through a new issue of shares in 1992 Vodafone's shares in AB NordicTel were transferred to shares in NordicTel Holdings AB, giving the British company a share of 18.5 per cent.[180] Vodafone's investment in NordicTel was approximately SKr 218 million. The company's estimated value was then SKr 1 billion.[181]

Vodafone application

The conclusive factor behind Vodafone's part ownership in NordicTel could be found in 1990. Because, in July 1990, Racal-Vodafone applied to the Frequency Management for allocation of frequencies to establish a GSM network in Sweden, together with Swedish partners. The Frequency Management rejected the application. Racal-Vodafone appealed to the Government against the decision and claimed that the market was sufficiently large to support three network operators. Not surprisingly, Comviq and Swedish Telecom Radio argued in their submission to the Government that Vodafone should not be granted a licence. In the event, the Government did not have to take a decision since Racal-Vodafone informed the Government on December 11 that it withdrew its appeal, as it no longer had any ambition to establish a GSM-network in Sweden. However, the company was still interested in the Swedish mobile market.[182] Two days after Vodafone's notification of withdrawal to the Government NordicTel was awarded its GSM licence.

Air Touch becomes a majority owner

In October 1993, the Swedish owners sold 51 per cent of the shares in NordicTel Holdings AB to the American mobile telephone operator Air Touch for SKr 1.2 billion ($153 million). Subsequently, Air Touch has taken an active part in the business.[183] The remaining joint owners then had a capital gain of SKr 967 million, reducing the equity share from 27 per cent to 10 per cent. The company's estimated value at the time was SKr 2 billion.[184]

In May 1994, NordicTel was listed on the Stockholm Stock Exchange.

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180 NordicTel Holdings AB invitation to buying shares 1994, NordicTel Holdings AB Annual Report 1994.

181 Finanstidningen, 22 April 1994.

182 Magnus Karlsson, *The Liberalization of Telecommunications in Sweden*, Linköping: Linköping University, 1998 p 276. Based on Communication from Racal to the Government, 31 July, 1990, 11 December, 1990.

183 Interview Zeth Nyström, Europolitan, 25 May 1994.

184 Finanstidningen, 22 April 1994.

The part-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 per cent of the company. At the flotation, the company's estimated value was SKr 3 billion. Including 1994, the owners had contributed with SKr 916 million, in proportion to the number of shares each one had. In early 1995, Volvo sold its share holdings making a profit of SKr 576 million from its NordicTel investment.[185]

The Swedish part-owners have, to say the least, obtained a satisfactory dividend from the investments in NordicTel; each company has earned approximately SKr 580 million.

Opening of Europolitan network

In September 1992, Europolitan, which was the name NordicTel labelled its mobile service, introduced its GSM network. It was not an easy start for Europolitan since competition was severe and the company was initially far behind Comviq and Telia Mobile. Nonetheless, Europolitan has succeeded in building up a significant market share. From the start, the company did not anticipate the need to pay commission to distributors and retailers in order to obtain customers. However, competition between the network operators forced it to pay commissions and other compensations to retailers from 1993-94.

The Marketing Manager at Comviq, Ulf Groth, 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 on the market. This meant, according to Comviq's manager, that Europolitan did not keep up with the competition and had to settle for second rate retailers. On the other hand it accomplished fine relations with wholesale dealers, such as Scribona and Enström.[186] 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. According to the marketing manager Zeth Nyström, Bob Erixon was quite skilled at playing off the operators against each other.[187]

185 Finanstidningen, 22 April 1994, the figures is based on information from NordicTel Holdings AB Annual Report 1994, and the Prospectus for the Initial Public Offering NordicTel Holdings AB, April 1994

186 Interview Ulf Groth, Comvik, 10 May 1994.

187 Interview Zeth Nyström, Europolitan, 25 May 1994.

In order to strengthen its position in the market and obtain customers, Europolitan started establishing its own shops at the end of 1994 called Europolitan stores. NordicTel was renamed Europolitan at the beginning of 1995. Europolitan Holdings AB is the parent company for two fully owned operating companies in Sweden, Europolitan AB and Europolitan Stores AB

Europolitan has primarily focused on business users, and has a churn rate of about 20 per cent. The company has consistently developed new services for the high end users, supporting the integration between data and tele, and fixed and mobile communication. The installed base of subscribers and the annual growth are indicated in the following table.

Table 25 / **Europolitan's number of subscribers and annual growth 1993-98**

Year	Number of mobile telephone subscribers	Annual growth of subscribers in per cent
1993	14 000	
1994	70 000	400
1995	148 000	111
1996	281 000	90
1997	424 000	51
1998	642 000	51

During 1997, it launched the wireless office, or mobile office as a commercial service enabling corporate users to replace the fixed communication with Europolitan GSM based wireless office solution. Other services are LAN Direct, which enables business customers to connect to internal networks to reach email, to get files and information and mobile Internet. Europolitan launched a prepaid telephone card Europolitan EASY at the end of 1997, distributed through a wide range of retailers. In July 1998 Europolitan started to market its service on dual band.

Europolitan has extended its network with about 200 radio base stations annually. Up to 1998, Europolitan has invested SKr 1.9 billion in infrastructure.

Europolitan Stores market mobile telephones and accessories and Europolitan subscriptions through 25 outlets throughout Sweden, with a market share of 10 per cent, and is thereby one of the largest specialist shops in Sweden. The firm also functions as a wholesaler of mobile telephones and accessories. The economic development for the company is presented in the following table.

Table 26 / **Europolitan economical performance 1992-98**

Year	Annual turnover in million SKr	Profit after financial items in million SKr	Investment in million SKr	Number of employees	Market capitalisation in million SKr
1992	0.6	-3	331	76	
1993	28	-225	323	151	
1994	278	-320	501	273	3 351
1995	752	-400	414	398	2 779
1996	1432	329	573	528	6 089
1997	2222	375	555	615	12 383
1998	3281	1000	643	740	38 823

Source: Annual report NordicTel/Europolitan

NordicTel also had a share of 20 per cent in the Danish GSM operator Dansk Mobiltelefon, Sonofon. But when Air Touch became majority owner in NordicTel, Bell South, one of the part-owners in Sonofon, asked to purchase NordicTel's shares in Sonofon as it violated the agreement between the part-owners in Sonofon. This led to NordicTel's ownership being transferred to an option that was placed in NordicTel's Danish firm and that the conflict should be settled in Danish court. In 1996, the conflict was solved and NordicTel sold its share in Sonofon to Bell South International and GN Great Nordic, making a profit of SKr 477 million.[188]

7.3 System supplier

Ericsson - mobile telephony more and more important

In the early 1980s, the business of mobile telephony accounted for only a marginal part of Ericsson's total turnover. It might not therefore be so surprising that mobile telephony was looked upon as a sideline, considering that the Group's core business was public telecommunication. But mobile communication has gradually increased its importance to the Ericsson Group, and the year 1992 marks a milestone when radio communication exceeded public telecommunication and became Ericsson's major business. The increased significance for radio communication is illustrated in the following table.

[188] NordicTel/Europolitan Annual Report 1996.

Table 27 / **Proportion in per cent of public telecommunication and radio communication in Ericsson's annual turnover 1969-98**

Year	Public telecommunication	Radio Communication
1969	58,4	4,6
1970	56,2	4,4
1971	59,9	4,0
1972	62,9	3,5
1973	72,4	3,1
1974	61,5	3,5
1975	54,1	3,6
1976	43,0	4,4
1977	53,9	4,4
1978	58,9	4,8
1979	44,8	5,4
1980	36,5	4,6
1981	29,4	4,5
1982	35,3	6,9
1983	33,7	5,8
1984	33,1	6,3
1985	32,6	7,6
1986	32,6	8,5
1987	33,6	8,8
1988	43,7	15,2
1989	43,7	20,4
1990	44,7	25,3
1991	42,6	26,8
1992	35,5	31,8
1993	30,2	40,8
1994	27,5	49,1
1995	22,0	56,4
1996	32,1	63,2
1997	28,6	66,8
1998	16,5	70,5

Source: Annual reports SRA, LM Ericsson

Mobile communication now accounts for over 70 per cent of the Group's turnover, and the key word for future investments is mobility and mobile Internet (Internet based (IP) technique). Ericsson holds about 40 per cent of the market for mobile telephone systems in the world.

Since the early 1990s Ericsson has intensified its research and development work, developing products for the various standards and working with the development of the third generation mobile telephone systems. Together

with other suppliers they have formed different projects, such as Bluetooth, which was presented in May 1998, developed in co-operation with IBM, Intel, Nokia and Toshiba. Bluetooth is a technology facilitating transmission between portable devices, such as mobile telephones and portable computers. Another project is Symbian, where Ericsson together with Motorola, Nokia and Psion, develops and market an operating system EPOC, for the future generation of mobile communications equipment.

The immense importance of Ericsson to the Swedish economy is illustrated by the fact that Ericsson accounted for 1.3 per cent of the GNP in 1996, 16 per cent (equivalent of SKr 100 billion) of Swedish exports in 1998, and now accounts for 1.2 per cent of the total labour market. If subcontractors are incorporated the figures are substantially greater.

New suppliers

New suppliers to the network operators emerge, offering operators products and services which enable them to connect the mobile telephone customers to Internet. One example is SendIt.

Sendit

Sendit is a Swedish firm that develops software and technology facilitating Internet access for mobile telephone subscribers. With the expansion of Internet the firm anticipates a growing interest among mobile telephone subscribers to get access to the World Wide Web. Moreover, the increased competition on the network operators market also stimulates the development of value added services, like mobile data.

Sendit's main product is an Internet server called Internet Cellular Smart Access (ICSA), which helps mobile subscribers to access Internet, receive, forward and send email to and from mobile telephones. The firm markets its products to network operators around the world, like Europolitan, with whom Sendit started to collaborate at an early stage, Vodafone, Hong Kong Telecom, and Telenor.

Sendit is working closely with mobile telephone manufacturers like Ericsson and Motorola, and with SIM-card manufacturers like De la Rue and Schlumberger, to improve the user interface for mobile Internet.

Paul Rönnberg, Jimmy Tjärnlund, and Hjalmar Winbladh founded Sendit in late 1994. The three of them had started a cleaning services, Pedant, and a delivery firm, Pedal, while they still were in school. As the delivery business expanded, consisting of a growing number of cars and bicycles, the management found it increasingly difficult to control the

operation. This gave Hjalmar Winblad an idea for a system where one could send text messages over the mobile network. In principal, customers called in their orders over the phone to Sendit, where an operator put the information into the corporate computer system. The system then transferred the order to the appropriate messenger bearer, who could confirm it on his terminal, and subsequently send a message when the order was accomplished. It was not long before the instigators saw the potential for a general application of such a system which was why they decided to start a company. The inventor of the idea Hjalmar Winblad was appointed managing director.[189]

Sendit has succeeded to attracting Åke Lundqvist, former executive director at Ericsson Radio System and Mats Ljunggren, founder of Europolitan, to their board of directors.

Due to vast investments in research and development, distribution, and marketing the economic result has hitherto been negative. The turnover for 1996 was SKr 4.6 million with a loss of SKr 11.3 million, the sales during 1997 were SKr 23 million generating a loss of SKr 9.8 million. During 1998, the firm produced a negative result of SKr 43.3 million on revenue of SKr 38.4 million. Like similar high technology firms the company anticipates continued large investments in research and development, market position and distribution, which is why the significant profits still lie in the future. The company made a share issue in June 1998 taking in SKr 71.9 million which considerably strengthened the balance sheet.

Since September 1997, Sendit is listed on the Stockholm Börsinformation, SBI -listan, which is a market for shares in smaller and medium size companies. Sendit's market capitalisation was SKr 467 million in early 1999.

Radio Design

Torbjörn Johnson founded Radio Design AB in 1995, and three years later the investment firm Morgan Stanley valued the firm at SKr 2.5 billion. The company shows continuous growth and has over 350 employees. In 1995, the revenue was SKr 10 million, in 1996 the sales were SKr 50 million. Chief Executive Torbjörn Johnson estimates that the company will reach a turnover of SKr 1 billion in the year 2000. [190]

Radio Design develops a new antenna technique for the NMT 450 system. The idea is to provide intelligence to the antennas making it possible to direct radio signals to a given subscriber instead of transmitting an equally strong signal over a large area. They could thereby achieve several

189 Dagens Industri, 29 September 1997.

190 Finanstidningen, 1 August 1998.

advantages: the coverage and capacity is improved, output power reduced, making the equipment cheaper, and the utilisation of the frequency spectrum is significantly improved.

The NMT Group has approved Radio Design's Low Emission Mobile Station (LEMS) developed jointly by a number of manufacturers, and the official name is NMT step 3.[191] It uses a very low output power, and it will, according to Radio Design, be possible with small and high performing handsets.

The company is not only involved in antennas because it is also developing new kinds of mobile telephones, the work being carried out in the company's subsidiary in the United Kingdom.

Radio Design's plan is to approach the mass market with products for a revitalised NMT 450 standard offering low cost for network operators and subscribers. The firm is approaching developing markets, like east-Europe and it has hitherto succeeded in selling systems to network operators in Bulgaria, Hungary and Russia.

Radio Design's vision is that mobile telephony should replace fixed telephony, that radiation should be minimised to decrease interference and reduce the risk for negative effects of radiation, talk time should be increased substantially, and batteries should offer longer lasting energy.

Antech Communications AB, formerly Antel Sweden AB based in Kalmar, is incorporated into Radio Design. The firm's focus is on development, production and sales of antennas and antenna based products. Of Antech's net sales of SKr 65 million, 95 per cent is exported. The firm employs about 40 persons.

Noalto

Noalto is a subcontractor to Ericsson and produces plastic covers for Ericsson's mobile telephones. Of the company's 775 employees 350 employees are occupied with components to mobile telephones. Noalto is directly dependent upon how successful Ericsson is on the market for mobile telephones. Noalto also supplies products to Nokia and Siemens. The company is listed on the Stockholm Stock Exchange. [192]

Time Space Radio

Time Space Radio AB was founded by Karl-Axel Åhl in 1990. He has a background at Telia, and has developed fixed wireless, local and regional tele- and data communication with broad band capacity, suitable for speech,

191 Business Wire, 15 October 1998.

192 Finanstidningen 21 May 1997.

data and image communication. It could be deployed in cities and industrial areas for various applications, such as the Internet, mobile base-station networks and telephony. The company has established a number of pilot systems. The company has 40 employees.

Cetronic – InfoCast AB

Cetronic AB, founded by Kurt Sjöblom in 1985, develops and markets systems and products for wireless communication, alarms and remote controlling. InfoCast, a subsidiary to Cetronic where Kurt Sjöblom is managing director, has developed a product for mobile web casting which facilitates access to the Internet from a mobile phone or a pager. The product combines push technology and a user-programmable smart agent that can tailor the type and amount of information which is transferred to a mobile phone. InfoCast has developed an information server that automatically delivers information from Internet, Intranet, databases and email servers to portable receivers such as GSM-telephones.

Cetronic AB is listed on the Stockholm Stock Exchange, the largest owner is Telenor Venture with 22 per cent, Kurt and Monica Sjöblom with 12 per cent. The turnover 1996 was SKr 14 million. The number of employees is 25.

Moteco AB

Moteco AB develops, manufactures and markets antennas and antenna systems for mobile telephones, which the company sells to mobile telephone manufacturers around the world. The firm has also developed antennas for dual band telephones. Moteco has its head office in Kalmar, while research and development activities are located in Lund. Invoiced sales 1997 were SKr 189 million, earnings after financial items SKr 58.2 million.

Carant AB

Veronica and Ketty Cramner established Carant Antenn AB in 1969. The company started with antennas for car radios and mobile radios. Sales to telecommunication manufacturers began in the mid 1970s. The firm supplied antennas to the Swedish Defence during the 1980s, when they also became involved in development and production of antennas for mobile telephones and data terminals.Carant delivers products and systems to the major suppliers of mobile telephone systems and to leading vehicle manufacturers. In 1997, annual sales were SKr 80 million and the number of employees 65.

7.4 Mobile telephone suppliers

Nokia together with Ericsson and Motorola dominate the world market for mobile telephones. During 1998, Ericsson sold 24 million mobile telephones, an increase of 50 per cent compared with 1997. The competition is fierce, pressing down prices by about 20 per cent annually. Since 1987 the weight of a handportable has decreased significant as the following table show.

Table 28 / **Weight and speech time for handportable mobile telephones 1987-98**

Year	Weight in grams	Speech time in minutes	Brand
1987	750	180	Nokia
1988	650	120	Ericsson
1989	500	80	Philips
1990	350	90	Motorola
1992	300	180	Mobira
1993	265	90	Motorola
1994	149	140	Motorola
1995	149	140	Motorola
1996	151	140	Nokia
1997	110	140	Motorola
1998	95	140	Motorola

Source: Corporate material

When prepaid mobile cards took off, the demand for low price mobile telephones further increased.

GSM was first introduced on a broad front in Germany, mainly due to the fact that Deutsche Telecom's analogue system was expensive to use, that penetration was low and that a private operator, Mannesmann had established a GSM network in Germany. The mobile telephones for the analogue network cost about $ 2700 in 1992 compared to $ 1780 for GSM phones. In contrast to the more developed mobile market, the German customers were prepared to purchase mounted GSM telephones at this stage when the handportable mobile telephones for GSM had yet to be introduced.

Dual band telephones for GSM 900 and GSM 1800 were launched in 1998.

Ericsson

During the 1980s, Ericsson specialised in NMT telephones, extending the knowledge of land mobile radios. Ericsson had given little serious thought to manufacturing a range of mobile telephones until 1990. A major step

was the formation of GE Mobile Communications in 1989, together with General Electric. This gave Ericsson access to an established trademark and a distribution network in the US. In 1998, Ericsson bought the remaining 20 per cent in Ericsson-GE Mobile Communications from General Electric.

Ericsson's development of GSM-telephones was driven by the demand from Mannesmann, to whom Ericsson had sold a mobile telephone system and who were eager to attract customers to generate some traffic in their network.[193]

Mobile telephones have come to be very important for Ericsson during the last years and now account for 27 per cent of the Group's revenue. The company plans to sell 10 million phones of the new platform to be launched during early 1999, which will give revenues of roughly SKr 20 billion, mostly generated in Sweden.

Possio System Innovation

Possio International AB specialises in paper-based mobile communication. The company has launched a brief-case portable, a multi-compatible device for both transmitting and receiving hardcopies of fax, Internet and email messages via cellular GSM handsets.

Possio International is a subsidiary of System Innovation AB, established in 1980. The greater part of production is exported, sales being routed via distributors and agents worldwide. Birger Tjälldin is the founder, managing director and owner of System Innovation AB.

7.5 Distribution

1990s[194]

The development of the system of distribution has been decisive for the expansion of mobile telephony. The distribution and retail business has gradually become more diversified and has moved towards a polarisation into a consumer mass market and a business market.

The emergence of a mass market for mobile telephony in Sweden was facilitated by the fact that network operators started to subsidise mobile telephones from 1993, by paying retailers a commission when they signed up new subscribers, which was invariably applied towards subsidising mobile telephones. Mobile telephones then became an interesting market for large Radio & TV retailers, such as Axlin, ONOFF and City Stormarknad.

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193 J. Meurling and R. Jeans, *The Mobile Phone Book*, London: CommunicationsWeek International, 1994.

194 Draws from Andersson and Mölleryd (1996a and 1996b).

The breakthrough of mobile telephony became a fact. Price competition was fierce since radio & TV retailers are used to working with huge volumes at considerably lower margins than the specialist mobile telephone retailers. This had a positive effect on the expansion of the market which grew substantially. Network operators introduced different tariff schemes specifically aimed at the consumer market. Products and services were continuously bundled, unbundled and rebundled.

The number of mobile telephones sold in Sweden from 1981 is presented in the following table.

Table 29 / **Number of mobile telephones sold in Sweden 1981-98**

Year	NMT 450	NMT 900	NMT900 handportable	GSM	GSM handportable	total
1981	1 652					1 652
1982	13 081					13 081
1983	16 517					16 517
1984	20 891					20 891
1985	31 774					31 774
1986	39 445					39 445
1987	31 000	7 525	1 294			39 819
1988	40 756	23 027	10 809			74 592
1989	32 099	47 307	35 902			115 308
1990	18 128	46 964	65 371			130 463
1991	13 702	22 103	87 275			123 080
1992	20 000	8 000	94 000	2 600		124 600
1993	27 000	9 380	123 620	989	43 011	204 000
1994	19 000		274 000	6 000	361 000	660 000
1995	9 000		87 000		764 000	860 000
1996	4 000		136 000		925 000	1 065 000
1997	3 000		44 000		1200 000	1 247 000
1998	2 000		2 000		1 550 000	1 554 000

Source: MobilTeleBranschen

The specialist mobile telephone retailers lost market share as mass-market outlets like Radio & TV shops and department stores gained dominance. The creation of retail chains served to emphasise this trend. The horizontal integration between retailers picked up speed after the mid 1980s and by 1993 only 15 per cent of retailers remained independent of any sort of retail chain.

Office equipment suppliers, car dealers, network operator shops like

Europolitan stores and Telia and computer vendors like the Lap Power chain offer alternative mobile telephone distribution channels.

Despite the increasing sales of mobile telephones and subscriptions, the intensified price competition resulted in the first serious shakeout of medium sized, local specialist retailers in 1991. Motorola, for example, estimated that it lost contact with around 20 per cent of its retailers, due to this shakeout.[195]

All suppliers and operators narrowed down the number of contacts with retailers during the 1990s, and simultaneously intensified their remaining retailer contacts. The three major suppliers continue to delimit the distributor contacts to 5-10 central purchasing organisations or wholesalers, all with contacts with the major retail chains. The mobile telephone suppliers, Ericsson, Nokia and Motorola directed attention towards the largest retailers and retail chains in the major city regions. Motorola appointed so-called megadealers while Nokia-Mobira tied-in their largest dealers by developing the marketing concept Mobira Business Partner. Ericsson made a similar move. Comparable concentration of interactions took place between retailers and the three network operators.

The formation of retail chains took off after 1991, creating more powerful retail organisations. The general change in retailer size indicated that the larger were getting larger, while many of the medium sized, regional and specialised retailers were departing the business. Prices dropped, margins were reduced and competition increased rapidly. Small retailers with their main business in other areas, car sales for instance, were somewhat less affected by the retailer shakeout.

Within the largest retail chains a polarisation trend started; small shops were opened in the cities directed towards the consumer market while special internal sales organisations were set up to handle corporate customer sales.

Despite being expected to lose out to the large Radio & TV retailers in the mid 1990s, the specialist retailer, as such, has succeeded in remaining as an important distribution channel. The specialist retailers have also extended their assortment to include computer equipment. A decisive factor behind this development is the fact that corporate customers have continued using local mobile telephone specialists. Companies have established direct contacts with the operators' sales departments which in turn have connected customers to local specialist retailers.

The wholesaler function has come to play an important role in the mobile telephone business what with the expansion in mobile telephony, the changing strategies of telephone suppliers, increased volumes, continuous

195 Interview Lars Norberg, Motorola, 4 May 1994.

price reductions and so on. There are a number of wholesalers active in the mobile telephone business in Sweden, as for example APE, Brightpoint, Scribona, and Geab.

Geab is expanding

Concurrently with the decrease in mobile telephone prices, it became more important to handle large consignments. This suited an expanding Geab, meaning that manufacturers who offered whole consignments often approached the company. Geab also used its stronger position to lower costs for purchasing as well as to obtain commissions and marketing support from operators.[196] 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 holds a strong market share.

The company Swatch, for example, launched its new mobile telephones through Geab.

The operators wanted to establish more connections with Geab, but required that Geab should sign up at least half of the GSM subscriptions to each operator. This meant that Geab had to drop one of its operators, and since NMT up until the mid 1990s was responsible for a great part of the sales, it was not possible to drop Telia Mobitel; instead the choice lay between Comviq and Europolitan. Geab opted for Comviq, which was considered the best complement Telia Mobitel could have had.[197]

Unisource purchase Geab and then sell it

In late 1994, Unisource Mobile bought Geab for approximately SKr 200 million. Unisource Mobile is a subsidiary of Unisource, Telia's international branch, which Telia owns together with the national telephone companies in the Netherlands, Switzerland and Spain. Unisource Mobile was established in 1994, with the strategy to market mobile telephone services all over Europe. A first step was to acquire Geab, and establish Geab stores in the rest of the Nordic countries before expansion took place in other parts of Europe. However, Unisource Mobile was not developing the way that the company had anticipated and the international expansion was not going as planned.

Geab was run as a separate company, performing both the retail and wholesaler functions. Geab, with 37 retail outlets with some 200 employees in 1998, is one of the leading actors on the mobile telephone market in

196 Interview Ulf Magnusson, Nokia-Mobira, 2 February 1994.

197 Interview Sören Hemmingsson, Telia Mobitel, 16 March 1994.

Sweden. The Unisource ownership ended in 1998 with the sale of Geab to the Carphone Warehouse, a company started in 1989 and now having 180 stores in the UK for mobile communication.

Talkline – aiming for business customers

The British company Talkline, a service provider and retailer in the UK, established itself in Sweden 1990. The company had a shop at NK department store in Stockholm, offering lease contracts and service contracts which was a good initiative according to Recep Celik who took over the business, but ahead of its time. Due to weakness in management and the shakiness of its business, Talkline's Swedish office did not do very well.[198]

Recep Celik, the manager at Talkline's Stockholm shop, took over the business in 1991 when the company was forced to suspend payments. He introduced a business idea including the sale of mobile system solutions designed to increase business customers' productivity.

Talkline worked systematically towards introducing paging. When paging was later accepted, the offer also included mobile telephones and now also computers. Talkline consciously invested in GSM from 1991 onwards. The company was trying hard to influence existing customers among larger companies. Talkline had contracts with 32 of the 100 major companies in Sweden.[199]

Despite the fact that operators and telephone manufacturers had 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 sold telephones exclusively from the three dominating suppliers: Ericsson, Motorola and Nokia.

As from 1993-94, Talkline expanded quickly. The company had by that time become the next biggest retailer after Geab. In March 1994, the Talkline had 30 employees, of whom 17 worked in Stockholm; the remainder working in Göteborg and Malmö. In 1995, the company had 80 employees, and its annual turnover was SKr 160 million. Talkline and Telebaren, which had seven stores in Stockholm for private consumers, merged in the same year to form People Cellular & Computers Sweden AB, with some 20 stores in Stockholm and in the south of Sweden. Recep Celik became Managing Director.

In 1996, Atle, a Swedish investment firm, together with the management at People Cellular & Computers Sweden AB recapitalised the company. Atle invested SKr 11 million and obtained 75 per cent of the company.

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198 Interview Recep Celik, Talkline, 14 March 1994.

199 Ibid.

As People Cellular & Computers has promoted the integration of mobile telephony and computers, selling different equipment for mobile computing, it was considered logical to integrate the operation into a larger group when Atle became part owner of Dafix Data & Telecom. The business areas now include peripheral equipment for computers, Calypso Internet service and People Cellular & Computer.

APE Telecom

APE Telecom is a leading wholesaler and supplier of mobile telephones and accessories in Sweden. The competitive advantage for the wholesaler is that it places large orders with the mobile telephone manufacturers, has a developed organisation for logistics, has access to financial resources, and has a well-established network of retailers. APE Telecom has connection to some 2400 retailers in a great variety of sales channels.

During 1997, APE Telecom sold more than 300,000 mobile telephones through 700 retailers. APE Telecom has 12 employees, and is part of APE Components, which is a wholly owned subsidiary of the Axel Johnson International Group.

7.6 End-users

With the private consumer market taking-off from the mid 1990s, mobile telephones become a consumer product. This marks a completely new departure in mobile telephony, as professionals or corporations had been its primary users up to this point. Yet parallel with the emergence of a consumer market, we see mobile telephony continuing to expand among large corporations and public organisations.

Judging from a survey, it could be claimed that users are not as sophisticated as the industry would like to think, only utilising a minor part of all the features and value added services that are provided.[200] This is also underpinned in a report published by the UK firm Spikes Cavell, which calls into question how effectively mobile telecommunication is being harnessed by business. Spikes Cavell found that the UK business approach to mobile communication is

> *"a mish-mash of ad hoc purchases and ill-trained staff, with barely one in five companies able to even to talk about a business strategy behind the technology".*[201]

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[200] Marie Bergholm, "Usage of mobile telephones in work, a qualitative study", February 1998. Magnus Hagberg, "Mobility – Purchasing and usage of mobile telecommunications", Stockholm School of Economics July 1998.

[201] Spikes Cavell & Co, "Mobile communications strategy?" A report for BT Mobile, September 1998.

Even though corporate users are getting involved in the development of customer adapted solutions it is not yet possible to characterise the development as customer driven. The market for mobile telephony could rather be described as supply side driven as the focus is on the mobile telephones and on price.

The cost for mobile telephones has decreased significantly over the years as this table shows.

Table 30 / **Price development in SKr for mobile telephones 1957-98 at 1998 year's prices**

	Telephone	Handportable
1957	64 912	
1968	32 410	
1971	40 429	
1972	38 175	
1976	38 403	
1980	51 384	
1981	45 844	
1982	42 216	
1983	38 758	
1984	35 868	
1985	33 417	
1986	32 066	
1987	27 679	46 132
1988	21 809	36 348
1989	19 123	28 684
1990	14 856	22 284
1991	11 311	19 228
1992	7 739	16 030
1993	6 337	10 984
1994	5 169	6 203
1995	4 033	5 041
1996	3 010	4 014
1997	2 500	3 000
1998	2 500	2 000

Sources: corporate material, daily papers

The customers can be categorised into the following groups: small companies, medium sized companies, large companies, public organisations, and private consumers.

Mobility

The feature that mobile telephony offers users, which here is labelled mobility, lies at the very center of the emerging information economy. This is underscored by Goddard and Richardson who state that:

> *"As more and more work involves the processing and exchange of information, fusing of telecommunications and computing into the networked telematics characteristic of ICTs (Information Communication Technologies) means that this work can become more portable or mobile"* [202]

Mobile telecommunication is a pervasive technology, with far reaching consequences on how people communicate and work. However, it is far from straightforward to appreciate the economic value of mobile telecommunications on an aggregated level. Individual users certainly have an opinion on what it means to their respective activities. This is the case for small companies where managers emphasise that it is necessary for them to be accessible, available to offer clients or other actors an immediate response. Otherwise, the threat is that the customers go to another firm with their business.[203]

The Office of Technological Assessment (OTA) underpins that the concept mobility is rudimentary, unfocused and that no theoretical framework exists for studying mobility as a unified concept.[204] Moreover, OTA emphasises that the impact of wireless technologies on individuals, organisations, and society is only now emerging, and OTA states it will involve increased personal and business efficiency, as well as increased stress and concern about monitoring and privacy. Wireless technologies, according to OTA, are likely to play a role in the continuing evolution of new organisational and social forms, potentially reinforcing geographic dispersion and functional dissolution.[205]

Mobile telecommunication facilitates ubiquitous communication, people can stay connected as they move, communicate and work independently of location, and it opens up new ways of performing business operations.

To develop a thorough understanding of the concept mobility I have carried out a survey of reports and literature, to identify motives and

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202 J. Goddard and R. Richardson, "Why Geography Will Still Matter: What Jobs Go Where?" in *Information and communications Technologies, visions and realities*, edited by W. H Dutton. Oxford: Oxford University Press, 1996, p 198.

203 Marie Bergholm, "Usage of mobile telephones in work, a qualitative study", February 1998.

204 U.S. Congress, Office of Technology Assessment, "Wireless Technologies and the National Information Infrastructure", (Mobility and the Implications of Wireless Technologies), OTA-ITC-622, Washington, DC: U.S. Government Printing Office, July 1995.

205 Ibid.

objectives behind the usage of mobile telephony.[206] An exploratory interview survey of user motives and opinions of using mobile telephones have also been a valuable input.[207] I have formulated eight variables which attempt to grasp the scope of mobility, which indicate the extensive implication of mobility on professional as well as individual life.

1) Communicate & co-ordinate: By using mobile telephones users become available for others, they can reach others, co-ordination and communication can be improved, internal and external co-ordination of firms is facilitated, connectivity increased.
2) Organising: Mobile telephones enable users to arrange meetings, report different activities, confirm decisions, change schedules, make route planning, inform, co-ordinate projects, be updated. Mobile telephony facilitates allocation of resources, and continuous arrangements of transport and travelling.
3) Flexible work: Mobile communications enable people to work any–place–any-time, it blurs the distinction between work and leisure time, new work forms and super flex, facilitates a flexible work environment, facilitates decentralisation and empowerment of personnel, telework
4) Customer service: Enhances customer services through use of mobile solutions, improves response rate to incoming calls.
5) Security: useful in emergency situations, increases the feeling of personal security, and enables various kinds of surveillance.
6) Personal communication: Mobile telephones facilitate family co-ordination, reduce insecurity and satisfy personal demands.
7) Efficiency and productivity: Augments time utilisation, and improves more efficient cash flows.
8) New possibilities: Facilitates new ways to do business, it opens for mobile commerce, and the completion of new functions.

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206 Telecom Markets FT, UK telecoms policy fails to promote advanced services, says report, Issue number 325, 23 October, 1997. • Schedl, H., Garbe M., Mastropasqua, R. The Effects on Employment of the Liberalization Process in the Telecommunications Sector, IFO Institute Munich, May 1996. • Ross, Malcom H. Finding the user – choosing the applications, IBC: the 1993 Pan-European Digital Cellular Radio Conference Lisbon, 16/17 February 1993. • Mobile Europe, Mobile phone use: it's a family affair, November 1997. • Lunds Universitet, En undersökning om våra telefonvanor, Medie- och kommunikationsvetenskap Lunds Universitet 1993. • Katz, James E, Social Consequences of Wireless Communications. A Selective Analysis of Residential and Business Sectors in the United states, ITS, Eleventh Biennial Conference Seville, Spain June 16-19, 1996. • Haddon, Leslie (Ed.), Communications on the move: the experience of Mobile telephony in the 1990s, The future European Telecommunications User Mobile Workgroup, COST 248, August 1997. • European Foundation for the Improvement of Living and Working Conditions, Flexispace/Mobility of work – A Problem study on the future of spatially flexible forms of work, working paper no: WP/95/29/EN by Thomas Maier, Claus Edelmann, Steffen Hiring. • Dholakia, R.R. et al (eds), New Infotainment technologies in the home – demand side Perspectives, Lawrence Erlbaum Associates, Publishers, Mahwah, New Jersey 1996, • Chalmers Tekniska Högskola, Strategisk marknadsbaserad planering av GSM-nätet, 1996

207 Marie Bergholm, "Usage of mobile telephones in work, a qualitative study", February 1998.

Purchasing

Corporate customers predominately centralise purchasing decision to one organisational unit for negotiating with network operators while maintaining localised contacts with retailers for the provision of mobile telephones and services.[208] While purchasing of mobile telephones and subscriptions for the personnel could be handled formerly by administrative units with fairly little influence on the overall communication strategies, the ongoing development has made these purchasing decisions become part of more long-term and integrated information and communication strategies. It is increasingly becoming a part of top-level strategic decision making in public and private organisations.[209]

The cost for having a mobile telephone has dropped considerable over the years as the following table indicates.

Table 31 / **The cost for connection fee, annual fee, call charges for one year and the cost for a mobile telephone 1956-98 at 1998 year's prices**

	MTA 1956	MTB 68	MTD 73	NMT 81	NMT 900, 87	GSM 93	GSM 98
Connection fee	18 462	17 050		687	462	318	250
Annual fee	15 825	10 230	3 270	3 664	1 232	1 488	1 944
Charges for calls 1800 min per year	27 324	18 414	9 661	12 366	9 563	6 582	6 200
Mobile telephone	67 688	32 410	35 770	45 800	45 900	10 600	2 000

Source: Corporate material

7.7 Entrepreneurship in the international phase

The reason for defining an international phase is that suppliers, network operators and standards are becoming international. Prior to the introduction of GSM, the market for mobile telephony was fragmented with a number of incompatible standards. GSM has not only become a European standard but also a de-facto world standard.The transition from the national/Nordic phase to the international phase is not distinct, as the

208 Magnus Hagberg, "Mobility - Purchasing and usage of mobile telecommunications", Stockholm School of Economics July 1998.

209 Building on interviews with private and public organizational buyers of mobile telephony, telecommunication systems and information technology during the spring 1996.

diffusion of NMT prompted several firms to work on the international market after taking a share of the Swedish market.

The individual as entrepreneur

With the introduction of GSM the competition increased from two to three operators, a substantial increase, in the Swedish network operators' market. This is an example of an individual entrepreneurship as a result of Ulf Johansson and Mats Ljunggren, who not only established NordicTel but also obtained frequencies, creating a new organisation of industry. Competition has led to operators investing more and more in marketing, to the benefit of retailers. Bob Erixon, for instance, continued to expand Geab's chain. Other firms approached, such as Talkline, founded by Recep Celik, who used the increasing market support to develop the distributor role, as well as creating a new distribution channel and a new type of marketing.

The company as entrepreneur

Several of the companies active in the national/Nordic phase have also accomplished entrepreneurial activities in the international phase. Telia Mobile 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 Comviq, when it concerned its own interests, argued in favour of competition, it had difficulty in accepting the need for a third operator in Sweden. Since Comviq was already in the market, the company was automatically allocated GSM frequencies. After the GSM start, Comviq employed an aggressive way of marketing mobile telephones in order to make them consumer products. The company was first to introduce prepaid cards for mobile telephony, which turned into being a tremendous success which was why the other two network operators followed suit (a new type of marketing).

Ericsson Radio's success in mobile telephony is mainly due to the company's substantial 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 system and mobile telephone aerials for various niches and the company has thus managed to gain a strong market share (new product). Europolitan introduced a new distribution channel when it opened up its own shops selling subscriptions and telephones.

The network as entrepreneur

In the international phase, Ericsson Radio/Telia through their co-operation in developing GSM products have fulfilled the network as entrepreneur. The GSM-Group is another kind of network entrepreneur.

Table 32 / **Entrepreneurship in the international phase**

	Individual	Company	Network
1) A new product		Allgon	Ericsson
		Ericsson Radio	Radio/Swedish Telecom
		Swedish Telecom Radio	GSM group
2) A new production process			
3) A new input			
4) A new market		Ericsson Radio	
		Swedish Telecom	
		Radio	
5) A new organisation of industry	M Ljunggren, U Johansson		
6) A new type of marketing	R Celik	Comviq	ONOFF/ network
		NordicTel	operator/mobile telephone supplier
7) A new distribution channel	R Celik,	NordicTel	ONOFF/ network operator/mobile telephone supplier

Entrepreneurship placed in the technological system

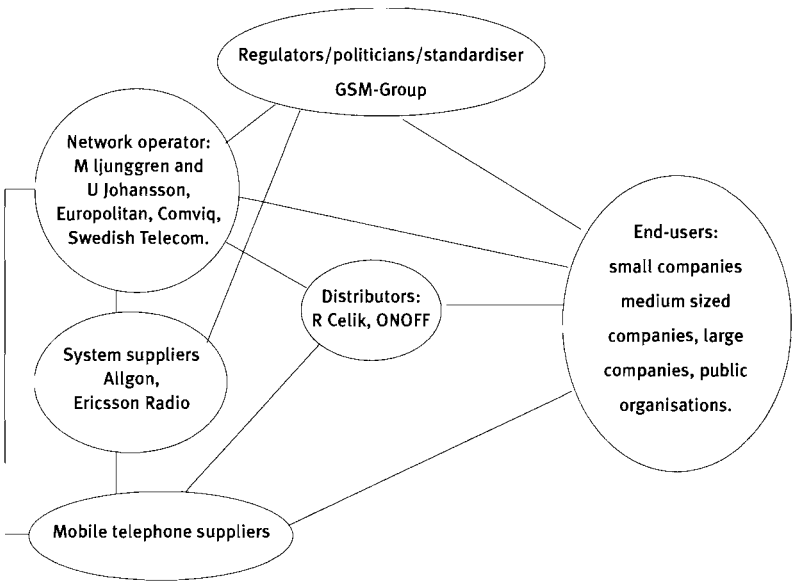
During the international phase, a technique oriented entrepreneurship is carried out by companies and networks, which has mainly to do with the various efforts - individual or collective - of the network operator Telia Mobile and the system supplier Ericsson Radio.

A market oriented entrepreneurship is carried out by individuals, companies and networks. Individuals carry out an organising entrepreneurship only.The GSM-Group as a standardiser is responsible for an entrepreneurship based on networks, where I also find Telia and Ericsson Radio. Allgon operates a technique-oriented entrepreneurship.

Ulf Johansson and Mats Ljunggren, NordicTel, operate an organising individual entrepreneurship. NordicTel as well as Comviq are responsible for a market-oriented entrepreneurship.

Moreover, the number of firms becoming active in the mobile industry supplying systems equipment is contributing to the development of the technological system, which means that the industry expands.

Figure 5 / **The technological system in the international phase**



This figure place the entrepreneurship that I have identified into the technological system for the international phase. It is therefore time to conclude this study.

8. Conclusions and an entrepreneurial spiral

Concluding

It is now time to wind up this study and elaborate on the analysis. This concluding chapter addresses some theoretical issues and highlights the findings from the study. Let me first recapitulate the research question:

How did entrepreneurship over time contribute to the development of the Swedish mobile telephone system?

This chapter is organised along the findings that I have made from this study, listed under five headings below. Concluding this chapter, I develop a model called the "entrepreneurial spiral", which conceptualises the development process over time and place the entrepreneurship into a dynamic context. Finally, I present a suggestion for future research.

The findings are grouped into the following five headings:

1) Interpretation of three sources of entrepreneurship,
2) The end-users changed perception of mobile telephony,
3) The co-evolution of the development,
4) The role of mobile telephony as a National System of Innovation,
5) The cumulative character and the connection of entrepreneurship – the entrepreneurial spiral.

8.2 Interpretation of three sources of entrepreneurship

In the previous chapters I have presented the case study divided into three phases where I have identified entrepreneurial activities performed by three sources of entrepreneurship: the individual, the corporation, and the network. Given the assumption made at the outset of this study concerning entrepreneurship - that it plays a key role in economic and technical development – I see entrepreneurship as a vehicle for the development of

the technological system.

The classification scheme makes it possible to examine and determine the entrepreneurship in the mobile telephone development. It represents an attempt to handle the participants activities. In the following, I discuss the sources of entrepreneurship that I have identified and classified, and relate them to the development to the technological system.

During the three phases – local, national/Nordic and international – the Swedish mobile telephone system has undergone dramatic changes and continuously expanded. It has gone from being a business involving relatively few people with a limited system to becoming a large industry involving a great number of firms and organisations. It is no exaggeration to claim that mobile telephony has become one of the strongest industries in Sweden, attracting capital, development and research resources. Sweden has become a frontrunner in this industry.

This is extraordinary as few, if any, anticipated that mobile telephony would become such a growth market. Mobile telephony was generally viewed as being peripheral to the fixed telephone network. Therefore national telephone administrations were more interested in developing the technical capabilities of their established fixed networks and in expanding services such as the ISDN, videotext and teletex rather than in deploying costly mobile telephone networks. However, at an early stage in the development Swedish firms gained a technical and market advantage.

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

Telia has played a major role due to its early involvement in mobile telephony. Based on Åsdal's investigation in the 1960s, Swedish Telecom initiated the development of a new national mobile telephone system, but since the company discovered that it was not technically feasible to realise the plans, the company went for a long-term solution in the Nordic countries instead. Together with the Nordic telecommunication administrations, a decision was made to develop a common system. The market expanded considerable, attracting system and telephone suppliers to invest in development work. This was further reinforced by the fact that the Nordic system was an open standard and could be used by any interested supplier or telecommunication network operator.

There have been some structural conditions to build on which have facilitated the development of the Swedish mobile telephone system. For example the co-operation between Ericsson and Swedish Telecom which goes beyond mobile telephony, where the explicit aim from the Swedish

state has been to support Swedish export industry and at the same time make an advanced technology available in the Swedish telecom network. When developing NMT, Ericsson was able to take advantage of publicly financed development work arising out of the co-operation between the Nordic telecommunication administrations in order to launch competitive products on the international market.

Swedish Telecom and Ericsson played central roles in the development of the Swedish mobile telephone system. Both offered a good training ground and when entrepreneurial activity resulted in new competitors, their need for qualified employees was to some extent satisfied by the flow of people from these two established firms. Moreover, the expansion of mobile telephony attracted more people to a career within the field.

The characteristics of entrepreneurship in the three phases

Since mobile telephony went through such a vigorous expansion during the three phases, it is interesting to explore whether the entrepreneurship appears in different shapes, and whether the entrepreneurship changes between the phases. The former question deals with differences between which source – the individual, the company or the network – carried out the entrepreneurship. The latter question deals with whether the types of entrepreneurship – technique oriented, market oriented or organising entrepreneurship – differ in the three phases.

However, before I discuss the differences between the three phases I would like to summarise the characteristics of the entrepreneurship in the three phases. Let me begin with the local phase.

Local phase

Individual entrepreneurs carry out a technical entrepreneurship in the local phase. The corporation Swedish Telecom pursues a market related entrepreneurship. Moreover, the network constituted by Swedish Telecom and Ericsson and SRA performs a technical related entrepreneurship. It is a specialised entrepreneurship, focusing on one thing, and it has a technical focus. Local private mobile telephone networks are launched by entrepreneurs in different parts of Sweden.

National/Nordic.

Individual entrepreneurs carry out entrepreneurial activities with all of the seven innovation types, which mean both technique, organising and market related innovations. Individual and corporation entrepreneurs dominate this

phase. Several of the entrepreneurs perform entrepreneurial activities in more than one category.

This implies that the entrepreneurial function in this phase were to act as a co-ordinator in the expansion of the Swedish mobile telephone system.

The international phase

Even though the individual performs the entrepreneurial activities they have to a large extent been taken over by corporations and networks. For marketing related innovations the network as an entrepreneur has taken a strong position. Compared to the earlier phase we see a more specialised entrepreneurship where firms in principal pursue one goal.

Comparison of the entrepreneurship in the three phases

The extent of entrepreneurship changes over the three phases. The most entrepreneurial activities take place in the national/Nordic phase for the reason that mobile telephony was going through a tremendous expansion at the same time as a Swedish mobile telephony industry was being established; in the local phase mobile telephony was still a limited business.

Individual entrepreneurship

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. Examples supporting the individual entrepreneurs are to be found in Åke Lundqvist and Östen Mäkitalo, who, together with Sven-Olof Öhrvik, Ericsson Radio, and Lund Institute of Technology, were awarded the Royal Institute of Technology's first prize.

The individual entrepreneur in the case sets new directions for the development. Examples are the entrepreneurial activities of R. Berglund, Ö. Mäkitalo, Å. Lundqvist, C-G Åsdal, and J. Stenbeck that I have discussed previously. The individual entrepreneur develops from being technically oriented into being market oriented. Individuals as entrepreneurs play a less significant role in the latter development stages when the industry matures and the technology gets more complex.

Corporation as entrepreneurs

The corporation as entrepreneur play a major role in the nordic/National and international phase. In the national/Nordic phase, corporations carry out technique oriented, organising and market related entrepreneurship. In

the international phase corporations as entrepreneurs carry out technique and market related entrepreneurial activities.

Networks as entrepreneurs

Networks as entrepreneurs perform entrepreneurship in all three phases. This takes the form of technical innovations in all three phases, as well as market innovations in the national/Nordic and the international phase.

The innovation types

If the three innovation types are placed in the center the following picture emerge.

Technique-oriented entrepreneurship occurs in all three phases. In the local phase it is being carried out by individuals and networks; in the national/Nordic phase by individuals, firms and networks, while only firms and networks operate during the international phase. One explanation for this might be that there is also room for individual entrepreneurship before the technique has been designed, but when the technique becomes more and more complex and productive, as was the case with GSM, companies and networks are responsible for the entrepreneurship.

Organising entrepreneurship is absent from the local phase. The reason for this is that the mobile industry, when in its infancy, attracted only a few participants. But in the national/Nordic phase, an organising entrepreneurship is carried out by individuals and firms, to be followed by an individual in the international phase. It is interesting that an individual entrepreneurship gives industry a new organisation in the international phase. This shows that it is possible for individuals to influence the design of technological systems. [210]

Market oriented entrepreneurship – carried out by firms in the local phase, and in the national/Nordic – as well as the international phase – by all three sources of entrepreneurship. In the international phase the mobile telephone technological system expands though the market related entrepreneurial activities.

Taken together

The early stage of mobile telephony was technically oriented, the core competence in mobile communications being radio technologies inter-

[210] This is in accordance with the conjectures on the role of individuals in system building presented by David (1992).

twined with telephone techniques. The technology drives the development but is not sufficient to accomplish the development without the introduction of market related innovations, and organising innovations are necessary to create incentive structures that result in high sustainable growth rates – or to put in the language of T. Hughes "momentum".

It could be stated that the individual entrepreneur decreases in significance as the mobile telephony system matures and grows in size. The corporation and network of entrepreneurship sources increase in significance.

8.3 How end-users changed the perception of mobile telephones

User interpretation of mobile telephones and the social norms define how mobile telephones are apprehended. Lead users brings the technology further by penetrating new areas and breaking social barriers or institutions which thereby change the definition of the technology (Bijker 1995b).

Mobile telephones were originally seen as a communication tool for limited numbers of professionals, becoming a ubiquitous phenomenon only later. Increasing user demand for mobile telephones has certainly been decisive for the expansion of the mobile telephone industry. The mobile telephone habit gradually spread to new groups among professional users and from the mid 1990's diffused to private consumers.

The industry was unable to foresee the tremendous growth in mobile telephony and how it would continuously spread to new user groups and, in the long run, become an established mode of communication. The suppliers and operators had a fixed idea what mobile telephony was and how it should be used, implying that it was suited to the needs primarily of a limited number of users. The inability to predict how the technology would spread is not confined to the mobile telephone industry because, e.g. according to Paul Saffo, it is not feasible to anticipate how a particular technology will be used and by whom. It has to be broadly enough designed therefore to allow any kind of usage pattern.[211]

At first, the mobile telephone was entirely car-related; it was mounted in the car with battery placed in the trunk. Only a limited number of users, like doctors, banks, Taxi and transport firms, were considered likely to benefit from the service due to the high cost and the inconvenience of installing the bulky equipment. However, these types of adopter groups gave a new dimension to business and service could be extended.

During the 1970s, mobile telephones were used primarily by small firms when out and about in pursuit of their business. The use of mobile tele-

[211] Intreview Paul Saffo, Institute of the Future, 17 December, 1998

phones extended to artisans, craftsmen, service technicians, sales forces, and various other mobile professionals during the 1980s. The introduction of the handportable mobile telephones for NMT 900 in 1987 provided the younger generation of business executives with a sought-after status symbol. The facility of conducting telephone conversations, often ostentatiously, in bars, restaurants and other public places met with their aspirations towards recognition which broached with the social convention, but nevertheless opened the possibility for the mobile phone becoming an omnipresent communication tool. The handportable was consequently nicknamed the "Yuppie phone".

Large firms and public organisations did not become users to any extent until the 1990s.

In the early 1990s, Swedish Telecom launched the first subscription form aimed at the consumer market, popular initially with boat/yacht owners, summer cottage owners and the like but soon taken up by the general consumer.

As the habit spread, the market expanded and this enabled mobile telephone manufacturers to achieve economies of scale in production and to reduce costs. The downward press on prices increased market growth, allowing penetration of new segments. However, the real boom came when the network operator started subsidising the mobile telephones themselves, considerably lowering the cost to the customer of entering the market. Market growth was also influenced by the bundling of tariff adjustments by network operators.

The rate of growth in mobile telephony was consistently underestimated. It was just not feasible at the time to see how intricately the feature of connectivity and mobility would suit the modern style of living, characterised by a constant press to communicate and be available, coupled with an ever-increasing demand for rationalising and efficiency. It would also suit the emerging work styles marked by flexibility and service. Sweden's leading position in mobile communications with a penetration rate of around 50 per cent means that mobile telephony has undergone a development to become an established way to communicate. It is even relevant to talk about a new techno-economic paradigm, the feature of mobility facilitating a new way of working and a new mobile lifestyle.

The entrepreneurship in relation to the technological system.

The development of the Swedish mobile telephone technological system could be seen as a knowledge-creation process. The development of products, solutions and procedures for products and services are based on knowledge, which means that knowledge is implicit in the entrepreneurial

activities. The profile of knowledge is indicated by the three types of innovation that I elaborate on: technical, organisational and market related. The drawing of a distinction between incremental and radical innovations is one way of highlighting the effect of innovations on the environment. However, the influence of innovations on the technological system is not automatically linked to the magnitude of the innovations but rather to the resultant consequences. Moreover, innovations often cause chain reactions and diffuse to totally unforeseen areas.

How does it relate to the different participants in the technological system. What does this leave us? How does the interconnection between the different entrepreneurial activities look like? It is relevant to question whether it is possible to identify a coordinating mechanism for this development.

Over time the technological system expands as the number of subscribers grows, leading to a substantial increase in employee numbers in the firms actively engaged. When new participants get established there is a movement in the workforce, which leads to competence dissemination in the technological system.

By linking the entrepreneurs to the innovation types and the theories that I discussed in the theoretical frame it is compelling to characterise the entrepreneurs in relation to their activity in the technological system. It could for example be stated that there is a kind of Schumpeterian entrepreneurship, where the entrepreneurs see the opportunity to expand the market, which, is the case for J. Stenbeck and the founders of NordicTel/Europolitan who through their activities transformed the regulatory system.

Another type of entrepreneurship is Hughesian, to solve reverse salients, which is the case of Mäkitalo who through his technological insights extended the technique.

The entrepreneurship that re-establish balance in the system evolution could be labelled a Kirzner type of entrepreneur. C-G Åsdal could be identified as an example of this entrepreneurship through his actions to find pathways between different mobile telephone system generations.

8.4 The co-evolution of the development

The complexity of the technological system leads to the fact that entrepreneurial activities are performed both sequentially and simultaneously. The entrepreneurial activities are simultaneously interconnected and occur interdependently, which makes it relevant to regard the totality of these activities as being an interactive entrepreneurship.

I stress that there are interdependencies between the different participants, and a relevant concept for this is co-evolution. The point is that different environments – technology, institutions, industries, and firms – interact and affect each other as Nelson repeatedly has stated. This influence could be in the form of dynamic externalities that result from different actions (Hultén 1999). An example of this type occurs when mobile telephony users through their use of the technology create externalities that facilitate new types of organisation and new work methods.

8.5 Mobile telephony as National System of Innovation

As the technological system covered in this study is essentially Sweden-based, even though it has some international involvement it is relevant to bring in the concept of National System of Innovation, that stresses the national context for innovative activity. Compared to National System of Innovation analysis which analyses the innovative activity in a particular nation, this study only covers a minor share of the Swedish economy in the form of mobile telephony. However, it is interesting to use the national context as a framework for the analysis of a technological area. Furthermore, it also influences the remaining telecommunications industry and its service has an impact on user activities. National System of Innovation primarily works with aggregated data for the national context and not at the level of firms or individuals. National System of Innovation emphasises structural conditions which makes it a reference point for the broad spectrum of entrepreneurship theories that this study works with.

This study indicates that it is possible for a country such as Sweden to develop a significant presence within an emerging and rapidly expanding industrial sector. It certainly resembles the ideas around regional cluster and localised industries that I discuss in the theoretical framework. And it is interesting to find that Saxenian (1994) explains the regional advantage that Silicon Valley develops within the information technology field as a network process characterised by both individual and collective entrepreneurship.

As I have previously mentioned, there has been no master plan, as such, for turning Sweden into a leading mobile telephone country. It could certainly have been possible for Sweden to formalise a strategy pointing in this direction, but this was not the case. This development is rather the result of entrepreneurship, the combined result placing Sweden in the forefront of the world's mobile telephone industry, turning mobile telephony into one of Sweden's strongest development blocks. It has not been a linear process but rather has been a concurrent development or

co-evolutionary, consisting of a series of events that have unfolded in such a way as to create the Swedish mobile telephone industry.

8.6 The cumulative character and the connection of entrepreneurship – the entrepreneurial spiral

The idea behind the entrepreneurial spiral – which is one interpretation of the entrepreneurial development – is to place the entrepreneurial activities that I have identified into a context that capture the dynamics of the technological development and which comprise the development over time. The basic logic of the entrepreneurial spiral is that the entrepreneurial activities identified in the three phases are interconnected and influence each other as they occur within a technological system. This idea corresponds to the notion of complementarities and interdependencies that I discussed in the theoretical framework, and to Dahmén (1991a), who underscores that innovations trigger subsequent chain reactions.

The entrepreneurial spiral is based on the technological system related in this study, but condensed to capture the dynamics of the dependencies between the entrepreneurial activities. This could be illustrated with the following examples Mäkitalo's entrepreneurship stimulates Lundqvist to pursue entrepreneurial activities at SRA/Ericsson Radio. It also stimulate the network entrepreneurship produced by SRA/Swedish Telecom. The entrepreneurship carried out by Comviq force Swedish Telecom to act more innovatively and thereby contributing to the development of the technological system.

I maintain that entrepreneurial activities, far from being isolated, are creating connections and are cumulative, which stimulate the development of the technological system. The entrepreneurial spiral is based on the theory of cumulative circular causality (Myrdal, 1958), and on Nelson and Winter's (1982) concept cumulative technology. The cumulative principle is based on the assumption that there are interdependencies between different parts of a system and that no single factor is decisive for the development, as everything is causing everything else to move in an interconnected circle motion. Moreover, the theory of cumulative circular causality states that a system exists in a temporary balance at a given point and that a change of any variable in the system leads to additional change, which sets the system in motion. This means that the final influence of a change could be of considerably more significance than envisaged at the outset.

The figure below show the entrepreneurial spiral into which I have

placed the entrepreneurship. In order to facilitate the presentation I use the division of three phases which the case is based on.

The starting point of the first phase is when mobile telephony, as an innovation launched by the network operator and facilitated by development work carried out by R. Berglund and S. Lauhrén, giving impulses to system and mobile telephone suppliers, sparks the entrepreneurial spiral to function. Concurrently, a co-operation is being established between Swedish Telecom, LM Ericsson and SRA to take care of further developments (however they also work on the first system), resulting in the development of a new product. Moreover, the users, like banks and doctors, stimulate the network operator to pursue further development work. The comprehensive entrepreneurship in the first phase influences the network operator in the second phase.

In the second phase, NMT as an innovation moves the spiral by the network operator's influence, emphasised by C-G Åsdal's entrepreneurship, on the standardiser, the NMT-Group. This creates new opportunities for Swedish Telecom, advanced by Ö. Mäkitalo's individual entrepreneurship, as well as for system suppliers like Ericsson Radio promoted by Å. Lundqvist's entrepreneurship and Radiosystem led by T. Johnson. Moreover, the entrepreneurship carried out by the network entrepreneur Ericsson Radio/Swedish Telecom moves the spiral further.

Moreover, Comviq's advancement, facilitated by J. Stenbeck's individual entrepreneurship, influences Swedish Telecom Radio. The network operator Comviq put pressure on politicians, which affects distribution, after changes in the regulatory system. It gave Comviq greater room to manoeuvre with the possibility of expanding its network.

In the second phase, it is not only system suppliers, like Allgon, who are being influenced by the standardiser's innovation. There is also pressure on mobile telephone suppliers as a new market is being introduced. When mobile telephone suppliers then manufacture new products, like for example P. Siversson's Spectronic, it affects distributors who are anxious to attract customers, signifying that entrepreneurship characterised by middlemen becomes important. This is underscored by the entrepreneurship carried out by E. Erixon in establishing the retail chain Geab. The end-users, which are found among the small and medium size companies, affect the continuing investment into the field. When the handportable mobile telephones were launched Yuppies play a key role to extend the market and redefine how the mobile telephone could be used. This stress mobile telephone suppliers to develop new products and network operators to improve their service.

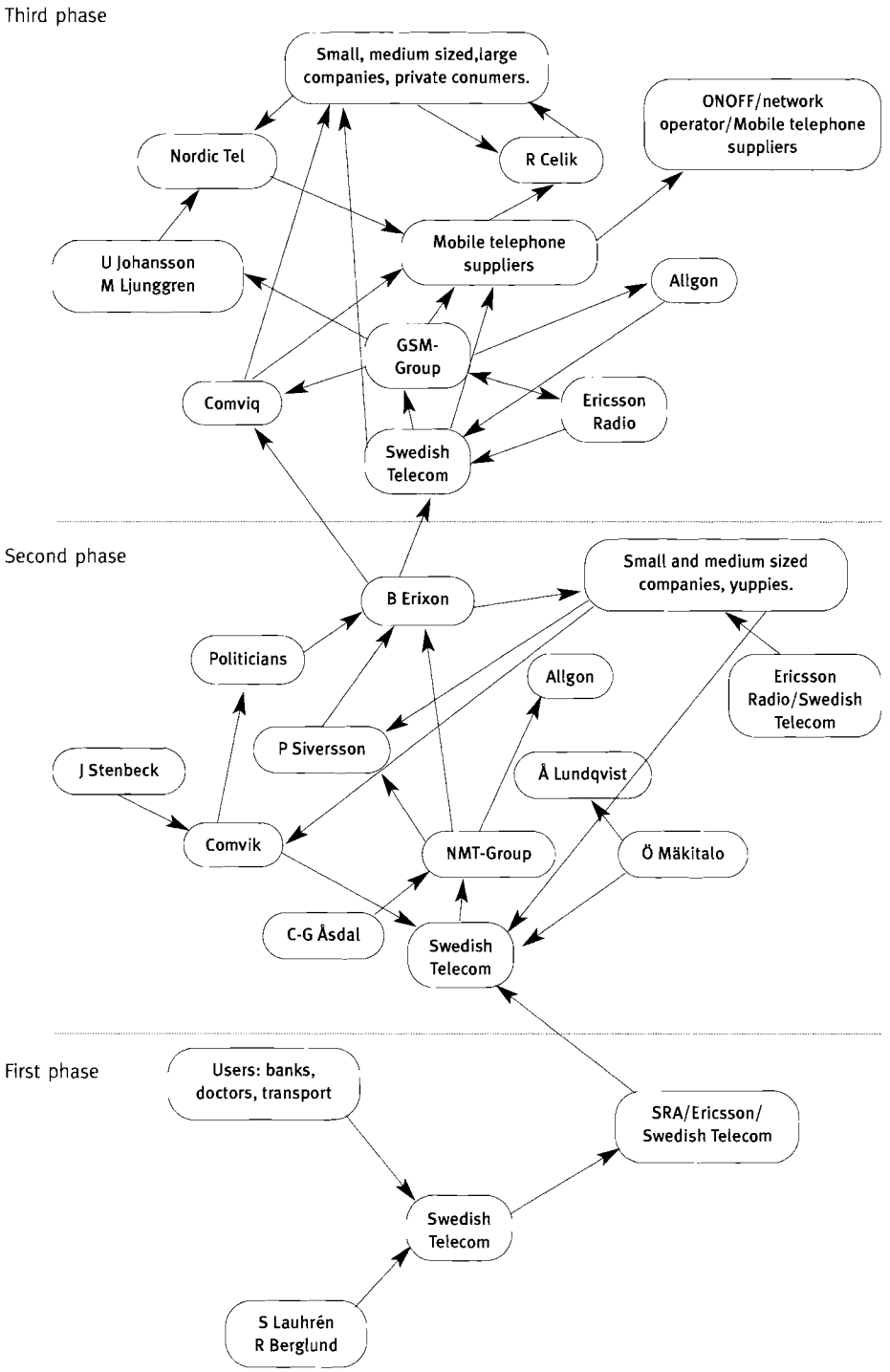
The transition from the second to the third phase takes place due to

network operator Swedish Telecom, and system suppliers influencing the standardiser, the GSM-Group. The GSM-Group requested that network operators like Comviq establish new digital mobile telephone systems. The standardiser also influences the system and mobile telephone suppliers since they were asked to develop products for the new standard. The establishment of a new mobile telephone standard inspire the individual entrepreneurs U. Johansson and M. Ljunggren to found a network operator NordicTel.

Moreover, distributors at the second phase influence network operators. This concerns the marketing of the mobile telephone services by new distribution channels launched as well as the introduction of a new type of marketing, which Comviq was successful with. The breakthrough in market innovations basically influences the network operators' activity. It is not sufficient to only offer the service, to be competitive one also has to keep abreast with the market. Besides, the more and more sophisticated technology systems from suppliers such as Ericsson Radio and Allgon put pressure on network operators to make use of the complex systems in a creative way. Since mobile telephones are the tool in the hands of end-users, which in this phase are small, medium size, large companies and private consumers, network operators consequently exert influence on mobile telephone suppliers to secure their business. The requirement for more sophisticated and cost effective mobile telephones is intensified, concurrent with the increase in network operators' innovative activities. Mobile telephone suppliers for their part put pressure on distributors to stimulate the spread of mobile telephones so as to make the market grow. It is identified by the individual entrepreneurship carried out by R.Celik and a network entrepreneurship produced by ONOFF/network operators/mobile telephone suppliers facilitated by that network operators transfer resources to distributors, which creates new distribution conditions facilitating a vigorous growth of the market.

Next side:

Figure 6 / **Entrepreneurial spiral.**


Third phase
Small, medium sized,large companies, private conumers.
ONOFF/network operator/Mobile telephone suppliers
Nordic Tel
R Celik
U Johansson M Ljunggren
Mobile telephone suppliers
Allgon
GSM-Group
Comviq
Ericsson Radio
Swedish Telecom
Second phase
Small and medium sized companies, yuppies.
B Erixon
Politicians
Allgon
Ericsson Radio/Swedish Telecom
P Siversson
J Stenbeck
Å Lundqvist
Comvik
NMT-Group
Ö Mäkitalo
C-G Åsdal
Swedish Telecom
First phase
Users: banks, doctors, transport
SRA/Ericsson/ Swedish Telecom
Swedish Telecom
S Lauhrén R Berglund

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 at later stages. This constantly produces a learning process in progress and creates new chances for the 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. At the third phase, standardising processes, technical development and market feedback increasingly become concurrent and interrelated processes.

The entrepreneurial spiral also illustrates that mobile telephony has not been developed with the help of any one individual, firm or network of companies, but in interaction between different types of entrepreneurs.

I propose that the entrepreneurial spiral could be interpreted as a market process. This opens up the possibility, in line with Volbereda and Cheah (1993), of combining Schumpeter's theory and the Austrian theory. Volbereda and Cheah put forward the view that the entrepreneurial process consisted of a dynamic alternation between the Schumpeterian and the Austrian entrepreneur. Austrian entrepreneurship promotes equilibrium, which results in change within an existing situation as entrepreneurs strive to discover gaps, increase the knowledge about the situation and reduce the general level of uncertainty. The short-run processes, which Kirzner perceives as being comprised of arbitrage and speculative activities, are based on the fact that at a given date a market economy is not fully co-ordinated. This means that entrepreneurship could be regarded as a coordinating mechanism, as the innovations turns out be considerable less disruptive than they are in the end/market because here they are influencing the direction of the entrepreneurial spiral. Examples of these co-ordinating activities are inter-company development work, standards, acquisitions, organising. In other words this is a way of putting innovations into a context.

Given these ideas, the system is moving towards equilibrium but the entrepreneurial activities make it disruptive with the entrepreneurs continuously changing the definition of what the goal is and moving it forward.

8.7 Future research

The dynamics of entrepreneurship makes it to a fascinating area of research. It would certainly be interesting to further develop the idea of the entrepreneurial spiral to embrace entrepreneurship in a dynamic context, and to further elaborate on the relationship between the individual and the collective entrepreneurship.

As this study only covers Sweden it would be interesting to pursue a similar study to cover other regions and countries to exploit the findings from this study. Moreover, it would be interesting to extend the empirical material to cover other industries.

However, the most compelling question concerns the role of mobility, when technology is placed in the hands of the users, and whether this pervasive technology could reshape the way we work and live. It raises fundamental questions on how internal and external activities in organisations could be altered by the new technology. Although it is easy to be carried away by the technology the decisive question is how the users interpret the technology and what kind of meaning they accord to it. This is actually the litmus test of all major innovations: the degree to what they become integrated into other technologies in the end becoming invisible to the mind but constantly shaping our lives.

Appendix

Personal interviews

Allgon

Ulf Saldell 1993-03-26, 1993-06-10, repeated contacts 1993-98

AT&T

Anders Fernstedt 1998-12-16

Axlin

Ingmar Stenhagen 1994-03-07

Banverket

Lars-Göran Bernland 1993-05-27

Comviq

Ulf Groth 1994-05-10
Tomas Julin 1991-04-11
Håkan Söderholm 1991-03-06, 1991-04-11, 1994-02-02

Ericsson Group

Ingvar Bevenius 1994-01-31
Bengt Dahlman 1991-05-07
Björn Eriksson 1990-04-10
Johan Falk 1991-05-07, 1991-08-27
Torbjörn Johnson 1993-02-23
Kurt Larsson 1990-09-05
Åke Lundqvist 1994-02-22
John Meurling 1993-05-25
Per Sveen 1994-04-28
Jan Sverup 1991-05-07
Claes Tådne 1991-05-07, repeated contacts 1991-97

Geab

Stefan Olsson 1994-03-11

Geoworks

Lars Stenstedt 1998-12-18

Institute of the Future

Paul Saffo 1998-12-17

Ministry of Transport and Communication

Jerker Thorngren 1991-09-12
Gisela Löf 1992-10-09

Millicom

Håkan Ledin 1991-03-12
Frank Miller 1991-03-13

Mobil Tele Branschen

Arvid Brandberg 1994-05-27, repeated contacts 1992-98
Bengt Erntsson 1994-05-27

Motorola

Lars Norberg 1994-05-04

Nokia Mobile Phones AB

Ulf Magnusson 1991-02-20, 1994-03-02, repeated contacts 1991-98

NordicTel AB

Mats Ljunggren 1990-11-01
Zeth Nyström 1994-05-24

ONOFF

Allan Karstedt 1994-03-04

Public Network Europe

Jim Chalmers 1994-07-01

Scribona

Björn Forsberg 1994-03-09

Spectronic

Ola Josefsson 1994-10-11

Stockholms läkarförening
Stig Valentin 1991-10-04

Talkline First Class
Recep Celik 1994-03-14

Teleradio
Östen Nordlander 1993-10-11, 1994-05-11

Telfack
Lars Andersson 1994-03-08

Telemuseum
Ove Steen 1993-05-20

Telia Group
Ragnar Berglund 1991-05-20
Olle Gerdes 1991-02-13, repeated contacts 1991-94
Thomas Haug 1990-09-11
Sören Hemingsson 1993-09-16, 1994-03-16
Åke Jansson 1990-09-11, repeated contacts 1991-93
Dennis Larsson 1993-03-10
Sture Lauhrén 1994-02-11
Anders Lundblad 1990-08-23
Roland Lundqvist 1992-03-09
Bo Magnusson 1991-09-20
Peter Meurling 1993-10-10
Östen Mäkitalo 1993-02-24
Per Sjöstrand 1991-04-23, repeated contacts 1991-94
Bertil Thorngren 1990-05-27, repeated contacts 1990-98
C-G Åsdal 1991-04-16

Tele Mobil Norge
Hans Myhre 1993-07-25

Telestyrelsen
Ulf Alhtin 1993-06-08
Lars-Erik Almberg 1990-09-07
Håkan Lilja 1994-01-27
Kjell Pettersson 1993-06-09

Vinge Advokatbyrå
Lennart Tengroth 1991-08-12

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1968

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1970

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Abbreviations

ADC American Digital Cellular
AMPS Advanced Mobile Phone Service
AXE Computerised digital telephone stations
CEPT Conférence Européenne des Administrations des Postes et des Télécommunications, Conference on European Posts and Telecommunications
D-AMPS Digital Advanced Mobile Phone
DCS Digital Cordless System
ETSI European Telecommunications Standards Institute
FDMA Frequency Division Multiple Access
GSM Groupe Spécial Mobile - Global System for Mobile Telecommunications
ISDN Integrated Services Digital Network
ITU International Telecommunication Union
JDC Japanese Digital Cellular
MBS Paging service, Swedish Telecom
MTA Mobile telephone system A
MTB Mobile telephone system B
MTD Mobile telephone system D
MTX Mobile Telephone Exchange
NMT Nordic Mobile Telephone system
PCN Personal Communications Network
PDC Personal Digital Cellular
TACS Total Access Communications System
TDMA Time Division Multiple Access

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