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Ari T. Manninen

Elaboration of NMT and GSM Standards

From Idea to Market

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UNIVERSITY OF JYVÄSKYLÄ

JYVÄSKYLÄ 2002

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ABSTRACT

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The focus of this study is on elaboration of NMT (Nordic Mobile Telephone) and GSM (Global System for Mobile communications) standards. It seeks to understand the standard-making process from a system's philosophy to market entry.

The specific objectives of the study are 1) to reconstruct the original ideas of innovation, 2) to reconstruct standardization processes of NMT and GSM systems, 3) to reconstruct interplay and impact of key players during standardization process, and 4) to explain success of NMT and GSM standards. Analyzing processes of two successful mobile communication standard-making aims to reveal what were the specific Nordic standardization practices and principles, and what were the most important issues that were adopted to standardization of following generations. The role of Nordic countries is not just focused on direct impact on standardization process, but also to indirect outcomes of practices of other countries.

The basic shortcomings of existing studies relates to national study approach or supremacy of theory over empirical facts. In order to avoid these weaknesses, this study implies methodology of history and original sources. Standardization process is not seen as a deterministic process, but as interplay with standardization environment (key players) and circumstances.

The major findings of this study relates to the importance of basic view (philosophy), to necessity of flexibility, balanced cooperation and certain purposefulness and independency in crisis situations for the committee responsible in standard-setting. Historically the most important observation is, that Nordic countries were unique in understanding the relationship between technology and society; that technology is socially shaped and it had to serve needs of society. This basic starting-point gave tremendous lead to Nordic countries.

Keywords: cooperation, cellular mobile telephony, standardization, standards, history of NMT and GSM

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The aim of this study was to serve objectives of the STAMINA project. It was not always easy for a historian to understand mentality of computer scientists, but multi-cultural and multidisciplinary project turned out be challenging and rewarding opportunity. I learnt a lot of new skills while acting as a "Master sergeant" of STAMINA group. Sometimes requirements and wishes I had to solve seemed nearly impossible to fulfill. Afterwards I am pleased that professor Kalle Lyytinen was such a demanding leader, because behind one mountain peak there was always even bigger one. I am also grateful to my colleagues Vladislav Fomin, Juha Knuuttila, Anri Kivimäki and Ping Gao. To work with you guys was unforgettable. I can still nearly hear the crackle and whining of three scanners we operated in a tiny working room at Uppsala Provincial Archive. I am also thankful for the affiliate of STAMINA Group in the USA: Professor John Leslie King and Joel West..

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When I was writing the "NMT Report"my bother Esa Manninen helped me with language issues. I am very thankful, that he was able to organize his own schedule in such a short notice.

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Ari T. Manninen

Jyväskylä, March 2002

CONTENTS

1 INTRODUCTION

1.1 Frame of reference

1.1.1 Technology and standards: from concepts to practice

Technology is a concept, which does not have a simple content. In English language, technology is equivalent to hardware; technique is associated with methods, skills, routines, and also with concrete instruments; and technology has two quite different meanings - firstly, the science of technology and techniques, and, secondly, the advanced science-based organizational system of technology and techniques. The semantic content, however, is actually misleading, because most authors have indiscriminately used the word technology to cover all of these meanings. Much more vital from the scientific use point of view is the point that technology will have at least three different layers of meaning:[1]

- physical artifacts
- human activities (such as making the artifacts)
- knowledge (such as the know-how to build artifacts and the dynamics used to model them in the laboratory).

The definition considers technology as layers, which can exist at the same time. But when technology is seen as a system (including the abovementioned layers) it includes the production of technology, and the maintenance and use of it (Hughes).[2]

Standards are special cases of technology. Standards could be defined in several ways; for example, based on how their origin and their validity to the user.[3] In general, however, a standard can be defined “as a set of technical specifications adhered to be produced, either tacitly or as a result of a formal agreement”.[4] Standards can be also be seen even as synonyms for technology. In this case, a standard could be defined as “the set of technical specifications, regulatory rules and knowledge of uses, adhered to a specific technology”.[5] Yet this study does not adopt such a broad definition, because two countries could adopt the same standard, while at the same time they might have different experiences and regulatory rules. More appropriate from the point of view of this study point would be an approach seeing the standard as a special case of technology, which has the three layers of technology but two specific aims: firstly, to act as a set of specifications in order to make manufacturing possible,

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1 Bijker 1995.
2 Hughes 1991, referred in Miettinen 1999 (T.P. Hughes, From deterministic dynamos to seamless-web systems. In Sladovic, H.E. (Ed.) Engineering as a social enterprise. Washington, National Academic Press).
3 See e.g. David and Greenstein 1990; Bekkers and Liotard 1998.
4 David and Greenstein 1990.
5 Fomin 2001.

and secondly, to be available in order to be adopted by the market. The emphasis in this definition is on the fact that a standard is the outcome of a process aiming to bring a product to the market and to gain advantage in one form or another to the participant/participants in standard setting and to the standard itself.

Development of technology can be studied based on models like the Materialistic, the Cognitivist or the Social Shaping Models. From the present study's point of view, it is far more important to define the relationship of development of technology to society than to find the weak points of each model. As this study focuses on the elaboration of selected standards, the reasons for the involvement of different players were involved, and there is absolutely no point in basing the study on the idea of technological determinism. According to technological determinism, technological development is autonomous. The other dimension of this theory, regarding the point that societal development is determined by technology, is not relevant at all for the purpose of this study[6]. As state intervention in mobile communications cannot be denied,[7] the logical outcome is to accept the idea of Social Shaping Models, at least as regards the basic claim that technology is socially shaped.

The aim of this study is not to use or construct a model and use empirical facts as "input". As the focus is on the standardization process and reconstructing it in its historical environment with authentic relevant historical facts, the main interest need not be tied up with theories. It is much more important to link the study to a "correct" and relevant broader frame, which in this case is the relationship between technology and society.

Understanding, or more accurately misunderstanding, the substance of the term "cellular" is a good example of how ignoring the social shaping of technology leads to artificial classification and the selection of the wrong starting point. This wrong interpretation is a consequence of two facts. Firstly, technology is socially-shaped, but its societal importance could vary from low (technology push, market pull or regulatory driven) to a phenomenon of primary societal importance. Researchers studying mobile telephony did not internalize this fact. Secondly, different countries chose different approaches to developing and implementing mobile telephony because of the aforementioned relationship between "social" and "technology".

Already Calhoun emphasized that (analog) cellular radio was not so much a new technology as a new idea for organizing existing technology on a larger scale. Instead of using single high-power transmitters to cover as large an area as possible, a much larger area could be covered by using low-power transmitters and allocating the service area to "cells", each with a transceiver (base station) of its own. [8]

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6 See Bijker 1995.

7 The Nordic NTAs or PTTs were state institutions, and particularly in Sweden and Finland the state participated in the development of digital switching technology.

8 See Calhoun 1988, 39.

The term "cellular" was soon to become a watershed for the technology generations.[9] This was understandable because cellular systems used frequencies more efficiently, thus making it possible to have a larger number of customers and making the cellular business economically more important. On the other hand, the selection of cellular technology as the starting point led to a near total ignorance of "pre-cellular" mobile telephony. In cases when "pre-cellular" systems aroused interest, it was focused on the inefficient use of frequencies or on other technical features. Scholars were constantly asking how advanced the systems were, and how efficiently they were using frequencies, or what technically superior/advanced features they introduced. Mobile telephony was always seen as a technology system, which was defined primarily by its technical features. Thus, it was also logical to argue whether it was the technically "superior" or the technically "inferior" system that won.[10]

The fundamental driving force in the evolution of the mobile telephone was not the technical dimension of technology, but the relationship between technology and society. Calhoun claimed that the pre-cellular era in the United States was "every mom's and pop's business".[11] Yet even Calhoun did not recognize the total absence of the societal importance of the mobile telephone as the main cause for the low status it had in the United States. Instead, he explained that the regulatory environment was a major hindrance for the elaboration of cellular telephony.[12] It is a paradox that an approach focusing on technical features was adopted in the United States, but technology could not act as a driving force in the transfer to the cellular era. Pre-cellular automatic systems (previous generation) did not have the social importance to convince decision makers. Basically, the relationship between technology and society remained the same during the shift to cellular era. The pre-cellular systems elaborated in the 1960s could not have a societal importance, because they were of the single transmitter type of system, covering only one city. They were clearly technically oriented in the sense that they were packed with technically advanced solutions, which made the systems expensive, and thus expensive for users also.[13] This same composition was repeated with cellular system (AMPS), because the societal importance remained low (no national infrastructure or service) and technical solutions were the first things making the system expensive.[14]

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9 0 G = pre-cellular systems; 1 G = analogue cellular systems; 2 G = digital cellular systems; 3 G = next-generation digital cellular systems. In the United States, "cellular" became the synonym for "mobile telephone". In the Nordic countries, the term "cellular" was not used at all in the early 1970s in the context of re-use of frequencies.

10 It was totally out of the question in this approach to think that a system defined for one particular purpose would win. Thus, the selection was made according defined criteria, not according one visible feature (such as capacity).

11 Calhoun 1988, 51-52.

12 All scholars have adopted Calhoun's explanation, yet his explanation was actually a consequence, not a cause!

13 The US systems were studied by Nordic NTAs (National Telecom Administrations) for the 1975 Nordic Telecommunication Conference.

14 When the basic requirements for the AMPS system were made in the early 1970s, the system was made "top-heavy" duplicating its infrastructure with that of the public telephone

The Nordic countries adopted a totally opposite approach compared to the United States. Firstly, mobile telephony was considered to have essential societal importance, and due to this, society shaped the most essential features of the systems, not technology or individual technical properties. The societal need for telephony led to the construction of country-wide networks. It was clear from the very start that the needs of society were ranked first in order of preference, because the systems were manual. It was considered that "modern" country-wide networks could not be designed using current technology. This led to the adoption of "backward" technology (manual systems), even though it was considered that automatic systems would form the trend. The selected path was logical, because the country-wide network itself was seen as a means to stop the tendency of using frequencies inefficiently.[15] The shift to the cellular generation was no longer an end in itself as a goal to improve spectral efficiency, but rather an opportunity to provide an inter-Nordic mobile telephone service.

In the Nordic countries, social supremacy in technology (relationship between society and technology) was transferred also to the standardization process of the automatic cellular system (NMT), with its subsequent impact on the standardization process and practices, including also future generations. This "unnoticed" sequence forms the motive force for this study.

It is quite typical for people in the United States to wonder why it was in the Nordic countries that the commercial breakthrough first occurred, and why "insignificant" countries such as Sweden and Finland were able to create giant companies like Ericsson and Nokia.[16] This study does not regard this question as being especially important, preferring instead the question of how this actually happened.

1.1.2 Previous studies

1.1.2.1 Mobile telephony

By the eve of the new millennium, cellular telephony had become so important that changes, or even expected changes, shook the stock markets on both sides of the Atlantic. And still this phenomenon is rather new. Around twelve years ago, the people interested in cellular telephony were mainly engineers or other persons involved with the industry in the field. Quite logically, studies focused on the technical aspects of mobile telephone systems and on the comparison of technical features and architecture, or implementation of specific issues related

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network (see Calhoun 1988; Bekkers and Smits 1999). The AMPS system lacked the one feature that was held to be the most important one the Nordic countries, i.e. roaming, and then there were many technical features, which were implemented using costly technology, see Chapter 2.2.3.1.

15 Private Mobile Radio networks were becoming more and more popular, this causing construction of several parallel networks.

16 See Knuuttila 1997.

to the use of cellular technology.[17] In addition to this, numerous textbook-like books were published.

The aforementioned types of study considered society as something that could be ignored in the context of mobile telephony. In most cases, only a very short overview of non-technical issues was presented in the introductory chapters of these publications. A major exception was George Calhoun (1988), who in his book ("Digital Cellular Radio") did not simply jump on the "cellular bandwagon". Instead, he tried to understand why the launch of cellular system was not a great success in the United States; even though the technology had been invented there. In doing so, Calhoun added regulatory and economic perspectives to the launch of cellular telephony in the United States, and he even provided a historical survey of mobile communications from the time of their inception .

Calhoun optimistically named one chapter "End of an Era", to signify the shift from analog to digital technology.[18] Yet it was a paradox when Calhoun's book was printed the great break-through of (analog) mobile telephony finally started in United States, and the corresponding phenomena related to digital technology had to wait nearly a decade. Since mobile telephony in the United States turned out to be big business in the early 1990s, and at the same time Europe witnessed the introduction of digital technology (the GSM system) in 1992, the focus was no longer primarily on "technology" (hardware). Mobile communication was now seen from a much wider perspective. Authors were now interested in issues related to the evolution of mobile telephony.[19] The end of the decade and the switch-over in technology coincided with changes in the geographical location of the authors in this field. Previously most of the authors had been mostly American, whereas now they are mostly European.[20] The authors of the late 1980s were not familiar with the situation in Europe, which resulted in peculiar misunderstandings that were natural, though quite misleading as well.[21]

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17 E.g. Calhoun 1988; Lee 1989; Mehrotra 1993; Mouly-Pautet 1992; Balston and Macario 1993.

18 Calhoun 1988.

19 Paetsch (1993) studied evolution from regulation, technology and markets point of view in the United States and Europe. Schenk, Muller and Schnöring (editors) (1995) had nearly the same angle, but focusing in Europe, and consisting of in-depth studies with Sweden, Austria and East European countries. Bekkers and Smits (1999) widened the scope of mobile communications study to the whole field of standards in the era, not just limiting themselves to mobile telephony, but including also private mobile radio, paging and cordless telephones (see also Bekkers 2001). Garrard (1998) adopted the angle of market development, but broadened the scope to the globe.

20 Even though most of the authors referred earlier had been European, the books were published in the United States by Artech House Publishers except for the one by Mouly-Pautet 1992.

21 Calhoun (1988) omitted discussion of the European situation in his study, because he was not able to obtain the relevant information. Calhoun himself considered the omission of the European situation as a regrettable imperfection to his book. On the other hand, studies focusing strictly on the technical dimension did launch peculiar claims. Lee (1989), for instance, announced that Saudi Arabia, the Nordic countries, and Spain developed the NMT system, and that in Europe it was Spain, which would have been the first to implement the system!

Parallel with the diversification of interest from technical features to other areas related to technology, there was also specialization to selected players or sectors of the mobile telephone industry. Meurling and Jeans[22] introduced the story regarding the elaboration of mobile telephone systems, particularly NMT and also of GSM, from the Ericsson point of view. The aim of this book was to support Ericsson's public relations, a task successfully fulfilled. Unfortunately, the book also aired subjective views based on interviews of Ericsson's staff, and it contained numerous mistakes and misunderstandings. Since the book had a wide circulation and was published in English, these mistakes also accumulated particularly with authors unfamiliar with the Nordic languages. A similar PR publication was written to relate Nokia's success story, [23] but since it was written in Finnish, the damage was quite limited!

Other specialized studies (Koivusalo 1995, Häikiö 1998) published in Finnish were relevant, but again, due to the language barrier, did not gain a wide readership.[24] Common to them both was that they included an explanation of why the development of mobile communication industry[25] was successful in Finland.[26] One specific book was important particularly to Finnish scholars, not because of its scientific merits, but due to its topics.[27] Keijo Toivola, who was chief of Radio Department of Finnish NTA,[28] wrote an overview on the evolution of mobile services provided by Finnish NTA. His presentation included a short survey of the elaboration of standards relevant to the topics.[29]

The rise of Ericsson and Nokia stimulated also academic studies, first in Sweden and then in Finland. The topics did not essentially differ from those earlier mentioned specific studies, but they were more oriented to explain what

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22 Meurling and Jeans 1994; both authors were non-Nordic, but they were involved with the business in the field.

23 Mäkinen 1995.

24 Koivusalo 1995 and Häikiö 1998. Koivusalo actually told the evolution story of the mobile communication manufacturing industry in Finland, and Häikiö the elaboration of Radiolinja, a private operator that started to compete with Finnish PTT in GSM.

25 Industry in a wide sense including manufacturers, operators, regulators etc.

26 Koivusalo had worked a long time within companies operating in the field. Häikiö is a professional historian, who in addition to his special interest in political history was also familiar with telecommunication field (see Häikiö 1995).

27 In Sweden, Ole Gerdes (1991) had nearly a similar kind of importance to scholars. Toivola (1992) wrote his book in Finnish, but the Stamina group, University of Jyväskylä, Finland, translated it into English, though this translation has, as yet, not been published.

28 NTA, National Telecommunication Administration, or PTT.

29 Toivola 1992. The most severe shortcoming of this book is that Toivola does not recognize the importance of Scandinavian manual systems and he puts too much emphasis on the early importance of ARP, although Norway and Denmark were far ahead of Finland. Indirectly he imparts too optimistic a role to Finnish participation in the early phase of NMT, because he does not refer to this at all! Actually the Finnish role before mid 1970 was quite insignificant . It was not until 1978 that Toivola became the chief of Radio Dept, joining the firm from outside the NTA. The best part of the book is related to the elaboration of APR, Toivola being chairman of working section of CCFC responsible for the study of the mobile telephone network. In spite of the aforementioned criticism, it should be remembered that Toivola was one most influential "grand old man", who actually had an important impact on the development in Finland of the field of mobile communication (e.g. evaluation of candidates for the Finnish army "company radio", locomotive radio development, procurement of NMT base stations and elaboration of Finnish manufacturing of NMT base stations).

had happened. Particularly important were the studies of Mölleryd and McKelvey.[30] The former studied the elaboration and evolution of mobile communication in Sweden from the entrepreneurship point of view, although he also tried to enlighten the Swedish role in the elaboration of NMT and GSM standards, at least to some extent. The latter studied the elaboration of the Swedish manufacturing industry and interaction between mobile telephone systems, Swedish NTA and manufacturers.[31] Similar type of study was carried out regarding public procurement of the Finnish NTA and evolution of mobile communication manufacturing industry.[32] One study was focusing specially on breakthrough of Nokia as manufacturer of mobile phones.[33]

1.1.2.2 Standardization of mobile telephony

Standardization processes of mobile telephone systems have not interested many authors, but there are some studies, which just do not refer to essential phases of process, but also try to explain standardization processes in question from selected point of view or dimension. NMT standardization had been studied from the socio-cultural angle (Knuuttila)[34], and as an elaboration of technical innovation (Lehenkari and Miettinen)[35], while the elaboration of the GSM standard had been compared to Integrated Broadband Communication network (Cattaneo).[36] Also, the relationship between standard setting and diffusion of mobile telephone systems had been studied (Funk; Funk and Methe).[37] In addition to these studies, there were others dealing with the standardization of mobile telephony from secondary points of view.[38]

The growing economic importance of mobile communication standards has aroused interest in analyzing the changes in the standardization process with the generation shift, as well as in regard to refining theory. This task had been carried out by researchers in the Stamina Group in cooperation with other researchers.[39]

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30 Mölleryd 1996 and 1999; Mckelvey et al 1997.

31 In addition to the abovementioned studies, Karlsson 1998 studied telecommunication policy in Sweden and Lindmark 1997 studied the evolution of mobile telephony, focusing on technological change.

32 Palmberg 1997, 1997 A and 2001.

33 Pulkkinen 1997.

34 Knuuttila 1997.

35 Lehenkari and Miettinen 1999.

36 Cattaneo 1994. Cattaneo's article is basically the same as that published in PACE 1992 (Chapter 6. Options for a pan-European Network: From GSM to IBC).

37 Funk 1998; Funk and Methe 2001; see also Kano 2000.

38 E.g. Ruottu 1998, who studies administration with PAL Plus and GSM projects at the company level (Nokia), but the excerpt is regrettably lacking in volume, particularly with regard to mobile telephony and GSM, the supremacy of theory over empiric study is immense.

39 E.g. Kivimäki 1999; Keil and Fomin 2000; Fomin, Keil and Lyytinen 2001; Fomin 2001.

1.1.3 Research objectives and approach

Studying the elaboration of the NMT and GSM standards, to the extent to which is done here, is justified, even there already are several such studies. There are four main academic reasons for this study. Firstly, all specific studies focusing on the mentioned standards have chosen the national frame, as choosing just one player alone would have been a soloist effort without any impressive backup. This had been a practical decision, because the main interest was in the selected "domain country"; especially in the impact of the standards on the industry or the innovation system of the selected country.[40] Yet the processes were multinational, and due to this dimension it is not logical to study standardization process from a selected national point of view.

Secondly, all the aforementioned studies do not aim to reconstruct standardization processes, and due to this, they also use fragmented sources haphazardly. The main sources were a combination of interviews and three primary reports (1971, 1973 and 1975) for telecommunication conferences, or a combination of interviews and literature. The reconstruction of standardization process requires a systematic analysis of minutes, documents reports used, in comparison with interviews and literature.

Thirdly, the theories and approaches used in the aforementioned studies were intended either ultimately to explain economic or industrial/innovation policy outcomes,[41] or then their validity in implementing the selected theory was questionable. Path-dependency theory is a good example of the latter. Usually it is used in situations when markets fail and an "inferior technology" is adopted. The best-known examples are cases of the "QWERTY" keyboard and the VHS video recorder standard, even though alleged claims of "inferior technology" being adopted could not have been unquestionably verified by empirical facts.[42] The path-dependency approach was also implemented in the case of the GSM[43] to the extent where the theory and its concepts were misleading the actual study.[44] Theory orientation, in the worst cases, led to praiseworthy managing of theory, even to the extent where facts were of very little historical value.[45]

Fourthly, the previously criticized issues and their joint impact advocate the need to reconstruct the standardization processes of the NMT and GSM

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40 Mölleryd 1996 and Mölleryd 1999; Lindmark 1995; Knuuttila 1997; Lehenkari and Miettinen 1999. – Formally Cattaneo 1999 is in theory an exception because evaluates the roles of all essential players, but in practice she is not. Actually Cattaneo adopted a biased viewpoint, Franco-German co-operation, as being the most essential driving force, which did not have counter forces or interplay with other players. The used sources and methodology were the main reasons for this shortcoming; for more detailed criticism, see Chapter 3.2.4.

41 E.g. Mölleryd 1996 and 1999; Lehenkari and Miettinen 1999.

42 Liebowitz and Margolis 2000.

43 Cattaneo 1994.

44 The selection of the radio access method was seen as being the adoption of inferior technology (by Cattaneo 1994), although the customer (who was also the standard-setting body) set quite clear criteria.

45 Bach 2000 is an example of over-supremacy of theory, which leads to selecting a random fact and even to false interpretations, because knowledge of the facts is inadequate.

systems by using the original sources commenced during the process, and to analyze them systematically in their historical context.

This study focuses on the elaboration of the NMT[46] and GSM[47] mobile telephone standards. The elaboration of the standards is seen as an idea-to-market process. The first goal of this study is to investigate how the idea was conceived and what were the motives. The second goal is to reconstruct the standardization processes. The primary standardization process is divided into functional phases including: Feasibility (pre-study); Standard production (Defining specifications); and Implementation. The third major task is to identify and investigate the role of the key players involved with the process. The fourth task is to explain the success of the studied standards from the standardization process point of view.

TABLE 1 Research goals and essential questions

GOALS	QUESTIONS	WHAT WAS THE SPECIAL "NORDIC" ROLE IN FORMING A "SUCCESSFUL STANDARD"?
• Reconstructing the original ideas of innovation (system/standard/network) [48]	• How did society affect the idea directly or indirectly? (On the scale: creating atmosphere - intervention) • What were the circumstantial causes?	
• Reconstructing standardization process	• How was the standardization process was managed and organized? • How did the process change?	
• Reconstructing interplay and impact of key players	• What was the impact of key players? • How did the role of key players change?	
• Explaining success of NMT and GSM standards	• Why do existing explanations fail? • Why were the standardization processes successful ? • What are the factors shared by successful standardization processes? • Why did the NMT and GSM standards become commercially successful?	

The ultimate goal of the study is to explain the concept of "Successful Standard" and the specific role of the Nordic countries in the process. "Successful Standard" is not seen just as the life span of one standard eventually becoming commercially successful, but also as the transfer of knowledge, practices and procedures to the standardization of the next generation. The "Nordic role" is not only seen as physical impact of Nordic countries on specific standardization process, but more broader as a special

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46 NMT, Nordic Mobile Telephone.

47 GSM, Special Group for Mobile Communications, later Global System for Mobile Communications

48 In this study, these definitions all refer to a certain mobile telephony technology in question. There is no fundamental difference, but the use of the terms depends mainly on functional context: a standard setting body is developing a system, yet the defined specifications act also as a standard, but operationally it is a network.

method of standardization, and how other countries adopted similar kind of methods and procedures.

The study was carried out in a form of two case studies regarding the NMT and GSM standards. The standardization processes were not actually ceased suddenly on a certain date, but for practical reasons the main focus with the NMT system (including NMT-450 and NMT-900) is up to the mid-1980s, and with the GSM system to 1991, when the first phase standard was ready.

1.1.4 Sources and methodology

1.1.4.1 Sources

This study is based on original archival material. The material consists of minutes, reports, documents and memorandums. Basically the series of sources or the NMT and GSM committees shared the same structure. The reports of GSM to its supervisor body, the CCH Committee, were, however, not as important[49] as the NMT reports to the Nordic Radio Committee (NTR/NR) or the Steering Committee (NST). The NMT Committee gave primary reports to the bi-annually held Nordic Telecommunication Conference, and since 1974 it also issued periodic reports. Minutes of NMT and GSM Committees were the most important sources even though they had their specific internal limitations.

External limitations for use of original documents were caused by three major facts. The Stamina Group gained access to the archives of the Finnish National Telecommunications Administration (NTA), specifically known as Tele, later Telecom Finland, which was the predecessor of Sonera, but only up to 1988. The European Telecommunications Standardisation Institute (ETSI)[50] gave no access at all to the Minutes and Documents connected to the GSM system. The only possibility was to use the archive of Swedish NTA (predecessor of Telia), because it was transferred to the Public Provincial Archive of Uppsala (ULA). The archive of the Radio Division at ULA contained GSM series documents (documents and minutes)[51] up to 1991,[52] and NMT documents mainly up to 1984.[53]

The archive material was selected from the archives of Telia/Swedish Televerket, Sonera/Telecom Finland-Tele, and Telenor Mobil/Norwegian Televerket. The foremost reason for using these three archives in parallel was to fill the missing gaps. In this study, the archival connection is mentioned only on specific occasions, these being:

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49 Both from content and amount point of views.
50 GSM Committee was transferred from CEPT to ETSI in March 1988.
51 Actually all GSM documents are individually numbered documents, but for practical reason the author has classified them as Minutes, Documents and Reports.
52 This limitation did not cause principal weakness, because the study focused on Phase 1 version of the GSM standard, which was implemented commercially as of the summer of 1992.
53 The ULA NMT documents did not stop at 1984, but in 1984 both the chairperson and secretary of the NMT group went to Norway.

- Internal memos of certain NTAs that were not circulated among other Nordic NTAs
- Records showing that an internal memo or other kind of document was circulated to other NTAs
- Draft version of minutes that was later revised.

The aforementioned archives were not assorted systematically as historical archives.[54] Nearly all the used archive material is in the possession of the Stamina Group, consisting of around 12 500 pages of documents (divided among Telia, Sonera and Telenor as follows: 8 000, 3 000, and 1 500). Most of the acquired documents were digitized and a minor part was left in paper format.

In addition to written documents, also a large number of interviews were used. During the pre-Stamina and Stamina project over 20 persons were interviewed.[55] The most important for this study were the interviews of Thomas Haug, Matti Makkonen and Hans Myhre (in alphabetical order). Thomas Haug was secretary (1970-1978) and chairman (1978-1982) of the NMT group and chairman of the GSM Committee (1982-1991). Matti Makkonen participated in NMT work from 1978 to the mid-1980s and the early stages of the GSM work; he was also closely involved in the business activities of the Finnish NTA/Telecom Finland regarding the implementation of the NMT and GSM networks. Hans Myhre participated in the work of the NMT group from 1976 on, leading the System sub-group from 1980 onwards and being nominated chairman of the NMT group in 1984, a post he held up to 1983.

Most of the persons interviewed were, or had been, employees of NTA-NTOs[56], because NTA-NTOs played the foremost role during the standardization of NMT and GSM.

1.1.4.2 Methodology and realization of study

Normal source criticism of historical research is especially important in evaluating secondary sources; particularly this applies to those related to European Community's role as regards GSM.[57] After GSM became a major commercial success, official and semi-official EC sources started retroactively to glorify the importance of the EC. This assumption became a paradigm and it started to escalate, because researchers were, in the first place, not familiar with the fundamental nature of the EC telecommunications policy before the mid-1980s. Secondly, researchers were not willing to estimate the quality, content

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54 Sonera's archives were mostly personal and partly thematic (e.g. Nordic Radio Committee); where as in the ULA archives the functional connection of the documents was afterwards broken unsystematically. This happened also in the Telenor archives, but mostly the documents were ordered on the basis of the numbering of the NMT documents. The same rule was implemented with GSM documents in ULA.

55 Not all of the interviews were relevant to this study, because other participants in the group had different focuses and scientific backgrounds.

56 National Telecommunication Administration, National Telecommunication Operator.

57 With NMT, this kind of parallel did not eventuate, most likely because in the Nordic countries the politicians were not involved with standardization of NMT at all.

and context of EC's measures related to the GSM system. The number and formal content of directives was considered to be enough! [58]

The aim of reconstructing the standardization process also set specific requirements for the use of primary sources. Minutes held by the NMT and GSM Committees were not evidence of intentions or interplay between participants, but mainly presentation of final protocols without the dialogue that actually took place. The use of relevant documents, which were made for a certain specific purpose, while analyzing the minutes, can expose intention and parallel activity.

The fundamental source criticism was implemented by comparing different types of sources. Interviews and documents could not be classified as discrete sources, because it is impossible to eliminate the possibility that a person who is interviewed did not check up on what he remembered. In cases where memos[59] exist, the ideal solution is to use minutes in parallel with the memos.

In principle, from the point of view of this study, it is not essential to emphasize the difference in the significance of written documents and oral sources respectively, but reconstructing of the standardization process limits the overall importance of interview for several reasons:

- It is practically impossible to remember individual events that happened 30 years ago
- Relevant information is lacking
- It is difficult to interpret past events

On the other hand, interviews were useful in cases of:

- Orientation especially
- Validation "peculiarities" in documents
- Ordinary procedures
- Opinions that prevailed
- Relationships between NTA and manufacturers

Interviewing the most essential key persons several times reinforced the validity of the information provided by interviews. Furthermore, one key person (Hans Myhre) was interviewed on two different occasions; the latter being an in-depth interview, carried out over a period of four days.[60]

This study was carried out in two phases. At first, I participated in the "Pre-Stamina" phase in the fall of 1997, when I acquainted myself with the field in question in general, charting possible sources. This period also included a detailed study of the Archive of the Finnish Radio Department of NTA including its activities, and a sieving-out of the essential material. In the spring of 1998, I joined the Stamina Group and started to compile a broader database consisting of relevant studies and publications and to carry out "orientating

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58 This phenomenon could be called a "mirage created by the Internet".

59 Here memo is an actual memorandum or internal draft notes outlined for use by a specific NTA.

60 The main interview was carried out during two first days. In addition, there were several shorter and "unofficial" interviews mostly held on social occasions during the next two days (without a tape-recorder).

interviews" (Hans Myhre and Thomas Haug). This period also included discussions with the Stamina Group regarding the appropriateness of several theories. In the fall of 1998, we made an excursion to the Uppsala Provincial Archives, where we acquired the foremost part of our NMT-GSM documents. Thereafter, I reorganized the acquired documents and began to analyze my documents and interviews. In the fall of 1999 I started to write the "NMT Report" of which the first version was finalized in February. At that time, I also started to carry out complementary and additional interviews and to fill gaps in the documents by using the Telenor Mobil archives. I started to work on the "GSM Report" in the fall of 1999, the first version being completed in the summer of 2001.

1.1.5 Special terms used

The most commonly used special terms are briefly discussed here, while others will be explained later in the text.[61] The concept pair of NTA-NTO is used in referring to National Telecommunications Administration, which during the period of monopoly in Europe had a dualistic role of administrator and operator (National Telecommunication Operator).

Mobile telephone networks consist basically of three main elements: subscriber equipment consisting of Mobile Stations (MS) (mobile telephones), which were originally auto-installed (fixed or 'luggable'), but later became portable, with a further development in the form of hand-held devices as well. Mobile stations could communicate with other mobile stations or fixed network telephones, and vice versa. Making a call from mobile station to another customer was not possible without the mediation of a radio network consisting of at least one base station or several base stations covering a large area. When a base station received a call from a mobile station it would transfer the call to a mobile switching unit controlling the mobile network and communicating with the fixed telephone network where necessary. The basic structure was typical of that of most mobile telephone networks, but a certain task could be divided between base stations and switching systems in order to increase the "intelligence" of the base stations.

The frequency-band mobile-telephone system used was divided into two: one part being reserved for the transmitter of the base station and the other for the transmitter of the mobile station. Between these parts, there was what was termed "duplex separation", which for the NMT-450 was 10 MHz and for the NMT-900 and GSM was 45 MHz.

Analog systems transmitted voice in analog format, while signaling could be digital. Digital systems transmitted voice in digital format.

This study classifies cellular systems into three generations in order to adhere to the commonly held practice: 1st generation refers to analog systems; 2nd generation refers to digital systems; and 3rd generation refers to the coming

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61 The list of acronyms is on page 303.

generation. In order to take into account the criticism discussed earlier, the "pre-cellular" systems are defined as "0 generation".

1.2 Dawn of mobile telephony

1.2.1 Adopting mobile telephony

The early history of radio communications was strongly related to shipping, because the size of equipment was to too large to be carried on land-based vehicles. The initial steps towards true mobile communications for land-based vehicles were taken in the United States and Britain. The Detroit Police Department was the first to experiment with voice transmission in 1921, and in London similar experiments were carried out two years later. Both countries opted for separate paths, because the police force in the United States preferred voice telephony, where as in Britain voice telegraph was considered more suitable. In the 1930s and 1940s, various police departments implemented mobile communications, Germany and Sweden being examples.[62]

The Second World War saw the advent of frequency modulation (FM) instead of amplitude modulation (AM), thus reducing the size and weight of equipment, and improving its performance. After the war, mobile communications started to expand into the civil sector. Private Mobile Radio (PMR) became the mainstay of mobile communications for nearly 40 years. PMR systems provided a closed communication network, which was usually denied connection to the public telephone network.[63] Whereas fixed telephony was normally a monopoly of the PTTs in Europe, PMR networks were usually owned by companies involved in a wide variety of business (e.g. taxi, gas, water, electricity, logistics, timber companies or governmental and municipal authorities). The popularity of PMR systems led to a shortage of frequencies due to the technically inefficient use of frequencies, the existence of parallel networks having a similar effect.

The difference between PMR and mobile telephony was mainly regulatory, since the latter was allowed to connect to the public telephone network. In the United States, all mobile services were within the sole rights of wire-line telephone companies, but in 1949 the Federal Communication Commission (FCC) introduced a new type of service, the radio common carrier (RCC), to provide mobile telephone service in addition to wire-line common carriers (WCC).[64] In Europe, the PTTs, which were providing fixed telephone service, also obtained a monopoly on mobile telephony. Only Sweden adopted a more liberal policy in the 1960s, and granted licenses to several companies,

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62 Garrard 1998; see also Gerdes 1991; Binz and Strunz 1969.
63 Garrard 1998.
64 Mehrotra 1994.

thus remaining the sole exception up to 1985, when the 'duopoly' policy came into effect.[65]

The fixed telephony service provider AT&T implemented the first public mobile telephone in 1946 in St. Louis, Missouri, in the United States. The system operated with only three channels in the range of the 150 MHz band. Originally six channels were available with 60 kHz channel spacing, but in 1955 the channel spacing was reduced to 30 kHz, which made available eleven more channels. Twelve more channels were allocated near the 450 MHz band in 1956 to meet increased demand.

Networks similar to that in St. Louis were soon installed in twenty-five other cities. All systems were manual, requiring the assistance of the operator to connect to the desired number, and using the simplex method, meaning that it was not possible to transmit and receive simultaneously. The construction of the system was simple, comprising only one relatively powerful single transceiver station. The drawback of this construction was immense, because a system with six channels allowed only six customers to have a conversation at the one time.[66]

In the United States, the first automatic system was introduced in 1964.[67] The IMTS-MJ system operated on the 150 MHz band, and the MK system, which followed in 1969, on the 450 MHz band. These duplex[68] systems allowed simultaneous transmission and receiving, and had automatic channel selection, in addition to direct dialing without the assistance of the operator.[69] These features increased user convenience, but the systems also had a far more important feature from the point of view of the development of mobile telephony. The IMTS systems introduced automatic trunking, which meant that a mobile station could use any free channel. Use of trunking increased capacity by eight to one compared to systems without trunking.[70]

In Europe, mobile telephony was adopted much later than in the United States. Usually the credit of being first in Europe is given to Sweden, which launched its service in 1956, but the Netherlands had already opened its OLN network in 1948. These and the other early systems adopted in the late 1950s or early 1960s had limited a number of channels, thus having also modest capacity. Being automatic, the Swedish MTA system was an exception from the European mainstream. However, since the system was based on the concept of one powerful transceiver, it was a city system with only a few hundred customers.

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65 Karlsson 1998.

66 Bekkers and Smits 1998.

67 Actually, the first automatic mobile telephone system was installed in Richmond, Indiana, in 1948, but it remained a mere curiosity.

68 With a duplex system, a mobile station could transmit and receive simultaneously, whereas with half-duplex system the customer had to cut receiving by pushing a "tangent button", but base stations were able to transmit and receive simultaneously. With the pure simplex system, it was impossible to communicate with a person using a telephone connected to the fixed network, because fixed telephones were not provided with a tangent button.

69 Mehrotra 1994.

70 Bekkers and Smits 1998.

TABLE 2 Pre-cellular mobile telephone systems in Europe

Notes: A = automatic; M = manual; Na = information not available; cc= calling channel; } = includes subscribers of both systems; UK = United Kingdom

Sources: Report of Swedish NTA (1967); SA RD Mobile telephone report. Overview; compiled from GSM Documents.

Country	Frequency band (MHz)			A/M	Start year	Subscribers in 1983	No. of channels	Channel spacing kHz	Notes
	< 150	150	450						
Austria		X		A	1974	1 200	38+1cc	20	Same as German B network
Belgium	Na	Na	Na	Na	Na	3 000	Na	Na	
Denmark		X		M	1962	7 500	48	25	
Denmark			X	M	1979	7 500	80	25	Same as Swedish MTD system
Finland		X		M	1971	30 000	80	25	ARP
France		X		A	1970	8 121	76/38	20	9 networks. Only in Paris were 76 channels available
France			X	A	1983	370		12,5	4 networks
Germany		X		M	1958		15/19	50	A1/A2 networks
Germany		X		A	na		23	20	A3 network
Germany		X		A	1971	18 500	37/75	20	B/B2 networks
Italy		X		A	1974	4 100	32+4	25	
Luxembourg		X		A	Na	Na	Na	20	Same as German B network
Netherlands	X			M	1948	2 000	(8)15	25	OLN, closed in mid 1980s. (Channels in late 1960s)
Netherlands		X		A	1980	3 500	37	20	ATF-1 (same as German B system)
Norway		X		M	1967	33 000}	Na	25	
Norway			X	M	Mid 1970s	}	80	25	Same as Swedish MTD system
Spain		X		A	na	800	12	25	Madrid, Barcelona
Sweden					1956	0	4	na	MTA, closed in 1969
Sweden	X			A	1965	600	35	50	MTB, closed in 1983
Sweden			X	M	1971	18 500	80	25	MTD
Switzerland	X	X		M(?)	1949	Na	1/4	Na	At least channel selection was automatic
Switzerland		X		A	1978	4 300	150	25	
UK	Na	Na	Na	M	1959	Na	Na	Na	System 1
UK		X		M	1971	2 000	50	12,5	System 3
UK		X		A	1981	1 300	42	12,5	System 4, same as German B network

In the late 1960s, mobile networks were operational at least in eight European countries.[71] These networks had limited capacities and modest numbers of customers (some hundreds only). But the tide began to turn with the Nordic countries starting to construct networks with capacities of 80 channels. The networks were manual and remained in the minority, because the general trend was to introduce automatic systems. This trend was clearly inspired by the IMTS systems installed in the United States, but there was also one notable difference. The IMTS system had only twelve channels, being designed for city use, but the German Netz B, implemented in 1971, had a capacity of thirty-seven channels and it was designed to provide service for a wide area.[72] Later the capacity was raised to seventy-five channels by constructing the B2 network.[73]

The German B system was also adopted in Austria (1974) and later in the Netherlands, Luxembourg. In the case of the United Kingdom, it was used also as an interim system before the introduction of the cellular system. The Nordic MTD, which was based on the Swedish concept, was also adopted in Sweden, Norway and Denmark. All other system were national ventures, or (as in France and Spain) modifications of the American IMTS system.

In Europe, mobile telephone systems originally used wide channel spacing, which was successfully dropped from 50 kHz to 25 kHz in the 1960s. Germany was the exception, because it adopted a channel spacing of 20 kHz, and the countries implementing the German B system also using the same.[74]

The triumphal march of technology turned out to be a spurious phenomenon, particularly in continental Europe with Germany, France and Italy introducing automatic systems in the early 1970s. These systems were technically sophisticated when they were adopted, but soon turned out to be obsolete, because they could not provide for the enlarged capacity of the new cellular systems or the features of hand-over or roaming. It seems that automatic systems also had their impact on the mentality regarding the manner of realizing the substance of mobile telephony. Since automatic systems were expensive[75] and capacity was limited, providing the service was also expensive, which meant that mobile telephony service was targeted to specified groups. Also, the development of early automatic systems gave a false impression of the required development time. This was clearly reflected later on in French and German cellular projects, which, it was thought, could be completed in just four

71 Denmark, France, Germany, the Netherlands, Norway, Sweden, Switzerland, and the United Kingdom; see SA RD Mobile telephone report. Overview.

72 B system was probably the first, which used digital signaling instead of tone signaling.

73 Binz and Strunz 1969.

74 United Kingdom and France differed from the others, because they used 12.5 kHz channel spacing.

75 E.g. Canadian AMTS system, which had similar channel capacity and band to IMTS of the United States, was manual (although channel search was automatic). There was a notable difference in the costs of the systems, because the cost of the equipment in the Canadian system was only half and the switching cost was only one-tenth that of the IMTS; see SA RD Mobile telephone report. Overview and TM Report of Swedish NTA, 1967.

years.[76] The final outcome of choosing the early path of automatic systems meant that these countries were not able to catch the "cellular wagon".

Japan was the major exception among countries developing a cellular system, but not implementing a pre-cellular system at all. Although Japan had developed an automatic pre-cellular system, which was completed in 1967, it was not put into commercial service because of the predicted lack of available frequency bandwidth in the 450 MHz band.[77]

Usually Nordic countries are mentioned as the first to commercially exploit cellular systems. This is correct, but their success rested on a foundation of pre-cellular systems. Of the European countries, only the Nordic countries and Germany managed to form a notable subscriber base during the pre-cellular period. There were nearly 150 000 subscribers, including all European pre-cellular systems, in 1983, but two-thirds of these were in the Nordic countries. At the same time, there were only 150 000 subscribers in United States. The leap to cellular systems was tremendous, because in 1983 (after two years of cellular experience) Nordic cellular systems had altogether over 97 000 subscribers. In 1983 Nordic countries had nearly as many subscribers as the rest of Europe and United States together, with cellular customers also included.

The shift to the Cellular Era caused a setback to Europe, because only the Nordic countries were among the pioneers. Actually, Japan was the first to implement a cellular system, when the NTT system became operational in 1979, but its commercial success was modest, both from the viewpoints of international diffusion and of the domestic subscribers.[78] Formally the "Swedish-American" Comvik system was the second representative of the 2nd generation, because it became operational in Sweden in the summer of 1981; however, it was not initially a true cellular system.[79] The Comvik system remained, as it were, a footnote in history, while the Nordic NMT-450, becoming operational in Saudi Arabia in September and in Sweden in October 1981, opened a totally new path. The NMT system was widely adopted right from the start, and it was the first cellular system to become a commercial success. Even though the development of the AMPS system was completed as early as in 1979; it was not until the fall of 1983 that commercial operation started after lengthy testing and disputing. The launching of the AMPS inspired

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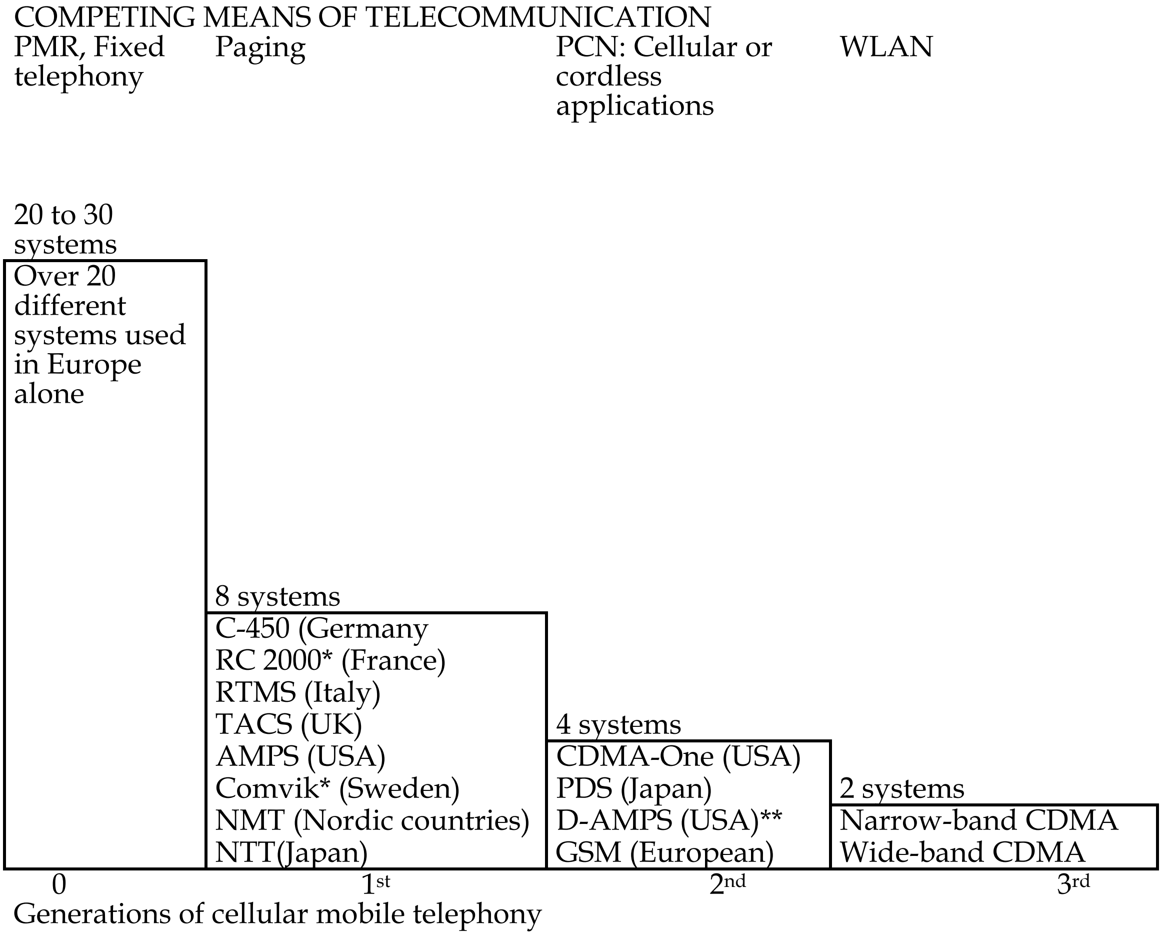
76 The development of the German C-450 system started in 1979. It was planned to get system operational in 1983, but this was postponed to 1985, commercial service actually starting in 1986.

77 Sakamoto 1993.

78 Four countries in the Middle East and one in Asia bought the Japanese system. According to Garrard 1998, the Japanese system (delivered by NEC) was implemented in Qatar (1982), Jordan (1985), Egypt (1987), and Hong Kong (early 1980s). It seems that the Japanese system had a series of setbacks on the export market, because Hong Kong dominated the markets of the early 1980s, the network becoming operational in 1984 (this was not a TACS system as Garrard 1998 claims!; see Ho 1984), and Egypt had ordered the system in 1983 at the latest, even though it did not became operational until 1987.

79 Comvik system was based on the experience the company called Millicom had gained with experimental test network of AMPS in the United States (one of three licenses granted for test networks). Millicom was established by the millionaire P. Stenbeck, of Swedish origin. In Sweden, he also owned the Kinnevik consortium, parent to Comvik. Millicom had an operator's license in Hong Kong also, initially deploying the Comvik system.

the British, who modified it and adopted it as the TACS system, and this became operational in 1985. Other leading industrial powers of Europe developed their national standards. In 1985, the development of the RTMS system was finalized in Italy, that of the RC 2000 system in France and of the C-450 system in Germany. The next year also saw the birth of the NMT-900, a modified version of original NMT standard.



Remarks: 0 Generation = Pre-cellular systems; 1st Generation= Analog systems; 2nd Generation = Digital systems; 3rd Generation = Further systems to come * = Originally not a cellular system, hand-over not being provided; ** = US-TDMA; PCN = Personal Communication Network; WLAN = Wireless Local Access Network

FIGURE 1 Evolution of cellular mobile telephony

The evolution of cellular telephony continued. The aforementioned standards belonged to the 1st generation, which used analog transmission of speech. 2nd generation systems used digital transmission of speech, and they became operational from 1992 onwards. The European GSM standard was first commercially deployed in 1992, and it turned out to be the most successful system ever.

The evolution of mobile telephony has had a remarkable, though nearly unnoticed, impact on mobile standards. While there were at least twenty different pre-cellular systems in Europe alone, the shift to the Cellular Era of 1st

TABLE 3 Compared popularity of cellular mobile telephony and paging in selected countries
Remarks: **bold =** cellular telephony had more subscribers than paging. France: Figures are from years 1987 and 1990; NA = Data not available
Source: ITU YSTS 1988-1997

COUNTRY	NUMBER OF SUBSCRIBERS			
	1986		1991	
	Cellular	Paging	Cellular	Paging
EUROPE				
Austria	19 100	Na	115 437	85 687
Belgium	3 798	31 905	51 420	138 464
Denmark	60 504	16 500	175 943	50 863
Finland	85 232	10 850	315 091	45 041
France	9 055	115 000	290 000	242 000
Germany	23 800	130 890	532 300	342 000
Italy	9 044	Na	568 000	133 000
Netherlands	15 300	Na	115 000	Na
Norway	106 178	27 378	227 733	88 141
Sweden	112 600	Na	568 200	131 500
United Kingdom	64 000	390 000	1 230 000	650 000
ASIA				
Australia	4 423	Na	435 000	Na
Bahrain	618	912	7 354	15 508
Malaysia	10 817	7 476	70 917	40 000
Japan	Na	2 487 846	1 378 108	5 911 377
NORTH AMERICA				
United States	681 825	Na	7 557 148	Na

generation systems saw the introduction of only eight systems world-wide (see FIGURE 1). The transition from generation to generation started a phenomenon that could be named "halving", because during every shift the number of mobile standards has decreased by half. Another essential feature was the uniqueness of the Nordic countries. They were possibly the only countries in which cellular telephony surpassed paging in popularity even before the mid 1980s (see Table 3). Although means of telecommunication competing with mobile telephony have continually been improving, to offset the competition of mobile telephony, mobile telephony has succeeded in assimilating the best features of its challenger, and it has grown ever stronger.

1.2.2 Socio-Technical restraints of cellular telephony

Cellular systems are based on the idea of re-using frequencies (channels). Even pre-cellular systems re-used channels, but since the transmitter power of a base station was high, the radius of each base station area was as high as 40 to 50 kilometers (compared to from 60 to 80 kilometers with single-base-station systems). The same channels were not available for the adjacent base station, which meant that the re-use distance was high, and thus the spectrum efficiency was not the best possible. The main idea of cellular systems was to split areas into cells ("base-station areas"), originally with a radius of from 2 to 20 kilometers, depending on the frequency band used. This meant that transmitter power had to be markedly lowered.

The cellular concept caused elaboration of two new requirements, which could not be neglected, as, indeed they were at an earlier stage. Since the base station radius could be only a few kilometers, a terminal could be caught on the edge, something that would close an ongoing call. This was an immense risk, particularly since all first cellular systems (as well all pre-cellular systems) were auto-phone systems. The procedure of transferring an ongoing call, without a discernible delay or interruption, from one cell to another is called hand-over (or hand-off). As a mobile station (an auto equipped with mobile telephony, in this case) was able to transfer from one base station to another, it had to be able to roam freely within the network. The system had to keep a record of the location of the mobile stations in order to direct incoming calls to the mobile stations. This ability was called roaming.[80]

Basically, the idea of the cellular network is a simple one. Bell Laboratories of AT&T presented the concept in 1947, but it took until 1962 before Bell Laboratories finally demonstrated their pilot experimental cellular system. It has been claimed that lack of frequencies prevented the development of cellular telephony, though the technology was already available.[81] It is true that, in the United States, developments received a major impetus after the FCC allocated 75 MHz for mobile telephony in May of 1970, but this explains only the situation in United States. It still leaves questions: Why did the Japanese and Nordic countries launch their projects about the same time? Was cellular technology really available in commercial terms? The first question would require a totally separate study to get a convincing result,[82] but the second one is far more easily solved. Yet the only question to have fascinated the minds of scholars was whether or not the technology was available.

In order to develop a cellular telephony system, there were technical obstacles to be overcome in both the switching and the radio communication fields. The Storage Program Controlled (SPC) switch was available as early as in the 1960s. The computing power of switches would have been sufficient for the cellular system. Time-division (digital) switches were introduced in the 1970s, but they were not a prerequisite for the cellular system, although the coming of digital switches, based on modular structure, made cellular systems economically more fascinating. In the field of radio communication, trunking has been implemented since the mid-1960s in making a group of channels available to a larger group of customers. Automatic trunking required that a mobile station had to be able to tune efficiently to a variety of channels. Since

80 The meaning of 'roaming' had changed. Nowadays the roaming feature is so common that the concept is used to refer to an agreement between two operators allowing customers to use another operator's network while travelling abroad.
81 Bekkers and Smits 1998.
82 However, it is most likely that circumstantial reasons gave the prime impetus to the launching of the cellular project in Japan; the pre-cellular project had been a commercial failure. For the Nordic part of the story, see Chapter 2.2.1.1.

each channel required two crystals, this set limit the total number of channels. A solution to the use of crystals was invented in 1960s, when channels were synthesized electronically.[83] It was, however, only slowly that crystals were replaced. In the early 1970s, typical mobile terminals were equipped with only twelve channels, a 16-channel terminal being seen as a luxury representing the peak of development on the commercial sector. The only terminals having 24 or 30 channel terminals were those of professional networks, such as the military or the railroads.[84] In the mid-1970s, the number of channel terminals was raised to 80 following the adoption of synthesizers. Yet, even after this point, in the late 1970s, there were still commercial limits on the maximum channel capacity of terminals.

In principle, the cellular system could have been implemented in the mid-1970s, particularly after the introduction of the microprocessor, which made hand-over possible.[85] In practice, however, the technology available would most likely have made the construction of system very expensive. The case of the United States' AMPS system supports this view.[86] The AMPS standard was mostly defined before fundamental inventions such as the microprocessor, the digital switch, and the microwave link were introduced. This meant that, by the time it was implemented commercially in 1983, the system was technically outdated, besides which its cost was high.[87]

It is generally claimed that the launching of the cellular service in the United States was postponed by several years mainly due to inconstant regulatory policy.[88] The dilemma did not fall just within the field of regulation, but it was wider issue of telecommunication policy. The Wire Line Common Carrier AT&T was used to seeing to many issues related to social policy, which did not fall within the limits of the commercial enterpriser. When AT&T was split into seven regional Bell companies, the possibility of creating a country-wide service vanished, because the FCC did not heed this requirement while granting licenses. [89] In practice, the main issue was whether to allow regional monopoly or competition. From this point of view, it was obvious that mobile telephony as a service did not have high intrinsic value.

It is true that mobile telephony was left in the dark shadow of television, a commercially important factor in the United States, when the pressure for

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83 Calhoun 1988; Lindmark 1995.

84 Toivola 1992; see also Koivusalo 1995.

85 Lindmark 1995.

86 The Nordic countries evaluated the AMPS system for the 1975 Teleconference, and they considered it to be too expensive; see NMT chapter.

87 Calhoun 1988; Bekkers and Smits 1998.

88 In 1970, the FCC tentatively reserved frequencies and decided to allow the operation of Wire line Common Carriers (WCC), but in 1971 both WCCs and RCCs (Radio Common Carriers) were allowed to operate, thus adopting also competition (two carriers in the same market area). Again in 1974, the FCC restricted eligibility to the WCCs. Finally the policy of having parallel WCC and RCC operators in same market area was accepted in 1975, and the District Court of Columbia Circuit of the U.S. Court of Appeals reaffirmed the FCC's position. The FCC authorized two developmental cellular systems (test networks) in 1977, and one more in 1980. It was the FCC's aim to have commercial cellular service in 1981, but even this goal was missed by two years; e.g. Calhoun 1998 and Mehrotra 1994.

89 King and West 2000.

frequencies for mobile telephony started.[90] It has also been explained that mobile telephony was not so important, because United States had high fixed telephony penetration and public telephones were easily accessible.[91] These claims are most certainly correct, but one can argue that in the early 1970s they were as much cause as consequence of a more fundamentally reason. The characterization that the deployment of IMTS systems was every "mom's and pop's business"[92] is quite apt. In 1976, New York City had six channels of the IMTS-MJ system serving 320 customers, and the IMTS-MK system six channels serving 225 customers.[93] Pre-cellular mobile telephony was certainly not of great value for society. One could indeed question the meaningfulness of such a "service", posing the associated question: "Why on earth would anybody in charge allocate more frequencies for such a waste?" The basic dilemma was not in the shortage of frequencies, but in the way in which the mobile telephone was used. The idea of implementing one-base-station city networks was certainly not of much use to society, compared to country-wide networks, which the Nordic countries and Germany started to deploy from the 1960s onwards. It was not a technical innovation, but one of mental insight being applied in how and why technology was to be used.[94]

Most commonly it is felt that the major goal of the cellular concept was to improve spectrum efficiency. Usually, spectrum efficiency is defined technically as the ratio of channels to coverage area or available band.[95] These technical definitions consider efficiency in the form of mathematical formula consisting of specific variables, but they do not take broader relevant issues into account. This is a dilemma of a fundamental nature, because regulatory policy also has an impact on the use of frequencies. In the United States, the policy measures decreased spectral efficiency, because introducing two operators in same area decreased trunking efficiency. Regulatory application had a similar impact, because a channel spacing of 30 kHz (which was used by pre-cellular IMTS systems) was adopted for the cellular AMPS system as well. This caused notable loss of available frequencies (channels). If the Nordic countries had adopted 30 kHz spacing instead of 25 kHz, they would have only 150 channels instead of 180. The third issue relates to the system concept of the AMPS, in which a large number of channels was reserved for the use of calling channels. The total impact of these factors was notable. In United States, the 20+20 MHz[96] band was reserved for the cellular system, whereas in the Nordic countries the band was only 4,5+4,5 MHz. The total population of the Nordic countries was

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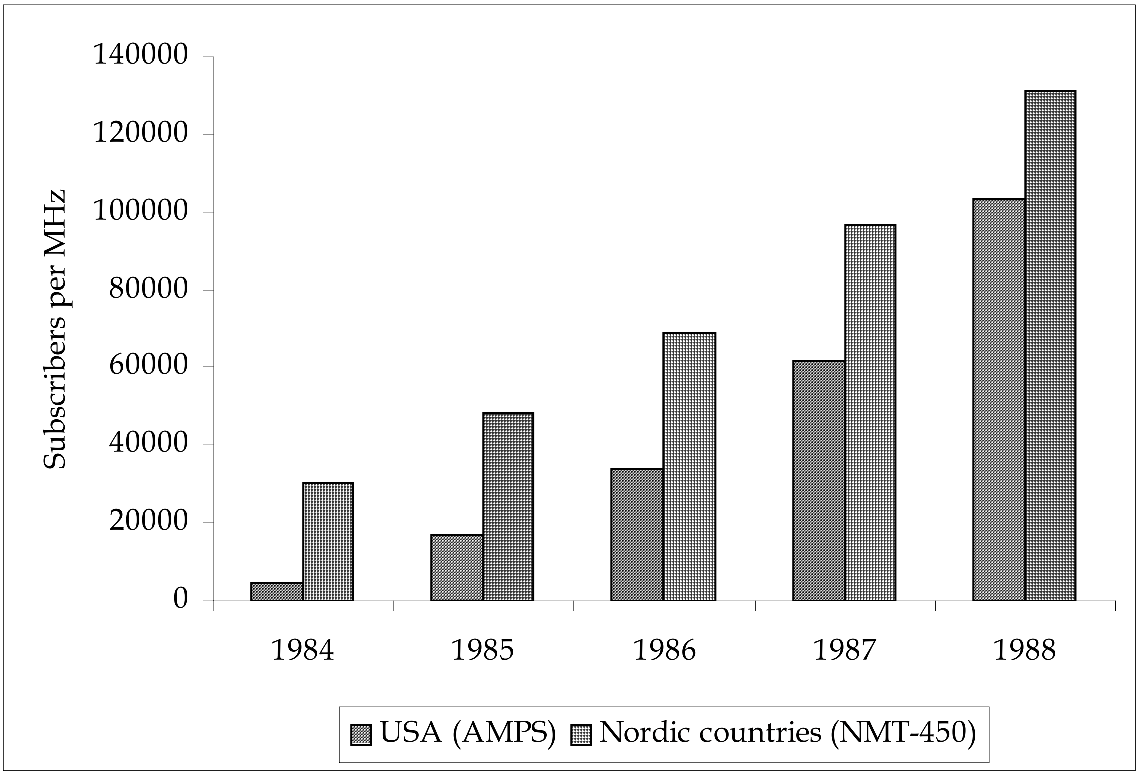
90 Calhoun 1988.
91 King and West 2000.
92 Calhoun 1988.
93 Lee 1989. The capacity of first MTS system was 11 channels, IMTS-MJ 11 channels, and IMTS-MK 12 channels compared to the various Nordic systems, which had a capacity of 80 channels.
94 This difference is not observed in the reference literature used.
95 According to Lee 1989, the spectral efficiency with cellular systems is one channel per cell; Macario 1993 defines it as either a voice channel per MHz per square kilometer, or radio channels per MHz of the allocated bandwidth.
96 One part is used by the transmitter of the base station and the other by the mobile station.

not even one-tenth of that of the United States, and thus, relatively speaking, Nordic countries allocated more frequencies for mobile telephony. The vital issue is the use of these frequencies. The ratio between subscribers per allocated megahertz reveals the "social spectral efficiency", which focuses on the social value of mobile telephony as a user of frequencies. The Nordic countries had nearly 69 000 subscribers per MHz in 1986, whereas in the United States the corresponding ratio was only 34 000. Before that, the ratio had been even more striking, making frequencies allocated to cellular telephony really precious.



Source: TN NMT Statistics (NMT); Paetsch 1993 (AMPS)
FIGURE 2 "Social efficiency" of using frequencies in United States and Nordic countries

It is not a credible claim that regulatory policy was the most essential force preventing the development of cellular telephony in the United States. It was just a reflection of something else; particularly because the social idea of mobile telephony (including cellular) was on a very narrow basis. This was visible on all levels of the cellular project:

- Usage purpose; networks of limited areas without roaming
- Technology push (supremacy of technical dimension) while developing the system
- Implementation solely on the precondition of increasing competition

One can argue that the outcome resulted from cultural factors, but this is not true. There was a clear discontinuity point, because of the breaking of the monopoly status of AT&T in telecommunications that was more important than mobile telephony. Mobile policy was not consequential and it was servicing other purposes. From the cellular idea point of view, it was actually a paradox that the main idea for using frequencies efficiently was watered down.

2 STANDARDIZATION OF THE NORDIC MOBILE TELEPHONE (NMT) SYSTEM

2.1 The Situation in the Nordic countries

2.1.1 Societal reasons behind cooperation in telecommunications

2.1.1.1 Economic integration

The Nordic cooperation was elaborated in the 1950s, when Finland and Iceland joined the Scandinavian cooperation already being practiced by Denmark, Norway and Sweden. Earlier Scandinavian cooperation was based on the premises of the 19th century ideology (*scandinavism*), where as Nordic cooperation lacked a distinct ideological base. Scandinavism had assumed its most concrete forms between the 1870s and the First World War, a period during which Denmark, Sweden and Norway formed a monetary union.[97] Between the two World Wars there were also attempts at establishing military cooperation on the Nordic level, but this did not eventuate.

Nordic cooperation became properly organized in 1953, with the establishment of the Nordic Council. This cooperation was on a voluntary basis with no supreme authority above the national governments. The Nordic Council could not even give issue directives of a final nature; it could only make recommendations to the governments. This was both its strength and weakness. Decisions were made on a consensus principle. The beneficial side was in the aspirations towards shared objectives within the Nordic Council organization. On the other hand, there was the possibility that the Nordic Council could distance itself from the political decision-making of its member countries, which did not have such far-reaching consensus on national level. Economic issues, in particular, were difficult because different countries had different interests, which prevented the cooperative projects from succeeding. The political dimension was totally omitted from Nordic cooperation, Denmark and Norway being members of NATO, Sweden being neutral, and the Treaty of Friendship and Mutual Assistance between Finland and the Soviet Union restricting Finland's activities.

In some areas, the Nordic countries made more progress in their integration than did the European Economic Community. These achievements were practical by nature, making many bureaucratic formalities unnecessary. Mobility of labor between the Nordic countries was made possible. Passports between Nordic countries were no longer needed, a feature unique in the world. Even crossing the borders became a formality hardly to be noticed, making transport between the countries easier.[98]

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97 NC 1972; NC 1988.
98 NC 1972.

On the economic front, the Nordic countries did not attain their goals. The Nordic countries had two alternative strategies, cooperation and integration, which they implemented in turn.[99] Since the inception of the Nordic Council, there were attempts at forming a customs union, but when it was deemed impossible to achieve this objective, the Nordic Council focused on cooperation and the development of joint projects instead of integration. In 1966, the Nordic economic integration process began afresh.[100]

European economic integration affected the strategy of Nordic cooperation. The European Economic Community (EEC), which had started out as the European Coal and Steel Community, tried to create a common market by using legislation as a tool. Those Nordic countries that were members of European Free Trade Association (EFTA) began to prepare for more intensive European integration by starting their own integration process in 1966. The Nordic aim was a common market and a customs union to be called NORDEK. At the public servant level, the NORDEK plan was furthered efficiently on a wide front, even though different parties in different countries did not share consensus on the NORDEK plan, because Denmark and Norway informed the other Nordic countries that they would be applying for EEC membership. In January of 1969, a preliminary report was completed by a group of civil servants, the draft NORDEK Treaty being introduced in July.[101]

Nordic integration aimed at great heights. The meeting between Nordic Prime Ministers that took place in spring 1968 in Copenhagen set goals for increased cooperation on legislation regarding competition. It was also deemed necessary to create a unified policy in the fields of energy and industrial policy and research and development of technology.[102]

Nordic integration had its impact on standardization. In 1968, the Nordic Council recommended to boost Nordic cooperation. The aim was to give extra assistance to Nordic organizations and institutions responsible for standardization and controlling of materials. Further, it was recommended that acceptance of international standards be promoted.[103] The following year, a Nordic standardization conference was held, setting standards for current European and Nordic integration processes and considering standards as a technical barrier to trade.[104] In June of 1969, the management responsible for standardization on the national level made a decision to prepare a plan for Nordic cooperation in standardization.[105] This led to the signing of an agreement on cooperation between the Nordic standardization bodies in December of 1970. Still, it was emphasized that the aim was not to create

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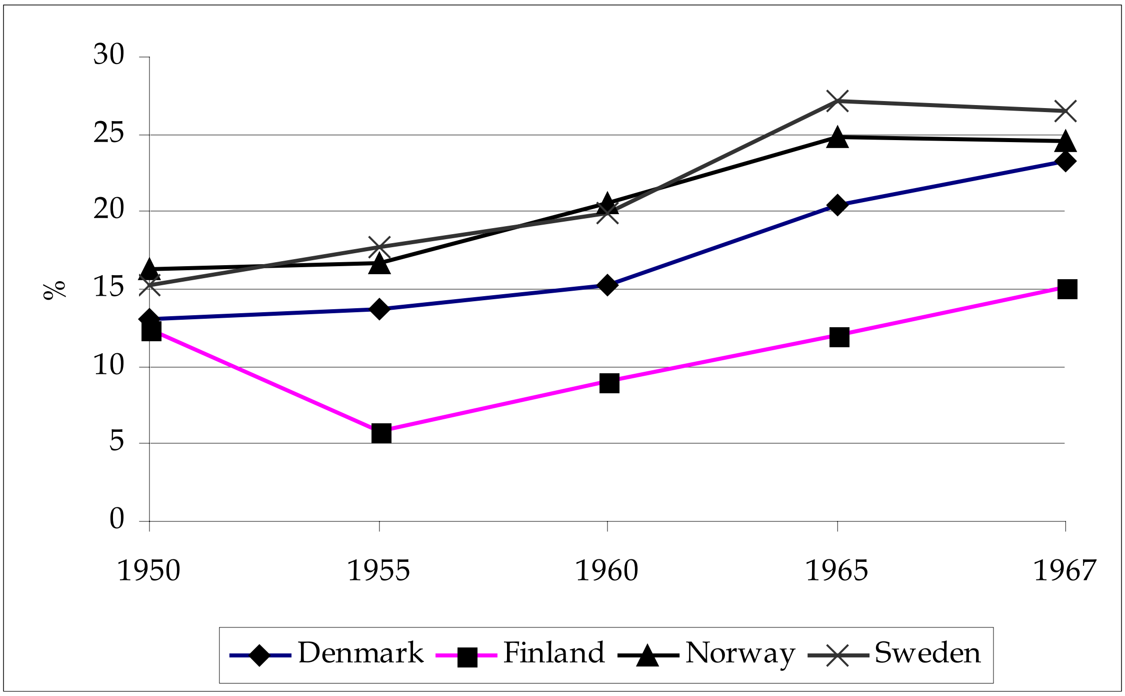
99 Integration period between 1953-1959; cooperation between 1959-1966; integration between 1966-1970; cooperation since 1970.
100 NC 1972; NC 1988.
101 NC 1972; see Kalela 1969 and Koivisto 1997.
102 NC 1972.
103 NC 1972.
104 NC 1969: 14.
105 This was a so-called meeting of INSTA chiefs. INSTA (Inter-Nordic Standardization) was responsible for implementation of the ISO standardization on the national level.



Sources: NC 1969:13.
FIGURE 3 The share of inter-Nordic trade of the total exports of the Nordic countries

Nordic standards, but to secure the implementation of international standards.[106]

At the beginning of 1970, practical measures were taken to prepare for the inauguration of the NORDEK plan. There were even negotiations about the location of the NORDEK organization. Then, however, a very short time later, the whole NORDEK plan failed, thus also putting a stop to far-reaching plans regarding joint industrial and energy policy, which were buried along with the NORDEK plan.

The failure of the Nordic integration process did not eliminate the projects that were necessary even when the policy shifted from integration to cooperation. One of them was the logistics issue, which had gained extra impetus from the integration process. In 1967, the Nordic Council made a recommendation on broad lines regarding transport policy.[107] The aim was to see whether it was possible to change intra-Nordic vessel transport for road transport. The report of 1969 regarding the prerequisites for a joint transport policy estimated that trucks would provide the fastest growing mode of transport in the 1970s. The volume of truck transport of goods had already increased two and half times in Finland during the early 1960s. In the same period, it had nearly doubled in Norway and Sweden.[108] The method of transport was a significant issue even on the grounds that intra-Nordic exports had increased significantly with growth in intra-Nordic trade. While its share of the total exports varied between 12-16 per cent in 1950, it had increased to 15-26

106 NC 1972.
107 NC 1972.
108 No comparable information was obtained from Denmark.

per cent in 1967.[109] Intra-Nordic trade had become very important for Sweden, Norway and Denmark, while in Finland this trend was not as important (see FIGURE 3).

2.1.1.2 Nordic cooperation in telecommunications

The birth of organized Nordic cooperation within the limits of the Nordic Council did not create cooperation in the field of telecommunications. Yet it had been falsely claimed that there was a close connection between cooperation in telecommunications and the Nordic Council. It had been also claimed that the NMT Group had received its mandate from the Nordic Council.[110] All that these arguments reveal is a total ignorance of the forms of Nordic cooperation. Furthermore, they confuse the Nordic Council and the Nordic Teleconference. It is true that in 1953 the Nordic Council did recommend the establishment of a Nordic PTT Union, but this was not the start of cooperative ventures. The Nordic Telecommunication Union was established as early as 1937. According to the Union, telecommunication connections should be organized in a unified manner and in the simplest possible way in all the Nordic countries.[111] The Nordic Council exhibited interest in telecommunications, but its main focus was on broadcasting, satellite projects and programs on television and radio. It did not give exclusive directives for the field of mobile telecommunications.[112]

Nordic Telco cooperation is much older than cooperation at the Nordic Council forum. The Telco cooperation of Nordic National Telecommunication Administrations (NTA) assumed an organized form in 1917 with the holding of the first Teleconference. Subsequently, these conferences were held bi-annually, and they became a forum for top-level cooperation between NTAs.[113]

In the late 1960s, the bi-annual forum of the Teleconference was found to be inadequate, a permanent organization being designed at the 1969 Teleconference to respond to increased demands for cooperation. The timing and starting point for the permanent telecommunications organization may be seen as having hinted at the possibility of a planned common industrial policy. The plan for such a joint Nordic industrial policy in the field of technological research and development included both already existing projects as well as new fields of technology. The aim in forming industrial policy goals for the new fields of technology was to increase industrial potential especially as regards the growing, technologically sophisticated domains.[114] But there are no signs that certain segments of telecommunication were seen by the Nordic Council to be important from the industrial policy point of view, the only possible

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109 NC 1969: 13.
110 Meurling and Jeans 1994. Several studies had quoted to these authors, and thus spread the false assumption.
111 NC 1972.
112 NC Catalogue 1988; NC 1972; NC 1988.
113 See Heimburger 1968.
114 NC: 1969:2.

exception being telecommunications satellites. This was an era where there was Nordic cooperation even before the creation of a solid organization in telecommunications.[115] A major area of technological focus for Nordic cooperation was nuclear energy, which, of course, had nothing to do with telecommunications. [116] The reasons for creating solid forms for cooperation in telecommunications were mainly practical, because there were growing numbers of issues requiring harmonization. For example, the issue of standardizing automatic exchanges for international calls was raised at the 1969 Teleconference.[117]

The forms of Nordic Telco cooperation were defined in the Telecommunication Pact of 1971. The organization[118] carrying out cooperation was constructed in such a way that the Teleconferences maintained their status, but the NST (Nordic Steering Committee) would be in charge between one meeting and the next. The NST consisted of general directors of the Nordic NTAs. Teleconferences set the general guidelines and handled issues of economic significance. Both Teleconferences and NST had the power to appoint harmonizing committees for certain purposes. At first there were two of these: the Nordic Telecommittee and the Nordic Radio Committee (NTR). This typical division between "telegraph" and "radio" entities followed the practice of the International Telecommunication Union (ITU), which had an International Telegraph and Telephone Consultative Committee and an International Radio Communications Consultative Committee.[119]

Harmonization committees were basically administrative units, which had operational working parties responsible for specific harmonization issues. The relationship between a committee and a working party was so defined that the committee recommended changes regarding the mandates of the working parties, prioritized their objectives, and received their reports to NST and Teleconference. In practice, working parties presented their suggestions to the committee, which made the decisions. The relationship was flexible, and there was no intention to bind the working parties closely to the harmonizing

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115 In 1961, the Norwegian, Danish and Swedish NTAs established the Scandinavian Committee for Telecommunications Satellites and the Council for Scandinavian Committee for Telecommunications Satellites to monitor progress in the field. With Finland joining the venture in 1967, the attribute "Scandinavian" was replaced by "Nordic".

116 The preliminary NORDEK report prepared by civil servants gave cooperation of Nordic NTAs on telecommunications satellites as an example of cooperation already in existence. The focus of the report related to technology research was on nuclear energy, marine research, and automation. Telecommunications was not mentioned; see NC 1969: 2, NC 1969: 15. Nordic NTAs invested in telecommunications satellite technology. The cost estimate for the satellite land station in Tanum was FIM 21 million (expressed in terms of 1975 money) whereas the costs of the NMT test system were only SEK 1.5 million.

117 See PTT FD 225/809 1968, Minutes of 1969 Telecommunications Conference.

118 The organization of Nordic Telecommunications conference (NT) consisted of committees including NTD (Harmonization Committee for Utilization and Rates); NTT (Harmonization of Technical Issues of Telecommunication); NTR (Harmonization of Radio Technical Issues); TS (Board of Tanum Satellite); NTSK (Telecommunication Satellite Committee); and ISDN (Nordic Data Network). The NST (Steering Committee of Cooperation) had the group directly under its supervision.

119 SA RD Nordic Telco pact of 1971; NTR # 1 Minutes (10.5.1972).

committees. Quite the contrary; working parties were encouraged to be spontaneous. In cases where working parties met problems that exceeded their competence, they were advised to turn to the experts of each domestic NTA instead of the Harmonization Committee in charge.

The number of the committees and their subsidiary groups increased, but the organization of Nordic Telco cooperation remained unchanged until the end of the 1970s. At that time, the NST was disbanded and the abbreviation for the title of the Nordic Radio Committee NTR changed to NR.

2.1.2 Market

2.1.2.1 Operators

Organizationally, the Nordic countries did not have a uniform structure in the hierarchy of the administration. Denmark and Finland had a joint Posts and Telecomm (PTT) structure, whereas in Norway and Sweden these branches were separated.

All Nordic National Telecomm Operators (NTOs) held monopoly status at least in certain segments of the business, but this was an outcome of a historical process, and there was variation on status of the NTO. Originally, all Nordic countries had several operators providing telecommunications services. In Sweden, the NTO (state operator) had bought the locals out of the market, and achieved its de facto monopoly without legislation. In Norway, the state operator enjoyed statutory status. Also Denmark had such a law, but during the recession the process of nationalization of private concessions had been halted, and as a consequence there were three private operators and the state operator providing services, each within their regional limits. The state operator had a monopoly in long-distance calls in addition to its role as a regional operator. There was no clear confrontation situation, because the state of Denmark owned over half of the shares of the two largest private operators. Neither had private operators formed any counterbalance, because they had no cooperation between them.[120] In Finland, the situation was somewhat different, because it was not until the country had achieved its independence that the state's telephone operator was established. As a consequence, there were hundreds of local operators. The number of concession operators was 61 up to the early 1980s.[121] Only the telegraph was a statutory state monopoly, but the state had also bought the long distance services. All private operators had regional concessions. Private operators in the more densely populated southern and western Finland governed the local loop, whereas the state operator provided the service for the least populated eastern and northern areas of the country.[122]

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120 Robertsen 1984; Larsen and Hald 1995; Alffram and Themptander 1995
121 Televiestintätilasto 1990. There were over 800 concession operators in Finland in the 1930s.
122 Turpeinen 1996 B.

In Finland, the fragmented field of the operators provided for a good setting, because in order to stay in touch with the technological development and to watch out for the their interests, the private operators had established a subordinate organization, which was able to challenge the state operator. The largest of the regional concessions had the competence and the urge, due to its firmly-established subscribership, to bring new technology to the market. An example of this was its early involvement in data transmission and paging during the 1970s.[123] On the other hand, the fragmented and dispersed situation in the telephony business, and the fact that equipment was supplied by several manufacturers, set their own requirements on the state operator. The state had its own telephony laboratory. Also, the largest of the concessions operators, the Telephone Association of Helsinki (HPY), had its own research laboratory.[124]

The National Telecommunications Administrations had a dual role, because they functioned simultaneously both as operators and regulating authorities responsible for the granting of the frequencies. At least in Finland and in Sweden, both of the functions were allocated to the same department of the administration. In Denmark and in Norway, where telecommunication services were defined by law, no private operators came to practice the mobile phone business. In Sweden and in Finland, legislation did not restrict the rights of the business except through the control of frequencies.

In the Nordic countries, commercial mobile phone operations were launched in Sweden, the Nordic pioneer in land-based mobile radio. The Stockholm and Gothenburg Police Departments had implemented mobile radio as early as before the 2nd World War. The state operator launched commercial service in 1956 in Gothenburg and Stockholm, where a second system was commissioned during 1965. It was then implemented in Malmö two years later.[125] Mobile telephone networks opened also in Denmark in 1963, in Norway in 1966, and in Finland in 1971.

During the 1960s, Sweden was adopting a more liberal policy. The NTA made its first frequency reservation for private operators in 1963. At the beginning of the following year the first private operator applied for frequencies, beginning its operations in 1965, and applying for further frequencies in 1967 in order to form a country-wide network. This meant competition with the state operator, which had local networks in three cities only. The activity was relatively low key as during the 1970s the largest of the private operators barely had 150 subscribers, the total of even the state operator being also meager (only some hundreds). This situation begun to change, however, when in 1971 the state operator began to offer country-wide manual services. Whereas in 1970 there had been thirteen private operators, at the end of the decade only one remained. Again this one tried to challenge the state operator by bringing to the market a country-wide automatic system. The state operator attempted to prevent commercial competition by denying automatic

123 Häikiö 1995.
124 Häikiö 1995; Turpeinen 1996 A; Turpeinen 1996 A-B.
125 Gerdes 1991; Mölleryd 1996; Mölleryd 1999.

connections with the public fixed network for technical reasons, but obviously it was also aiming at securing its own automatic service system (NMT), which was on the verge entering the market. Its objectives were not, by any means, to remove the private operators from the market, but nevertheless competition was not encouraged. The state operator even offered to share the market by making suggestions regarding the direction of manual system subscribers to the private operator. The competitive advantage would, in any case, have stayed with the state operator due to its broader scale of frequencies.[126]

Finland was the sole Nordic country not to have a public land-based mobile phone network by the mid-1960s. The country had some closed networks, the largest of which was HPY's network. When the idea of a public auto-based telephone service was brought up in 1966, it was not by any means obvious that the state operator would be entitled to build the network. The matter was settled in favor of the state operator when it took the issue away from the Consultative Committee handling the network issues, to be decided, case by case, between the state operator and concession holders.[127] This tactic was assisted by the network being intended to be country-wide, but the concession holders were only interested in building the structure of the network for the areas covering their regional limits.[128]

At a later point in time, before the mid-1970s, HPY opened up an automatic network based on the Storno system, primarily intended for internal use, but which would also serve a small number of subscribers.[129] In 1985, HPY tried to apply for frequencies for a cellular network, to be either the NMT or the TACS system. The matter was being decided jointly in the Nordic countries at the highest Teleconference levels. All of the Nordic countries opposed the proposition because the experiences in the United States, regarding the opening of the competition, were felt to have been one-sidedly negative. Sweden had fears that the intentions of HPY would spread to the other Nordic countries, a concern which was well-grounded because a similar application was also made by Comvic.[130] Upon receipt of a negative decision, HPY opened an automatic system network in 1989 by the name of Autonet, with seventeen other regional operators following in its wake. However, its total number of subscribers of was so small that they could not compete with the state operator.[131]

2.1.2.2 Pre-cellular networks

In Sweden, the state operator began to develop the mobile auto-based telephone system after the Second World War in collaboration with SRA and

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126 Karlsson 1998; Mölleryd 1999.
127 Toivola 1992.
128 Turpeinen 1996 B; private operators were interested in constructing radio telephone networks within their concession areas, but were not interested in country-wide networks.
129 Häikiö 1998.
130 Toivola 1992; NR # 24 Minutes (3.-4.12.1985) and NR # 24-5.
131 Toivola 1992; Televiestintätilasto 1990-1994.

LM Ericsson. Tests of the "System Lauhren" (later to be known as MTA) began at the beginning of the 1950s, and commercial use started in 1956. The system was local; it had one base station and four channels. Switching was automatic and it was connected to the PSTN. [132]

There were notable defects in the MTA system: the equipment was too big and expensive and the connection times were too long. Consequently, Ragnar Berglund, who had invented the radio technical parts of the system, started to develop a new system. The testing of the MTB system took place in 1957. Compared to the earlier system, the MTB had many benefits: it was 20% cheaper, lighter, consumed less energy, automatic switching was faster, and the system was connected directly to a telephone exchange. However, the system required subscriber relays and subscriber cards, and because of this, the system could not be expanded regionally.[133]

Both of the aforementioned Swedish systems were suitable in practice only in meeting the needs of the local systems, and this was precisely the purpose that they were developed for. The equipment was expensive and was owned by the state operator. They did not quite fit in as the foundation for the country-wide system, although the proposition made in 1967 was one envisioning the use of the MTB system as a supportive function locally for the planned automatic country-wide network. The local nature and the low capacity of both of the first automatic systems had the effect of keeping subscriber numbers small. The MTA system closed down in 1969 and the MTB in 1983.[134]

In Denmark, experiments with a manual system were started in 1953, but at that time there were only twenty subscribers in the network. It took twelve years before a system, which became known as System A, began its operation in Copenhagen. At a later point in time, the network was extended to encompass the whole country, and by the end of 1969 it covered 95% of the area of Denmark. It had 1 200 subscribers, approximately half of these being in Copenhagen.[135] A similar kind of system was opened in Norway in 1966, the network covering most of the country by the end of decade. The manual network had 21 000 subscribers in 1978.[136]

In Finland, the ARP system was started in 1971, but it was not until the end of the decade that it was built to cover the whole of the country. The number of subscribers exceeded the popularity of all Nordic country networks. The ARP remained popular a very long time, and at its peak, in 1986, it had 35 000 subscribers.[137]

The manual systems of Denmark, Finland and Norway used semi-duplex, which, compared to the duplex of the Swedish automatic systems, enabled a

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132 Gerdes 1991; Mölleryd 1996.
133 Gerdes 1991; Mölleryd 1996.
134 Mölleryd 1996; Mölleryd 1999.
135 Jacobsen 1969.
136 Hans Myhre's interview; see also SA RD Mobile telephone report by Finnish NTA. Overview
137 Toivola 1992.

larger range for base stations, an essential requirement in building a country-wide network. From the viewpoint of the subscriber, this was manifested as declining user comfort, a disadvantage that was, however, offset by the feature of selective calls being implemented in the early 1970s.

The systems in Denmark, Finland and Norway operated on the VHF range. Also in Sweden, the MTA system operated on the 150 MHz frequency band, while the MTB system was located on the 80 MHz band. During the mid-1960s, the 400 MHz band was released in Sweden, serious plans being made to use it in the plans for the country-wide network. According to this plan, there was an attempt to build an automatic system based on existing technology, the lack of coverage being complemented by the MTB system. Instead of this plan, a decision was made after the Teleconference of 1969 to launch a country-wide MTD system.[138] By 1971, it had been opened in Sweden, and in the latter half of the 1970s in Denmark and in Norway. The MTD system in Sweden had at most 21 000 subscribers, but the network was closed in 1987.

Before the 1970s, it was typical for mobile telephone systems to have only a very limited number of channels. Both the ARP and MTD systems represented a new wave, and they were designed to be used with a capacity of 80 channels. Even as late as at the beginning of the 1970s, there were no mobile stations which could have more than sixteen channels, but the latter half of the 1970s saw the advent of equipment operating across the entire band. Possibly due to the limitations in the capacities of the system, attempts were made to meet these needs by constructing several simultaneous systems. For example in Denmark, it was thought in 1970 that in five years' time the country would have five systems. In Finland, even before the implementation of the ARP system, it was estimated that, by the mid-1970s, the system would have to be complemented by second systems in the bigger cities.[139]

2.1.2.3 Market potential

The increasing popularity of mobile radio led to the uneconomic use of frequencies. Whereas in the mid-1950s there were in Sweden only 2 100 and in Finland only 1 200 mobile radios, a decade later the figures were 21 600 and 5 050, respectively. In relative terms, it meant that in Sweden one auto in ten had a mobile radio installed in by that time but in Finland only approximately one in twenty. What was alarming about the matter was that the rate of growth was rapid, but the proportion of auto-based telephones of all mobile radios totaled only 1 per cent in Sweden. In Finland, there was no public auto-based telephone system at that time.[140]

Both in Sweden and in Finland, the public mobile telephone network was seen as a method spectrally more efficient than the ever-growing number of

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138 TM Report of Swedish NTA in 1967; ULA MTD Report; Mölleryd 1996; Thomas Haug's interview; Östen Mäkitalo's interview.

139 NMT # 2 Minutes (11.-13.3.1970); SA RD Memo from NMT # 4 (5.-7.10.1970).

140 TM Report of Swedish NTA in 1967; SA RD Mobile Telephone Report 18.8.1967.

private mobile radio networks. In Sweden, a working party was assembled to study the issue of auto-based telephone systems, but it spontaneously extended the assigned task to include also paging, mobile radio, and fixed radio stations. The working party recommended that the state operator build networks for paging, auto-based telephone, and shared mobile radios[141]. It considered it difficult to estimate the number of users of telecommunication services, because the nature of the network to be constructed would affect the types of service the customers would be choosing from. Also in Finland, the economic use of frequencies was a central issue, and unlike the situation in Sweden, a more integrated solution was outlined. It was considered that the same network should serve the needs of auto-based telephone, paging, public phones on trains, and radios on boats (excluding Lake Saimaa).[142]

The more efficient utilization of radio frequencies was by no means the sole reason for the construction of country-wide networks, because they were regarded as beneficial for society at large. A Swedish working party considered the service to be important for many segments of the business world. Of all the mobile radio users, growth was considered to focus on controlling traffic, instead of taxi services or public organizations. Also, the experiences of other countries were deemed to be encouraging for constructing extensive networks, because over half of the users hoped to be able communicate over the range of more than one base station. In Finland, the social significance of the country-wide network was emphasized even more than in Sweden[143]. Big corporations were not thought to have enough interest in building networks for the more provincial areas, because it would not be economically rewarding. With the aid of the public land-based mobile network, transport control could be provided quite economically even to the remoter areas where the transportation distances are extensive, thus doing away with unnecessary driving. Furthermore, the network could be used to temporarily replace the fixed network at logging operations and in archipelago areas. Because of these features, it came as no surprise that the makers of the biggest profits were thought to include wholesale and transport services, governmental officials, and the State Railway Company.[144]

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141 TM Report of Swedish NTA in 1967; shared mobile radios used the same base stations.

142 SA RD Mobile telephone report 18.8.1967.

143 According to Keijo Toivola (interview 3.6.1998), the original proposal was presented by the General Staff of the Finnish army, which had prominent role in the CCFC (Consultative Committee in the Field of Communication or Viestintäalan neuvottelukunta). The CCFC was the forum for this issue. Toivola was nominated as chairperson of working section of the CCFC in December 1966. Toivola claims that the Army was in favour of a country-wide network, the first proposal of working section of CCFC being based on a network covering limited areas (mainly highways) in southern Finland. Subsequently, the Finnish NTA took the initiative from the CCFC. starting to construct a country-wide network (ARP system). Toivola’s claims are logical, because the task of the CCFC was strategic in the event of a crisis situation, the Army having a large influence in the CCFC, with one general and two colonels among its members. The Army had also a less visible role within the Finnish NTA. The top expertise in radio communications was invested the Army (in addition to the State Railways) and it was also the main customer for studies related to radio communications before the end of the 1960s; see also Chapter 2.3.3.2.

144 TM Report of Swedish NTA in 1967; SA RD Mobile telephone report 18.8.1967.

One can see a paradox of sorts in that in Denmark and Norway, where the state operator had no competitors, country-wide networks were constructed earlier than in Sweden and in Finland. In the latter two countries, the possibility of competition had an additional impact on the construction of country-wide networks.[145] In Sweden, the idea of the national network had been raised as early as the 1950s, but it took the possible threat of competition to speed up the process to such a degree that it was initially decided to build the network as a manual system.[146] In Finland, the state operator had constructed a radio network for the area of Lake Saimaa, a waterway important for the transportation of timber. This network was opened in 1967.[147] However, at the time there was already a shift taking place from water transport to land transport. According to the original plans, it was intended to cover only the most densely-populated areas of southern Finland. Upon the concession operator showing an interest in the construction of a network within their regional limits, the state operator became actively engaged in the process, proposing a model for the country-wide network, naturally to be built under the supervision of the state operator.[148]

The construction of national networks required much investment. In was easier to construct a manual network for the technology of 1960s, than building an automatic network providing service for a wide area. The manual equipment was cheaper, but the maintenance of manual network became much more expensive than that of the automatic system, because switching required a great deal of labor force. There was another advantage also, although it was not openly emphasized. Country-wide networks provided the only opportunity to get a large number of subscribers. The automatic city networks of the 1960s had very modest customer base, whereas the manual system was expected to receive 10 000-15 000 subscribers in Denmark, and 15 000 in Sweden. In Finland, the primary goal was 9 000 subscribers, but it was recommended that measures should be taken for a capacity of 20 000 - 30 000.[149]

The original subscriber prognosis was quite modest, and according to estimate made by the Swedish NTA in the late 1960s, the flow-in of new customers was also slow. The Swedish and Finnish initial estimates most likely show that the NTAs were deliberately cautious in their estimations, because with manual systems the rise of the number of subscribers to over 10 000 would lead to a fundamental increase in costs. It seems that, due to earlier experience, the Finnish NTA had to revise its estimates to a higher level, a level so high that it became over-optimistic.[150]

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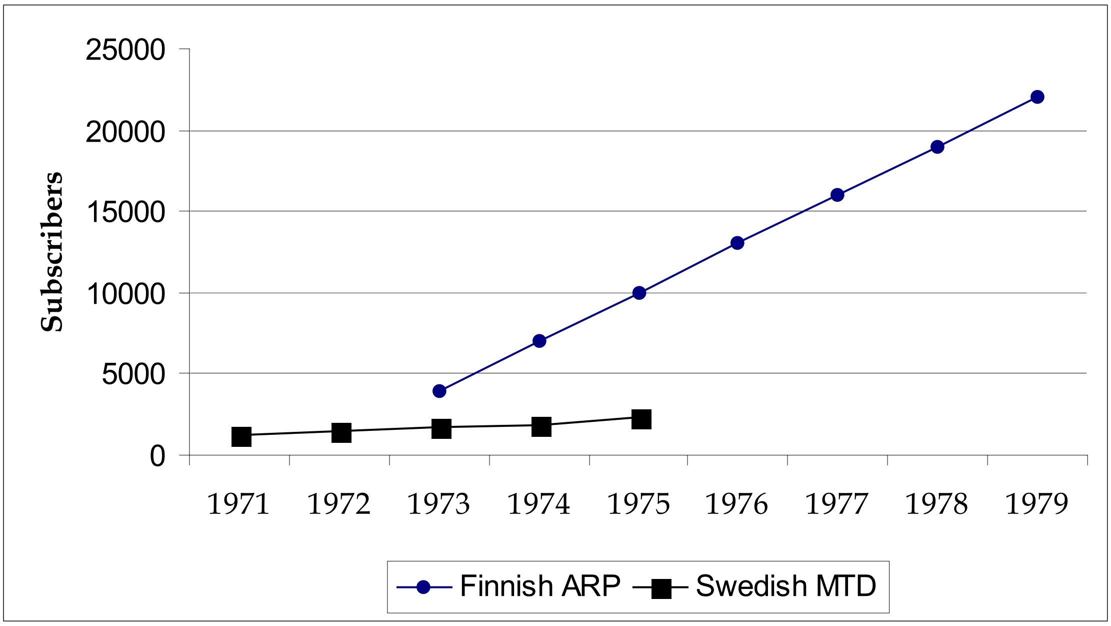
145 The origins of country-wide networks in Norway and Denmark remained unclear.
146 Mölleryd 1996.
147 Turpeinen 1996 B.
148 Toivola 1992; Turpeinen 1996 B.
149 SA RD Mobile telephone Report 18.8.1967; ULA MTD report; Jacobsen 1969.
150 SA RD Radio Department Plan of activity and economic plan for 1975-1979; Televiestintätilasto.



Note: The Finnish prognosis was made in the early 1970s (before 1973) and the Swedish in late 1968 or 1969

Sources: SA RD Radio Department's Plan of activity and economic plan for 1975-1979; ULA MTD Report

FIGURE 4 Subscriber prognosis for the Finnish ARP and Swedish MTD manual mobile telephone systems

The decisions of the Nordic NTAs to construct country-wide networks, at first turned out to be a faultless strategy, because manual networks became disproportionately popular during the 1970s[151]. This, on the other hand, certainly reinforced the strategy of the NMT Group to reserve an extremely long time for the development of future automatic systems in order to be able implement modern technology at reasonable cost. When the Nordic NTAs made their decisions in the late 1970s to construct automatic NMT networks, the manual networks had created large customer bases and showed that mobile telephony also had potential.

2.1.2.4 Manufacturers

The Swedish telephone firm LM Ericsson was an exchange supplier, and holding the strongest position in the Nordic countries. It had manufacturing plants in Denmark and in Finland, as well as in Sweden. In addition to this, it owned 25 per cent of the shares of EB in Norway. Ericsson was an old corporation and export-oriented. Of the multinational manufacturers, also ITT had manufacturing plants in each of the Nordic countries, although in Sweden it focused on military technology; in Norway it owned 60 per cent of the shares of the STK company.[152]

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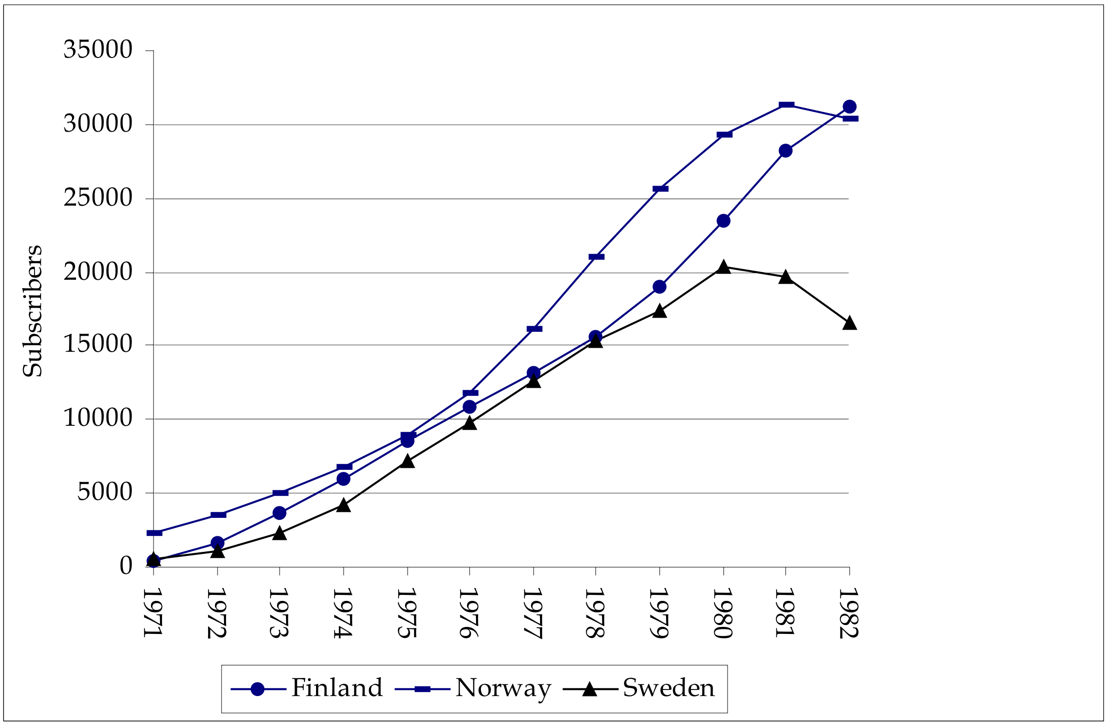
151 FIGURE 5 includes also Sweden's automatic MTA and MTB systems, but the total number of subscribers never surpassed 700 during the period in question.

152 Grandstand and Sigurdson 1985 B; Grandstand 1985; Kuhn Pedersen et al 1985; Ekberg



Note: The Norwegian figures include both OLT-VHF and MTD networks, the Swedish figures MTA, MTB and MTD networks (excluding networks of private operators), while the Finnish figures include only the ARP network.

Sources: Toivola 1992; Televiestintätilasto; NMT Doc1984-1163; Karlsson 1998

FIGURE 5 Subscriber numbers of Finnish, Norwegian and Swedish pre-cellular mobile telephone networks

By the early 1970s, each of the Nordic countries had several mobile-station manufactures. When Finland and Sweden followed the example set by Denmark and Norway in the early 1970s and liberalized the terminal market, a common Nordic market for terminals was created. It had an incentive impact on Nordic manufacturers, but manufacturers outside Nordic countries did not show much interest.[153] In the late 1970s, the Japanese Mitsubishi was the only outside manufacturer on the Swedish market. In Finland, the supply of terminals for manual ARP network was completely in the hands of Nordic manufacturers. The well-known manufacturers, e.g. Motorola, Pye and Brown Boveri, though all operating on the Finnish mobile radio market, did not begin to manufacture ARP mobile stations.[154]

In the Nordic countries, the most significant manufacturer of mobile radio equipment manufacturer was Storno in Denmark. In 1947, Great Northern Company founded Storno to produce radio equipment for utilization on both land and sea. In the same year, also Amplidan was established. Later, S.P. Radio

1985; Sognen 1985.

153 The relationship between market liberalization in the early 1970s and Nordic manufacturers has been disregarded in the research literature.

154 See Toivola 1992, Koivusalo 1995 and Mölleryd 1996.

and in 1953 AP Radiotelefon were established. Storno became the largest of these, and during the 1960s it had became the fourth largest manufacturer of mobile radio equipment in the world, being third in the following decade. Storno concentrated on closed networks. In the years 1976-1978, General Electric bought the company and sold it to Motorola in 1985. In 1978, another foreign company, Philips, bought the second of Denmark's leading companies, AP Radiotelefon.[155]

Typical for Denmark was the birth of new companies that would, however, not stay in Danish hands. Dancom, which was a spin–off from SP Radio, manufactured marine radio equipment and in 1980 it established Dancall, a firm manufacturing mobile radios. Dancall was the sole manufacturer to have a marketing agreement with local regional operators. In 1983, Amstrad (UK) bought Dancall and sold it to Bosch in 1997. Dancall then evolved as a spin-off into T-Com, which was bought by the South-Korean company Maxon in 1991. (Maxon was the world's second largest cordless telephone manufacturer). Another newcomer, Cetelcon, which was founded by the marine communications company Shipmate, but in the late 1980s it gradually went in Hagenuk Telecom ownership (FRG). In 1998, Telital S.p.A. (Italy) acquired Hagenuks mobile division, which was reshaped as Telital R&D Denmark A/S.[156]

During the 1970s, the Swedish Radio AB (SRA) and Sonab expanded to the level of Storno as manufacturers of mobile phones. In Sweden, up to the year 1983, LM Ericssson was interested only in military communications, but it owned most of the SRA shares. The Swedish corporations, ASEA, AGA and LM Ericsson founded SRA in 1919 to produce radio equipment for the Swedish Navy and the state operator. As a result of the re-organization of the ownership during the 1920s, 43% of the shares were owned by the British Marconi Wireless Telegraph Company while LM Ericsson owned the rest. Ericsson raised its stake to 71% in 1962. In the early 1960s, the SRA line of business included military radios, land-based mobile radio and broadcasting. During the same decade it sold its consumer electronics, shifting from the military to the civilian markets. The production of paging equipment provided new export openings. SRA had been cooperating with the Swedish state operator in the development of automatic MTA and MTB mobile systems.[157]

In Sweden, SRA had to compete with other domestic manufacturers. The gas company AGA's subsidiary AGA Mobilradio won a significant share of the Swedish and Finnish markets, also selling its products to Norway and Denmark. This company was sold to Sonab in 1974, because the exports of the mobile radio equipment required more marketing and service networks than the parent company's other activities. Sonab AB was a brand new company because it had been established in 1966 to produce loudspeakers. During the decade that followed, its line of business were to be industrial electronics,

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155 Kuhn Pedersen and Hartz 1988.
156 http://www.norcom.dk/index_alpha.html.
157 Mölleryd 1996; McKelvey et al 1997.

mobile phones and paging. Sonab became the leading Nordic manufacturer of mobile phones, and after having bought AGA, it rose to the level of SRA. Due to its heavy investments in R&D, Sonab found itself in financial trouble and was sold to SRA in January of 1978.[158]

Companies specializing in base stations evolved in Sweden. Magnetic was founded in 1952, focusing on military technology, but in the late 1960s it developed transmitters, subsequently starting to manufacture base stations for the MTD mobile networks. Because of the competitive offers of Magnetic in the 1970s, SRA could not get their base station sold and it bought Magnetic in 1983. Magnetic acquired a competitor when, in the summer of 1978, a couple of its workers founded Radiosystem, which initially produced filters, antennas, amplifiers, combiners for base stations, and later entire base stations. When LM Ericsson merged SRA into its organization in 1982, it had acquired the main segments of this line of business. The competitor company Radiosystem was finally bought by LM Ericsson in 1988, thus strengthening Ericsson's position.[159]

After the merger process was completed, LM Ericsson did not continue with this strategy. The only exception was Spectronic. Spectronic was founded as early as in 1964, but it had manufactured radio equipment for industrial use before turning to the manufacture of mobile phones. It started to develop a handphone in 1985, releasing its technically highly advanced product to the markets in 1989. (Spectronic started OEM production for Siemens.)[160]

In Finland, there was increasing demand for radio-industry products after the 2nd World War, because Finland had to pay extensive war compensations to the Soviet Union; these included ships and ship radios. Several companies were involved, but Televa[161] was the sole mobile-radio company remaining in this line of business after the changes at the end of the 1950s and the early 1960s. Televa was state-owned, and it had been founded in 1945. The abolition of import controls during the 1950s increased competition with foreign companies. In order to compensate for the imports, Televa started to develop and produce frequency-modulated VHF mobile radios in the mid-1950s. Gradually, Televa shifted from military production to the civilian field, its radio section concentrating on both mobile radios and radio systems. Important target groups were governmental departments, fire departments, and taxis. Televa began exporting radio systems in 1974, having manufactured exchanges since the late 1950s.[162]

The army initiated the Finnish auto-based telephone industry in 1963 when it ordered an experimental prototype for the infantry (the "company radio"). The Finnish corporations involved were Televa, Nokia, and Salora. The actual order was ultimately cancelled, and the companies that had participated had to remodel their product for the civilian market. This was particularly true

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158 Mölleryd 1996.
159 Mölleryd 1996; McKelvey et al 1997.
160 Mölleryd 1996; http://www.spectronic.se.
161 Televa's original name was Valtion Sähköpaja (State Electric Workshop), but it was renamed in 1961.
162 Televa 1980; Koivusalo 1995.

for the markets of the ARP auto-based telephone, which opened in 1971. Salora and Nokia were newcomers in mobile communications, but as enterprises they were of long standing. Salora had been manufacturing radios since the 1920s and television sets, later to be its chief product line, since the late 1950s. Salora achieved the leading position in supplying ARP terminals in Finland, starting its exports in 1975, at first to Norway and in the years to follow to Sweden and Denmark. In 1978, Salora became the biggest supplier of manual terminals in the Nordic countries. Salora had been concentrating on the production of terminals while Nokia was the third largest manufacturer of ARP terminals after Salora and Televa. In 1975, Nokia and Salora began a joint marketing venture in which Salora marketed Nokia's base stations and Nokia Salora's mobile phones. At at the end of the decade the companies launched exports to the United Kingdom. After Salora got into financial trouble and changed owners, Salora and Nokia founded their joint venture Mobira in 1979 to produce base stations and terminals. In 1981 Nokia bought half of Televa, Televa's radio production being merged with Mobira as of the beginning of 1983. In 1984 Nokia increased its share of Salora to 58%, buying the rest in 1988.[163]

In Finland, as In Sweden, the line of business for mobile telephone was concentrated, and no spin-offs emerged from Nokia. Benefon, founded by Jorma Nieminen, Mobira's former CEO, in February of 1988, was the sole exception.

One of the Nokia companies was the sole supplier of cables for the Finnish industry in the 1950s,[164] but the market situation was changing because the NTA took the first radio links into use at the end of the decade.[165] The company focusing on cable supply reacted and established a new Electronics Department in 1963, which (besides producing electronic equipment) sold and rented out computers and carried out computation operations. The Electronics Department developed PCM equipment before the mid-1960s in the role of a pioneer for the development of 30 channels PCM radio links. These were commissioned in the early 1970s.[166] The decisive step from digital transfer to digital switching was taken with the establishment of a new department, that of Transfer Technology, in 1972.[167] In 1976, Nokia acquired a license for the Alcatel digital E 10 R switching system, and launched production under name of DX-100. Finally, Nokia and Televa joined their resources in 1977 when they founded the joint venture Telefenno. At that point, the objective was not the development of exchanges for mobile telephone systems, the incentive coming from the remodelling of the NTA's long distance network. The aim of the joint company was the development and marketing of digital switching systems. After the

163 Koivusalo 1995; Palmberg 1997.
164 Suomen Kaapelitehdas Oy (literally: Finnish Cable Works). The consolidated corporation of Nokia was not established until 1966 by Suomen Kaapelitehdas Oy (established in 1912, Suomen Kumitehdas Oy ("Finnish Rubber Works"), established in 1912) and Nokia (established in the 1860s to manufacture paper).
165 See Turpeinen 1996 B.
166 Koivusalo 1995; Turpeinen 1996 B
167 Häikiö 2001 B.

product had been brought to prototype level, Nokia bought 51 per cent of Televa's shares, to form Telenokia Oy, and Telefenno was merged into it.[168]

The leading company in mobile phones in Norway in the 1960s was Nera A/S, which was a small single company. Once Nera retreated from the line of business, its place was taken by Simonsen Elektro A/S in the late 1970s. Simonsen concentrated on the development of compact and specialized high-quality terminals in the early 1980s.[169]

2.1.2.5 The relationship between operators and manufacturers

State operators (NTAs) in the Nordic countries followed different procurement policies, this being a reflection of their differences in structure. In the early 1980s, equipment procurement was concentrated in Sweden and in Norway, whereas in Denmark and in Finland it was decentralized.[170] Procurement was most concentrated in Sweden, were the NTA had its own production branch Teli. Teli supplied 40-45 per cent of the AXE exchanges produced and 90-95 per cent of the telephone terminals procured by the Swedish NTA at the beginning of the 1980s. The second most important supplier was LM Ericsson, which supplied the remaining share of the AXE exchanges. The Swedish NTA also had an agreement with Northern Telecom regarding technical cooperation and with Western Electric regarding license production.[171]

The Norwegian NTA bought 85 per cent of the equipment made in Norway from Elektrisk Bureau (EB) and Standard Telefon og Kabelfabrik (STK), while the share of imports was 15-20 per cent. The procurement of exchanges was highly concentrated, with the orders being split between EB and SKT. The procurement of the first digital switches in 1983 was an exception as it was based on a bid competition.[172]

In Finland, the procurements of the NTA were based on bidding, but confined to “domestic manufacturers”, because LM Ericsson, Siemens and ITT had their production plants in the country. In the early 1980s, the most popular exchange suppliers of exchanges for the private concession operators were Ericsson (60%) and Siemens (30%). The procurements of the NTA were divided more evenly between the state-owned Televa (34%), Siemens (28%), ITT (19%), Ericsson (18%), and others (1%).[173]

In Denmark, procurements were made based on competitive bidding as well as by state operators and by private concession operators, but even in Denmark the procurement of exchanges was concentrated between Ericsson and SEK-ITT and their “parent companies” in Sweden and in Belgium.[174]

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168 Koivusalo 1975.
169 Interview of Hans Myhre.
170 Grandstand and Sigurdson 1985 A; see also: Grandstand and Sigurdson 1985 B; Grandstand 1985; Kuhn Pedersen et al 1985; Ekberg 1985; Sognen 1985.
171 Grandstand and Sigurdson 1985 B.
172 Sognen 1985
173 Ekberg 1985.
174 Kuhn Pedersen, Kongstad and Nielsen 1984; Kuhn Pedersen et al 1985.

In the Nordic countries, technology procurement was seen to have a significant role as an instrument of the public sector in promoting and developing technology and industry. But there were no common procedures for the telecommunication sector. In Denmark, technology procurement was not applied at all in the field of telecommunications nor in Norway before the end of the 1960s.[175] In other parts of the world, it was a common practice for manufacturers and operators to have keen cooperation in developing computer-controlled exchanges. In Denmark and in Norway there were no "national" manufacturers and this resulted in there not being any joint projects. But in Sweden and in Finland, cooperation intensified to the level of integration.

The Swedish NTA and LM Ericsson established a joint Electronics Council in 1956, its task being to supervise and conduct the development of electronic exchanges. When both players started to develop exchanges, which would have resulted mutual competition and considering that the work needed more resources than they had expected, they founded a joint venture in 1970. The name of the corporation was Ellemtell and its aim was to conduct research, development and marketing related to the digital AXE exchange. The Swedish NTA participated in its financing until 1976 when the prototype was ready, although Ericsson was still responsible for the investment. Ericsson developed a special relationship with the state operator through the AXE project.[176] Throughout the 1980s, Ericsson steadfastly defended the state monopoly in telecommunications and even at the beginning of the 1990s, it refused to sell the AXE exchange to a domestic competitor of the state operator.[177]

The situation in Finland differed from that of Sweden, because the state-owned Televa did not manufacture products solely for the needs of NTA.[178] Even though Televa was subject to the Finnish PTT and connected to its budget, it was not operationally an integral part of PTT's operations. Televa had its own budget and board,[179] and according to the requirements of the legislation, it was to operate in accordance with normal sound business principles and to make a profit for the state. The manufacture of exchanges by Televa was motivated by the fact that big manufacturers were not necessarily interested in developing exchanges suitable for sparsely populated remote areas.[180] At the beginning of the 1970s, Televa launched a project for the digital ADS exchange, which ultimately managed to stay alive because PTT gave a very sizable order for the development. According to this contract, in practice, Televa could choose from three alternatives which one it wanted to deliver to PTT. The project continued

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175 Grandstand and Sigurdson 1985 B; Grandstand 1985; Kuhn Pedersen et al 1985; Ekberg 1985; Sognen 1985.
176 McKelvey 1997.
177 Karlsson 1998.
178 Televa 1980; although Ekberg 1985 misleadingly states that Televa was owned by the Finnish PTT and and it developed products to fulfill only the specifications of one customer (Finnish PTT). Both claims are false, see Televa 1980.
179 Televa was like a general store of telecommunications equipment, its range of manufacturing being very wide.
180 Televa 1980.

although it was relocated under Telefenno, the joint venture of Nokia and Televa, in 1977. At the same time, Nokia tried to enter the market through the license-manufactured DX-100 (Alcatel's E-10). Under Telefenno, ADS was named DX-200, the first prototype being ready in 1980. A year later Nokia bought Televa, but 49% of the recently founded Telenokia was still owned by the state until 1988.[181]

2.2 Development of the NMT system

2.2.1 Preparatory phase

2.2.1.1 The establishing of the NMT Group and its objectives

In the Teleconference held in June 1969 in Kabelvåg in Norway, it was decided that a working party should be formed. It was formally named NTR-69-5, but in practice it became known as the Nordic Mobile Telephone Group (Nordisk Mobiltefon gruppen). The group started its activities in January, 1970, and as a result of its work a temporary manual system MTD and the automatic cellular system NMT came into being.

Without any preliminary warning, Sweden informed the Kabelvåg Teleconference of its intention to start developing a next-generation mobile telephone system, which would not be completed before the end of the 1970s.[182] Sweden proposed a joint project, because a joint Nordic mobile service would provide great benefits. In principle, the idea was supported, but the Danish delegates proposed that negotiations regarding the Nordic mobile telephone service should include both manual and automatic systems.[183]

The different preferences of Denmark and Sweden are explainable on the grounds that these countries had chosen different approaches.[184] The automatization of the fixed network in Sweden was much further than in the other Nordic countries, where country-wide manual networks were under construction. The construction of country-wide automatic system was expensive and technically very demanding in the current situation.[185] The construction of an automatic system was proposed by a committee, which had studied services for mobile communications in Sweden during the summer of

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181 Koivusalo 1995; Palmberg 1997.

182 PTT FD Record book 1968-1969, and particularly 225/809 1968 (Letters regarding 1969 Teleconference); according Thomas Haug (interview) the proposition presented by C.G. Åsdal was not prepared in advance. Åsdal had chaired the committee which prepared the report to Swedish NTA regarding the automatic mobile telephony system (see TM Report of Swedish NTA in 1967).

183 PTT FD 225/809 1968 Minutes of 1969 teleconference.

184 The automatization rate of fixed telephone network was only 85,3 per cent in Denmark, while it was 99,5 in Sweden, 90,2 in Finland, and 81,3 in Norway; see TT 7/1970.,

185 TM Report of Swedish NTA in 1967.

1967.[186] The committee had not accepted any of the existing systems, and a manual system was categorically rejected as an alternative, because it considered that automatic systems would be the general world-wide trend.[187] A preliminary research had clearly shown that the development of an automatic system would have to await new technology.[188]

The different interests of the Danish and Swedish NTAs were combined in a task given to the NMT Group by Teleconference. It was defined very broadly.[189] The group had to study a common Nordic frequency plan, and to consider defining the future auto-based telephone system. It was also hoped that there would be negotiations as to whether it would be possible to standardize signaling in already existing auto-based telephone systems.[190]

In its first assembly, the NMT Group itself interpreted the task given by the 1969 conference and formed a mandate for itself. The mandate consisted of three goals: To study and construct a compatible Pan-Nordic auto-based telephone; to develop an interim manual system for the Nordic countries; and to study the possible compatibility of the existing systems and standardization of selective call.[191]

The aim of the frequency plan was not viewed as an independent issue, but instead as a prerequisite for different options. The compatibility of existing systems was soon found to be an unrealistic alternative.

Essential for the success was that the NMT Group interpreted the given task coherently in such a way that the primary goal was not to develop a common technical product but to create a common and compatible Nordic service. This was already clear in connection with the temporary manual system. Due to the unsolved frequency issue, the other Nordic countries were preparing themselves for a situation where Sweden would not be able to use the UHF frequencies for the manual system. Because of this, different "emergency solutions" were sought, based on an idea whereby the other Nordic countries would have shared a mobile communication service without the interim UHF system of Sweden. However, these were thought to be unrealistic because the participation of Sweden with its geographically central position was thought to be crucial for the system to operate.

The common service was thought to be more important than technology and this was already to be seen when the regulation issues were solved. They were solved, not system-specifically but in a harmonized way in order to create to create a common Nordic service. Even with the development work, the

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186 Mölleryd 1996; Mölleryd 1999.
187 TM Report of Swedish NTA in 1967.
188 Mölleryd 1996; Mölleryd 1999: Thomas Haug's interview; Östen Mäkitalo's interview.
189 It has been misleadingly claimed (Lehenkari and Miettinen 1999) that the Swedish NTA made a proposal for a manual system at the 1969 Teleconference. The manual system was clearly the initiative of the Danish NTA, and the Swedish NTA had on April 29, less than two months before the 1969 conference, decided to establish a committee (MTD) to study the prerequisites for the construction of a manual mobile telephone network, (see ULA MTD report).
190 PTT FD 225/809 1968 Minutes of the 1969 Teleconference; NMT #1 Minutes (14.-15.1.1970).
191 NMT #1 Minutes (14.-15.1.1970).

formal objective was not to create one possible system, but instead compatible systems: in each country there could be national systems that would be compatible.[192] In practice, however, for the 1971 Teleconference, the NMT Group recommended a model of one common system. In addition, the future system decision was made in 1971 in favour of the model of one common system, although it was not until the 1975 Teleconference that it was formally decided that the system should be automatic.[193]

The NMT Group did not initially write a document for a strategic plan to include explicit optional methods leading to the achievement of the goal, the official objective of the group being simply to study the prerequisites. However, in practice, the NMT Group had a holistic aim in its work. This process advanced step by step, so that the Teleconferences of 1971, 1973 and 1975 functioned as distinct intervals for the process. For the 1971 Teleconference, the NMT Group proposed that a temporary system be built and solutions for the frequency issue and major administrative issues be found. The basic functional requirements were presented to the 1973 Teleconference as well as also the rough system specifications, system description, and time schedule. The 1975 Teleconference marked a principal change for the project, because it finished the phase to study of prerequisites. The NMT Group recommended the development of an automatic system according to submitted rough system specifications. In order to carry it out, there should be preliminary specifications and they should be tested by the experimental system before the finalization of the specifications and purchase equipment.[194]

The activities of the NMT Group were based on the premises proposed by the Swedes that the development of the next-generation system could take approximately ten years. In the beginning, this was considered to be more than sufficient, but before the 1975 Teleconference the process advanced quite slowly. Following this, however, there was no surplus time left. It should be remembered, that the NMT Group was not only in charge of defining specifications (setting the standards), but it was also involved in the procurement of equipment, and the implementation and further development of the system.

The manner in which the NMT Group was founded is indicative of the actual motives behind the Swedish initiative and how they reflected on the work of the NMT Group. The most essential question is why the Swedes brought an issue to the 1969 Teleconference that was not on the agenda, and one of which the others were not informed beforehand.

In 1969, the situation for cooperation was the most favorable, because the process of economic integration was reaching its climax and cooperation in telecommunications was beginning to be organized, this providing a favorable base for a joint project. Yet the beneficial situation in itself does not explain why the project was launched so rapidly. Answers to this can be sought from the

[192] NMT #1 Minutes; SA RD Memo from NMT # 1 (14.-15.1.1970).
[193] NMT # 5 Minutes (20.-22.1.1971); NMT Reports to 1971 and 1975 telecommunications conference.
[194] NMT Reports to 1971, 1973, 1975 telecommunications conference.

situation prevailing in Sweden, from the objectives related to industrial policy, or from issues related to frequency administration.

Competition was beginning to be obvious in Sweden, one private operator planning to launch a new service by constructing a country-wide mobile telephone network, but the Swedish NTA did not have a similar service. [195] However, this explanation is not convincing, because the Swedish administration was primarily interesting in developing an automatic system, something that could not be acquired in time for this situation.

Because of the context of the period, one very tempting explanation would be the objectives of industrial policy. Thus far, studies have not revealed any connection between the political level and this sector of telecommunications. If the industrial policy were to be restricted to encompass only the attempt of the Swedish NTA to acquire competence for itself and for the Swedish manufacturers, this view is at least alluring. The Swedes were convinced that automatic systems would be the trend of the time and their administration gave more resources for this project than was the case in the other Nordic countries. The Swedish NTA had its own operative MTC Group studying mobile telephone system in the early 1970s. However, there is no evidence that the Swedish MTC Group would have tried to steer the work of the NMT Group.[196]

At least on one occasion, there was a possible Swedish attempt with possible industrial policy implications. In 1972, the NMT Group tendered for the study of signaling, tenders also being sent to the research section of Swedish NTA (Tv/Ur). However, even though it did not respond, the NMT Group, most likely in response to the proposal by the Swedish delegation, tried to form cooperation between Svenska Radio Aktiebolag (SRA) and the research section of the Swedish NTA.[197] In any case, bids were objectively evaluated, and the contract was given to Strorno of Denmark, which received the highest evaluation score. This attempt could not be defined as an exclusive sign of industrial policy. It was more like typical intercourse, organized in a manner enabling national delegation to be in constant communication with domestic manufacturers. Based on these examples, the motives of the Swedish NTA cannot be confirmed as resulting from industrial policy.[198] It was crucial for the progress of the project that during the development of NMT the interests of industrial policy remained outside, no manufacturer being favored because of its nationality.[199]

Securing the frequencies would be one of the obvious explanations for the Swedish initiative, because the other Nordic countries had constructed, or at

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195 See Karlsson 1998.

196 The NMT Group received assistance from the MTC Group in the early 1970s, and it did not find the existence or activity of the MTC Group to be disturbing. Thomas Haug's interview.

197 ULA Swedish NTA, tender for bids (Televerkets förvaltning, Inköpskontoret 1972/29, 15.5.1972); Thomas Haug's interview.

198 It was natural for an NTA to communicate with the domestic manufacturers, this procedure being adopted by the NMT Group. This was also convenient for the NMT Group, because if the group had carried out all the routine work without delegating it to NTAs, the work load of the NMT Group would have risen considerably.

199 Excluding procurement of equipment.

least had made the decision to construct, country-wide networks on the 160 MHz band. The contemporary view was that, in the future, there would be need for complementary networks and therefore there would be a need to secure the 450 MHz band. This explanation is logical, but not directly supported by empirical observations. The Swedish NTA did not hurry in reserving the frequencies for the automatic system, and for practical reasons it was not even willing to make a fast compact solution in which the frequencies of manual and automatic systems would have been solved simultaneously.[200]

Because the Swedes probably did not act purely on whim, the motives may have to be reconstructed on the basis of probabilities and logic. The starting point is the Swedes' insistence on sticking to the automatic system. The objective was becoming complicated and the alternative of developing a manual system had been brought up before the Teleconference. With the help of Nordic cooperation, the resources of the administrations of different Nordic countries could be combined. In addition, the common system would have been used to create sufficient market area as an incentive for the equipment manufacturers. This was an important question, because the 1967 report of the Swedish NTA stated that in Sweden there would not be such a volume in the production of exchanges, controlling units and maneuvering equipment that industry would be willing to invest in the development work without a specific production order. Even then, the Swedish NTA would have to provide resources to guide the development work.[201] The Swedish experience in having been dependent on just one equipment manufacturer may, for its part, explain why the development process required a great number of manufacturers. [202] The Nordic economic integration and transport on land was becoming a trend and both of these created larger and more beneficial environment for the project. Although these were not publicly voiced by the Teleconference or the NMT Group, it is highly unlikely that the top echelon of the Swedish NTA was not aware of the direction that social development was taking.

2.2.1.2 Prerequisites for Pan-Nordic use

2.2.1.2.1 The solution of the frequency issue

As early as in the 1960s, the CEPT had engaged in discussions regarding a common European mobile telephone system.[203] The issue was discussed in the

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200 The Swedish NTA was going to allocate frequencies above 400 MHz for the manual system, although there was no formal decision to this effect. The Swedish NTA could not use the 450 MHz band in the short term and it was not willing to take a decision which would allocate frequencies for the manual and future systems at the same time; see SA RD Memo from NMT # 1 (14.-15.1.1970).

201 TM Report of Swedish NTA in 1967.

202 Actually the Swedish NTA had two terminal suppliers for the MTB system, but it was facing problems because only one manufacturer was able to supply terminals with 16 channels, see NMT # 3 Minutes (27.-29.4.1970).

203 The Report of Swedish NTA (TM Report of Swedish NTA in 1967) referred this issue.

NMT Group as well, but the group was of the opinion that the obstacles in the way of agreement on getting common frequencies and signaling on a European level were too big. The NMT Group considered that the best way to reach the goal would be to set a less ambitious goal. It would be dualistic including restrictions on compatibility, and the setting of the task as a long-term process.[204] As there was no realistic possibility for a common European system, the NMT Group did not waste energy on the issue.

The frequencies for the NMT system were selected from the 450 MHz band, which became the typical band of European cellular systems by the mid-1980s. The 450-470 MHz band was reserved primarily for fixed and secondarily for mobile traffic as early as in 1959, with no changes in use during the 1960s .[205]

It was the general tendency in mobile traffic to start using higher frequencies, and this applied to the Nordic countries as well. The manual systems in Denmark, Finland and Norway, built in the 1960s and early 1970s, were based on using the 160 MHz band. The working party of the Swedish TNTA recommended in its 1967 report that a planned automatic system should implement either the 160 MHz or the 450 MHz band. It was not until January 1965 that the 400 MHz band was opened for the mobile traffic. [206]

The Nordic countries did not have a band wide enough in the 160 MHz range for a new country-wide system, which was also required to be inter-Nordic. The logical solution was to shift to 400 MHz. The decision behind this shift did not depend on any particular principles, although the band and the duplex separation of 10 MHz were in accordance with CEPT recommendations.

The decision to choose the frequency happened surprisingly. As early as in the first meeting of the NMT Group, it was decided that the frequency issues for the interim manual system and the future system should be solved separately. The frequencies for the manual system were to be decided before the summer of 1970 and for the future system before the 1973 Teleconference. It is most likely that the decision to separate the choices of frequencies for the manual and automatic systems respectively originated in the Swedish delegation, because in Sweden the 450 MHz band was not open for use in the near future. However, this attempt came to nothing, because later in the very same meeting the Danes, supported by the Norwegians, suggested a combined solution. According to the suggestion, the 453-457/463-467 MHz band was suggested for the frequency, with the proviso that the lower part be reserved for the manual system and the upper for the future system. The Swedes also made a proposal, which included three alternatives: 425-427/440-442 MHz, 423-425/430-433 MHz, or 453-457/463-467 MHz. The applicability of the last alternative for an interim system was not good, because in was already being used by the Swedish Army.[207] The middle alternative was reserved for mobile traffic only in Denmark, Norway and Sweden, while in other parts of Europe the 430-432/438-440 MHz band was reserved primarily for radio amateurs and

204 NMT # 5 Minutes (20.-22.1.1971).
205 Radio regulations 1959, 1968/1971.
206 TM Report of Swedish NTA in 1967
207 NMT # 1 Minutes (14.-15.1.1970)

secondarily for radio locating.[208] The first alternative was not possible in practice, because in Norway frequencies below 432 MHz would not be available for a country-wide network.[209]

Even though the Danish proposal was in accordance with the CEPT band, the motive of the Danes was not to attempt to create a new "Euro standard". Denmark simply had a need to coordinate its frequency planning with that of West Germany, although it also urged the securing of a possible joint use with the German system in the future.[210] This would not have been possible if the band for the automatic system had been selected below 455 MHz. The Danish proposal was the most noteworthy alternative, and the Swedish NTA began negotiations with the Army to clear the frequency reservation by as early as after the first meeting of the NMT Group. Yet negotiations could not be carried out along the NMT Group's planned schedule, which was quite demanding. Regardless of the pressure wielded by the Danes,[211] the issue was not resolved at the time of the third meeting in April 1970, and the meeting planned for early June could not be held until October. This failing of the schedule had its impact on connections to the interim (manual) system, because the intended frequency planning in the radius of 110 km from the borders (between Norway and Sweden, Sweden and Denmark) could not be started before October.[212] The Swedish NTA was able to make a compromise decision, and the Army cancelled their reservations for the reserved frequencies, which became available, but only during times of peace. ![213] As a matter of fact, the Swedish NTA was able to reach mutual understanding relatively easily.[214] The delay did not have any negative effect on the time schedule of the automatic system. Quite the opposite; the Danish proposal for reserving frequencies for the automatic system immediately, and not to postpone decision making for the 1973 Teleconference, removed the most essential problem from the agenda. Furthermore, choosing the adjacent parts of the frequency band (or actually splitting the band into two adjacent parts) made it possible to shift frequencies from the interim manual system to the automatic system. The NMT Group proposed at the 1971 Teleconference the use of frequencies fully in accordance with the Danish proposal.[215]

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208 Radio regulations 1968/1971

209 NMT # 2 Minutes (11.-13.3.1970).

210 SA RD Memo from NMT # 2 (11.-13.3.1970).

211 At the 2nd NMT Group meeting, the Danes presented a variety of emergency solutions to be applied, should the Swedes not manage to solve the frequency problem. The options were more or less unfavorable to the Swedes.

212 Originally the NMT Group had intended to solve the frequency issue regarding the manual system before the summer of 1970.

213 Thomas Haug's interview. The likelihood that Army would be constrained in its use of frequencies was only theoretical, since it was over 150 years ago that Sweden had last been at war.

214 It seems that the original agreement between the Swedish NTA and the Army was only preliminary, with negotiations continuing, and the NTA promising the Army use of the MTD system during a possible crisis situation.

215 NMT Report to 1971 teleconference.

Both manual and automatic systems had 80 channels, but subsequently this was not considered to be enough in then long run.[216] The NMT Group then recommended to the 1975 Teleconference that the frequencies of manual system should be handed over to the automatic system. In addition to this, it was proposed that an extra band of 0.5 MHz should be reserved for the automatic system. In Denmark and Norway, this reservation had already been made, the Swedes did it a little later, but in Finland it was no longer possible.[217]

2.2.1.2.2 Other administrative questions

Bureaucratic procedures demanded that a person had to have an administrative license for using a mobile telephone in a Nordic country even if that person was just visiting the country in question. For example, if a Finn was driving a car equipped with a mobile telephone in Sweden, Denmark or Norway, he would have to acquire the appropriate administrative licenses from the NTAs of all the three countries in question. This was an essential obstacle to pan-Nordic joint usage. The NMT Group's view was based on the premise that an auto-installed telephone should be allowed to be used in the other Nordic countries as well, once a license had been acquired from one Nordic NTA. Decisions regarding the licensing practice were not, however, in the hands of the NMT Group. Since it was thought that changes to these practices would require a long time, preparations were made for it right from the start. In Finland, this change required amendments to legislation. The other Nordic countries were of the opinion that these changes could be made within the range of NTAs themselves. It was only in Denmark, however, that this was the case. In the other countries, the procedure took a longer time and was more complicated.[218]

The NMT Group proposed to the 1971 Teleconference that the licensing practice be changed. The proposal was extended to cover all modes of mobile telephony service, this implying the harmonization of services in all the Nordic countries. Firstly, it included UHF systems, both interim and future solutions (MTD and NMT). Secondly, existing incompatible VHF systems were also included. The NMT Group recommended that the use of a domestic base station across the border be allowed. The same recommendation was also made for the use of closed networks. In the UHF and VHF systems, this change required the granting of a general license for foreign subscribers who only had

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216 During its firsts meetings, the NMT Group considered that the future (automatic) system would not replace the manual system but complement it. Yet as early as in the 4th meeting, the manual system was considered to be an interim system, and the group discussed the shifting of frequencies from the manual to the automatic system (see SA RD Memo from NMT # 4 (5.-7.10.1970).

217 NMT Report to 1975 Teleconference.

218 Toivola 1992; NMT # 2 (11.-13.3.1970), # 4 (5.-7.10.1970), # 5 (20.-22.1.1971), # 7 (2.-4.11.1971) # 9 (30.5.-1.6.1972, # 10 (5.-7.9.1972) Minutes; NMT Reports to 1971, 1973 and 1975 Teleconferences.

to apply to one administration for one license. The prerequisite for the granting of the license was that the subscriber lived in one of the Nordic countries.[219]

As had been expected, changing the licensing practice was a slow procedure. Before the 1973 Teleconference, the NMT Group recommended that individual administrations intervene in the process, an appropriate proposal being put to the 1975 Teleconference for an Inter-Nordic Pact. Originally, the NTR had supported a bi-lateral arrangement, but in 1974 it changed its mind, the Pact ultimately being ratified at the beginning of 1976 between the four Nordic countries in accordance with the proposal of the NMT Group.[220]

Billing was also a legal issue. The suggestions regarding billing made to the 1971 Teleconference were intended primarily for the interim system, but subsequently they were also applied to the automatic system (NMT). According to the NMT Group, foreign and domestic subscribers should be put in the same position, both paying the same tariffs. Fixed payments were to be made to the country from which the license had been acquired, while telephone call payments were to go to the country whose base stations were used. Billing in the manual system would be similar to that used for maritime mobile radio, since it involved only a small number of foreign customers. [221]

The original plan for an automatic system of billing was complicated. At the beginning of 1971, it was based on the actual location of A and B subscribers, but for the 1973 Teleconference the NMT Group proposed a much simplified scheme: billing would be dependent on the A subscribers and on the numbers selected. This was considered to be realistic, because the cost of the call was estimated to be the equivalent of an international call on the fixed network.[222]

There was no common ground in the numbering of manual and automatic systems, because in the manual system, the country of the caller could be also be provided with the billing manually. Only the subscribers that had selective call equipment could cause difficulties. The basic rules for the numbering of the automatic system had already been introduced before the 1971 Teleconference. The Danes made such a suggestion for the numbering, the prerequisites being as follows:[223]

- All subscribers should be provided with the same type of equipment.
- The number should identify the subscriber uniquely.
- The system should be adjusted to the PSTN.
- Same kind of calling procedures to be used as in fixed networks

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219 NMT Report to 1971 Teleconference.
220 NTR # 4, 5; NTR Report V/1973-IV/1975 to NST; SA RD Nordic Pact regarding use of mobile terminals on public mobile telephone networks, 14th January 1976.
221 NMT Report to 1971 Teleconference; NMT # 4 Minutes (5.-7.10.1971).
222 NMT # 5 (20.-22.1.1971), # 6 (25.-27.5.1971), # 7 (2.-4.11.1971) Minutes. At the 5th Meeting it was still considered to have billing based on location of A and B subscribers, but at the next meeting a new procedure was introduced and it was accepted at the 7th Meeting of the NMT.
223 NMT # 5 Minutes (20.-22.1.1971), see also # 6 (25.-27.5.1971).

In order to identify the subscriber's country code, "Z" would be used plus a five-digit serial for the subscriber, but the Z code would not be adopted until the number of subscribers in the network had exceeded 100 000 subscribers.

Directing of the call would take place with the help of certain sequences of numbers. There were three alternatives for the selection of numbers: dial plate, push-buttons, or "number–wheel" (sifferhjul). The group recommended push-buttons even though the dial plate was the most common in the fixed network.[224]

The decisive factors in numbering were the registration capacity, which allowed for three area digits plus five-digit subscriber numbers, and whether there should be a roaming function, a possibility for which preparations were actually being made. In Sweden, there was an option for an extra digit, the Swedes also wanting to have six-digit serials for the NMT system.[225] At the end of 1977, methods of increasing the number capacity were on the agenda. In the systems specifications of 1980, the numbering was based on six-digit numbers even though these still could not be used in Denmark and Norway.[226]

The issue related to ownership was not administratively or legally troublesome, but it was the most far-reaching decision with a tremendous impact on the industry, including both manufacturers and operators. The NMT Group suggested for the 1975 Teleconference, that the terminals be owned by the customers. This issue was not easily solved, because the Swedish NTA policy differed from that of the rest of the Nordic NTAs. Even in this question, however, the aim was to achieve a unified practice.[227] The Swedish NTA had problems with this intention, not merely because it had different practices, but due to aspirations in industrial policy, presented at the administrative level. There was pressure within the Swedish NTA for the number of equipment manufacturers to be restricted to two. [228]

2.2.1.2.3 Signaling

The choice of signaling was a prerequisite for defining the system. By the time of the third meeting, expressions opinion were already being aired regarding the need for measurements and studies which could be handed over to outsiders, because the group lacked the resources for this kind of activity. In November 1971, a decision was made that the signaling study would be given to some outside company. Thus the group relinquished direct control, stipulating that the company doing the study would not be allowed to apply for patents for its work. A bidding competition was organized for the signaling study, with Storno getting the deal as the result of an appropriate evaluation.

224 NMT Report to 1973 Teleconference; NMT # 11 Minutes (5.-7.12.1972).
225 NMT # 6 Minutes (25.-27.5.1971).
226 NMT # 26 Minutes (24.-28.10.10.1977); NMT System Specifications ("Yellow Book") 1980.
227 NMT # 14 Minutes (2.-4.4.1974); NMT Report to 1975 Teleconference.
228 Thomas Haug's interview.

Subsequently, all study projects for the industry were given directly to Storno, although the total number of studies executed by the industry was just three.

There were three alternatives for signaling: CCIR tone, CCITT two-tone, and binary signaling. The Storno study was completed during the fall of 1973, revealing that all options were considered satisfactory, but even so, Storno recommended tone signaling.[229] The NMT Group did not accept the Storno proposal, recommending binary signaling for the 1975 Teleconference. The group estimated that binary signaling would not be more expensive than tone signaling once the system became operational, but it had essentially a much larger data transfer capacity. As before, the Teleconference accepted this proposal.[230] Subsequently, Storno studied the effect of signaling speed on transfer security, 1200 bytes/second being found acceptable.

2.2.1.3 The implementation of the system

2.2.1.3.1 Basic operational requirements

During the first four years, the NMT Group acquainted itself with other systems sporadically. Especially the Norwegians, but to some extent the Danes as well, exhibited interest in the German Netz-B automatic system, even though its channel capacity was restricted and even though it lacked roaming and handover functions. The group also received information on the system, jointly being developed by the Australian subsidiaries of L.M. Ericsson, Pye and Philips. The plans included the roaming function.[231]

The lack of interest in systems operating on the markets was partly due to the fact that, up to the last meeting of 1970, the NMT Group had to focus on the pressing issues of the interim solution and also on administrative matters. But the chosen track turned out to be a question of principles, the NMT Group having set very specific requirements for the system, not easily satisfied by systems other than NMT (or the concept of NMT). The focus of work shifted to automatic systems at the first meeting of 1971. Even at that moment, basic operational requirements were being introduced. They were outlined by chairperson Håkan Bokstam[232] himself, although he had not been formally consulted about them. These same requirements were presented almost without any changes for the 1973 Teleconference.[233]

The basic operational requirements focused on the desired services and methods of functioning, not on the technological aspect, presuming that the system would be automatic. In the requirements, the premise was that the fixed network should be of greater importance than the radio system. The fixed network defined and restricted the properties of the system, which was to be an

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229 Mölleryd 1996.
230 NMT Report to 1975 Teleconference; Minutes of 1975 Teleconference.
231 NMT # 4 (5.-7.10.1970) and # 5 (20.-22.1.1971) Minutes.
232 Thomas Haug's interview; NMT # 5 Minutes (20.-22.1.1971).
233 NMT Report to 1975 Teleconference.

extension of the PSTN. The assumed needs of the subscribers in the 1980s were to to be taken into consideration in developing the system. They were interpreted to be such that the subscribers would increasingly demand already existing properties, or those that were being introduced to the fixed network. The automatic system should be defined in such a way that in the future it could represent "modern switching technology" when implemented in PSTN.[234]

TABLE 4 Basic operational requirements for the NMT system set by the NMT Group in 1971
Sources: MT Report to 1973 Teleconference; NMT # 5 Minutes

The system should create an automatic establishing of transmission and invoicing both to and from a mobile station.
A phone call should possible from a mobile station to any subscriber connection or another mobile station in the same or any other country.
A phone call should be possible when the vehicle is situated near the home base station or another base station in the home country of the subscriber or in some other Nordic country.
A phone call between two vehicle-mounted stations should be possible regardless of whether they are in the area of the same base station or in different countries. Invoicing will be addressed to the A subscriber according to location and selected number.
The subscriber capacity should be sufficient both with regard to radio channels and to subscriber numbers.
The system should search automatically for a mobile station on the basis of registered data throughout the whole area of the Nordic countries.
The system should be able to transfer an ongoing call from one area of the base station to another.
The use of a mobile station should correspond to the use of a fixed phone as precisely as possible.
The number switching of the system and the reliability of invoicing should correspond to the those of the landline network.
When developing the system attention should be attached to the costs. This especially concerns mobile stations.
The system should not be allowed to cause considerable requirements for changes in the fixed network.
The system should offer the same special functions as the fixed network. All the special functions used must be taken into consideration in invoicing.
The secrecy of telephone communication must be secured as reliably as possible.

The most essential features of the NMT system, such as roaming and handover, were not self-evident in the beginning. The bigger the base station areas were, the more important roaming would be. In order to justify this function, references were made to foreign systems, which, to some extent, were planning to use them. Secondly, it was assumed that the importance of the roaming function would increase in the future, because overall mobility would probably also increase. Thirdly, customer requirements would be larger than they are now.[235]

It was as early as in the report to the 1975 Teleconference that the roaming function was regarded as being vital.[236] Especially the chairperson of the group,

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234 NMT Report to 1973 Teleconference.
235 NMT # 7 Minutes (2.-4.11.1971); NMT Report to 1973 Teleconference.
236 NMT Report to 1975 Teleconference.

Håkan Bokstam, spoke on its behalf.[237] The NMT Group had a significantly broader and longer-term perspective than did the equipment manufacturers, this showing in the attitudes towards both roaming and handover functions. Behinds the scenes, Motorola was taking steps to abandon the roaming function because the company did not consider it important. [238] The leading Nordic radio company, Storno, claimed that the handover function was unnecessary, because the company assumed that the customers would only be willing to pay for essential features. Extra features would only increase the cost of mobile stations.[239] It was not until 1973 that the NMT Group took a decision in a report to Teleconferences on the application of the handover function. It was thought that the need for the function would depend on the size of the base station area. If the network would not be constructed as small-cell based one, then the range of base station would have to be large enough in order to prevent the subscriber from reaching the perimeter of a base station during a phone call. According to theoretical calculations, in a big city with a base station radius of about 4 miles, the likelihood of getting beyond its reach was 12 per cent when traveling at a speed of 25 mph.[240]

The small-cell concept was suffering from a technical impediment, because the antenna height was not to be too low in order to reach sufficient coverage in cities. According to the experience of the Norwegians, the minimum radius of a cell was 3 miles when using 450 MHz.[241] The views towards implementing small-cell structure began to be negative. Before the 1973 Teleconference, Norway even considered forbidding small cells altogether and restricting the number of subscribers. The Danes agreed with this.[242] However, a compromise was suggested for the 1975 Teleconference; the small cell was not ruled out as an alternative for metropolitan areas.[243]

2.2.1.3.2 Approach in implementation of requirements

In order to carry out the proposed operational requirements, various technical realizations were considered as possible alternatives. Some of the operative requirements were dependent on each other. Therefore, a similar kind of relationship applied also between their technical realizations. Several issues were left open without a positive or negative decision, because there was uncertainty as to their necessity, or as to whether realizations applying to some requirement could not be solved before their presuppositions for the

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237 Thomas Haug's interview
238 Mölleryd 1996; Mölleryd 1999.
239 NMT # 6 Minutes (25.-27.5.1971).
240 Toivola 1992; NMT Report to 1973 Teleconference.
241 In the United States, where 900 MHz band was used, the minimum radius for base stations of only 1.2 miles was attained. In 1971 NMT Group (# 7) considered that the minimum radius of base station would be 6,3 miles, in 1972 (# 8 NMT) 3,1 miles and in 1974 (NMT # 14) 2,5 miles.
242 NMT # 11 Minutes (5.-7.12.1972)
243 NMT Report to 1975 Teleconference.

requirement were solved. In addition to this, in some cases the NMT Group was not willing to exclude other possible solutions. For example, a document as old as the 1973 report[244] defined the mobile telephone exchange (MTX, or MTV as it was called at the time) as either an integrated exchange for PSTN (big) or a separate exchange for mobile telephones. By leaving it unresolved, there was no need to immediately decide whether the system should be centralized or decentralized.

Also, the early solution of an issue could be enabled to extend the range of possibilities for choosing proper realizations in cases where the delay concerned a feature, not a function. Already at a meeting following the 1971 Teleconference, a hierarchical structure was proposed for the network, thus dividing it into different traffic areas, which in turn were further separated into areas for base stations.[245] This approach enabled different kinds of calling procedures.

During 1973, the most essential questions regarding signaling were resolved, this being reflected in development process. For the 1975 Teleconference, the NMT Group recommended gradual implementation. This did not refer only to the construction of networks (an extension of the coverage), but also to the realization of the development process in a manner providing gradual improvement for the subscribers regarding a certain required service or feature. Thus some currently expensive or technically complex function could be realized, first in a more elementary manner, but in its full scale not until some later stage. This principle was intended for use in the realization of the following crucial properties, for example:

- Roaming: at first no roaming at all, in the interim phase only manual roaming or alternatively search for restricted areas
- Small-cell feature: even though it was difficult to lower the radius of base stations below 3 miles, this was a crucial feature in achieving an essential increase in frequency economy, It was decided to define the system in a manner where any possible implementations of small cells would not cause changes in the mobile stations
- Handover: this was defined because it was needed with the short-radius base stations. The crudest alternative included handover implemented by manual signaling.[246] Handover was taken care of in the signaling scheme. It did not raise the extra costs of mobile stations[247]
- Number of channels for mobile stations: duplex filters for over 120-channel mobile stations would be economically and technically beyond realization. In the first phase, it was planned to split the frequency band into two groups of either 100 or 120 channels (but this was not realized)

There is nothing in the properties of the NMT system, excluding the roaming facility, which would have given it any essential advantage over the American AMPS and the Japanese NTT system. As a matter fact, compared with these

244 NMT Report to 1973 Teleconference.
245 NMT # 6 Minutes (25.-27.5.1971).
246 NMT # 6 Minutes (25.-27.5.1971).
247 NMT Report to 1975 Teleconference.

systems, the NMT had significant weaknesses. Due to the lower frequency band, the size of the cell could not be reduced below 3 miles; nor was the small-cell structure initially implemented. From its very beginnings, the system was not intended to be using more than 80 channels.[248]

The exact evaluation of the development of telephone technology and particularly of its success was naturally important. According to Calhoun, in 1971, when AT&T proposals for the cellular telephone were being formulated in the United States, there was no such thing as a digital telephone exchange or a microprocessor.[249] But the same conditions applied in the Nordic countries, which also in 1971 set the basic operational requirements for the NMT system. In the NMT, the starting point was the primary position of the telephone networks, not of radio systems. In the Nordic countries, development work was not connected to the idea of the digital exchange either. Up to 1975, the discussions included exclusively electromechanical SPC exchanges.[250] The microprocessor for terminals turned out to be the most vital prerequisite, because it made sophisticated services possible.[251] But the Nordic countries did not make the specifications in 1971. Instead, they prepared requirements for services in early 1971, and it was actually not until after 1975 that they started to outline specifications, which still were not dependent on certain technical implementations. It was vital also that the NMT Group intentionally reserved enough time for development work, and that the solutions were kept open, making it possible to wait for mature and cost-effective technical implementations.

The NMT Group set demands that could not be accomplished using the existing technology, but the intent was to develop a functional and an adequate system, not to concentrate on applying the most sophisticated technical solutions possible. In the first place, this was a matter of costs, the aim being to keep the price of terminals low and the base stations easy to maintain. It paid off to focus on "phone-like properties", combined with the objective of avoiding too complex solutions, and also to keep the prices under control.

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248 The capacity of the NMT system was extended to 180 channels in 1975.

249 Calhoun 1988.

250 Actually, the 1976 budgetary bids for the MTX included several computer-controlled electro-mechanical exchanges as well the final bids in 1978; In January 1975, Danish representatives told the NMT Group that they were going to start discussions with Ericsson regarding the suitability of the AKE exchange system as MTX; see NMT ad hoc meeting 14.-16.1.1975.

251 Interview of Östen Mäkitalo; Interview of Hans Myhre.

2.2.2 Development phase

2.2.3 Ensuring implementation

2.2.3.1 Rationale for the development of a new system

The 1975 Teleconference marked a turning point in the realization the NMT mandate, because the group had accomplished its initial task. It had "considered" requirements for an inter-Nordic system. Now the decision had to be made regarding the construction of the system. In order to motivate this decision, other possible alternatives had to be expressed.

In 1974, the NMT Group studied the systems already in existence, whether they would stand up to the requirements made by the Nordic countries. These requirements concerned the level of service, traffic capacity and frequency economy. The group studied the question of whether these systems would be applicable for Nordic needs carrying out its study on the basis of documents and discussions with the manufacturers. The group met representatives of Tekade, ITT, Martin Marieta, Motorola, and also those of the Nordic AP Radiotelefon, Storno, Sonab and SRA. In addition to these, one of the group members had, during a trip to the United States, had discussions with the representatives of Bell Labs. The group was aware of the Japanese project operating on UHF frequencies, but had received no specific information about it.[252]

Of the systems studied, Netz-B, IMTS and HCMTS (AMPS) were classified as "promising", but none one them was considered as meeting the requirements set for a common Nordic mobile telephone service. Only the IMTS system had a long operational service career. Netz-B, a joint project of the German PTT and the Tekade company, was commissioned in 1971. HCMTS, which became known as AMPS systems, was just then being developed by Bell Lab.[253]

Netz-B system had been designed as a national service, but the subscriber search, the use of the calling channel, and the traffic capacity did not meet Nordic needs. In addition to these reasons, the price level of fixed and mobile equipment was too high and so the system was not recommended for Nordic use.[254]

IMTS was operating as local systems (city networks) in the United States, and also as a different version in Belgium, Paris and Madrid. The system had several features required by the NMT system, but its weakness was its locality. Extending this system country-wide would have required the construction of parallel groups of 16 channels, all of them with their own subscribers. It would have increased the costs of fixed equipment. Furthermore, the use of the calling

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[252] NMT Report to 1975 Teleconference; NMT # 14 (2.-4.4.1974), # 15 (2.-6.9.1974) Minutes.

[253] NMT Report to 1975 Teleconference.

[254] NMT Report to 1975 Teleconference; the Swedish and Norwegian NTAs were familiar with Netz-B project already before work of NMT Group commenced, and the Norwegian NTA went to Germany in the fall of 1969 to a demonstration of the system; see NMT # 1 and 5 Minutes.

channel did not fit in with a system of great capacity, the price of the exchanges and mobile stations was much lower than that of the NMT system, and it did not have the handover function. The only advantage in using the IMTS would have been its shorter time of delivery.[255]

There were many ways of assessing the HCTMS (AMPS) system. The use of the small-cell technology responded to the vision of the NMT Group. Even so, the system was not selected for Nordic use. There were several seasons for this. The technology implemented in HCTS was too ambitious and expensive for locating subscribers, and signaling was astonishingly fast. Both solutions raised the price of mobile stations. On the other hand, the lack of the automatic roaming feature was a serious weakness, as well as the fact that the central parts of the system were as yet untested. It is to be noted that the NMT Group did not made any reference to the feature that the HCTS systems used a frequency band not considered for common Nordic use.[256]

The NMT Group recommended the construction of the NMT system, firstly because the Nordic requirements were not met by any of the foreign systems, not even after slight modifications, and secondly because the NMT system was not thought to be more expensive than the foreign ones.[257]

At the same time with the official decision to develop NMT system, there was also a need to justify why the system had to be automatic and not manual. In the spring of 1974, an estimation of price differences between automatic and manual equipment had been obtained from five manufacturers: Storno, SRA, Sonab (AGA), AP Radiotelefon, STK and Tekade.[258] The extra cost of automatic mobile stations varied between SEK 2 100and SEK 3 300 (the average being SEK 3 000). This meant that an automatic mobile station was 30-50% more expensive than a manual station. The extra costs remained unchanged even though he number of channels were to be expanded from 80 to 120. After this, however, the expenditures increased significantly due to the requirements set for the duplex filters.[259]

The country-to-country variation in the costs of the manual exchanges varied within the range of SEK 1.5 - 2.5 million. The cost of an automatic exchange was estimated to be SEK 2.5 million, but about half of it consisted of development and programming expenditures, and therefore the effect on the costs of the increase in traffic was insignificant.[260]

Although the manual system was cheaper in the short run and with relatively a small number of subscribers, the NMT Group recommended the development of an automatic system. It was estimated that wages would increase much faster than the cost of electronics. This would lead to a situation

255 NMT Report to 1975 Teleconference.
256 NMT Report to 1975 Teleconference.
257 NMT Report to 1975 Teleconference.
258 NMT Min of "Little Group" Meeting 20-21.5.1974 Oslo.
259 NMT Report to 1975 Teleconference.
260 NMT Report to 1975 Teleconference; Mölleryd 1996; Mölleryd 1999.

in which the mere manual system salaries would be 40% of total annual costs of the automatic system.[261]

The ownership of mobile stations was an issue that had hitherto been left undecided. The practices in the member countries varied. Denmark and Norway had adopted subscriber ownership in the 1960s, and Finland followed suit in 1971. On the other hand, the Swedes had presumed that the operator would own the terminals of both MTD (manual) and MTC (NMT) systems. When the NMT Group submitted its report to the 1975 Teleconference, it recommended subscriber ownership. This decision would have spared the NTAs the need to invest in equipment or in sales and maintenance networks. Customer friendliness was another advantage, because there would be a larger selection of products, and repair service on visits to neighboring countries would be more easily obtained. The advantages for operator ownership were the control of the equipment maintenance and also easer standardization and modification.[262] The acuteness of the situation showed itself in the emphasis on investments, an essential issue, to be true, but in previous discussions the Norwegians had brought up the need to create a larger market and the Danes had expressed their wish for a common practice.[263]

2.2.3.1.1 Rationale for executing a system tests

The NMT group considered system tests essential for two reasons. They would verify the specifications of mobile stations, and it would thus be possible to indicate to industry that technically highly evolved parts of the system were based on proven technologies. With the help of these tests, system modifications would be possible without any great consequences. The test was intended to focus on the switching of the telephone call, whereas the internal function of the mobile telephone exchange and the testing of the interface between PSDTN and MTX was not considered necessary.

The NMT Group regarded the choice of the person responsible for the system test as being very significant. The group was insistent that control over the testing should remain with them and not be given to industry. This was justified in some significant instances:[264]

- The NMT Group had achieved knowledge that could not be passed to industry without time- consuming definitions of specifications for the task
- Companies organizing tests would gain competitive advantages, and this would not have a beneficial impact on the project
- The project carried out by industry should be guaranteed opportunities for further complementary studies

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261 The total costs of an automatic system included terminal costs for 5 000 subscribers. Actually, for operators, the automatic system was considered cheaper than the manual system, the NMT Group having recommended subscriber ownership.

262 NMT Report to 1975 teleconference.

263 NMT # 14 Minutes (2.-4.4.1974).

264 NMT Report to 1975 Teleconference.

- A system test carried out under the supervision of the NMT Group would enable full openness for all interested manufacturers

According to the NMT Group, the Swedish NTA would have the best preconditions for doing the test within a reasonable period of time, because it had had similar experiences with the MTD tests and because it had a radio laboratory. Because the system test was given to one NTA, a detailed time schedule was made so that the other NTAs could monitor the phases that were of interest to them in order to achieve the competence to implement their own system.

The NMT Group thought it necessary for all NTAs to be able to select their own representatives for the system tests in order to able to define the phases of the tests that could be easily separated from the whole and that could be realized elsewhere. It was suggested that the expenditure should be divided between the administrations and that they should decide about the principles of splitting costs.[265]

2.2.3.1.2 Time schedule

Before the 1975 Teleconference, the task of the NMT Group was to define the prerequisites of the system, thus initially it had no other time schedule than the presupposition that the development of the system would take approximately 10 years. It was not until the 1973 Teleconference that a rough schedule was provided, indicating the following:[266]

- The description of the functions and work for the principles of numbering and directing should be made the beginning of 1973
- The questions regarding the structure of the network and the size of the base station area should be solved during 1973
- Defining the interface between the base station and the mobile station after completion of the signaling study in the fall of 1973
- Defining the specifications for the interface between BS-PSTN, requirements for the mobile station and the accessories for connection to network can be made only after the system solution is clear (not until 1974)
- Before the final specifications, a test system should be built in which the principles of system technology could be verified and this could take place between 1975 and 1977
- The system could be operational between 1977 and 1979

Before the 1975 Teleconference, the NMT Group had not hurried itself. In 1974, only two regular meetings and one "small group" meeting were held. By the 1975 Teleconference, the issues still open had been broadly defined. Then the NMT Group received authority to begin to implement its plan, and the

265 NMT Report to 1975 Teleconference.

266 NMT Report to 1973 Teleconference; NMT # 11 Minutes (5.-7.12.1972).

group had to outline a detailed time schedule for the phases of the work. According to the group, the most essential of these were:[267]

- The work for the system test to begin in August 1975 and to be finished by 1977-1978
- At that point there should be national decisions about the implementation of NMT
- By the summer of 1977 activities connected to the final system should begin
- The ordering of MTX in March 1977
- The system in operational condition at the beginning of 1981

As already foreseen by the report to the 1975 Teleconference, the development of MTX took more time than that of the other parts. After the conference, a meeting was held in September 1975 with several equipment manufacturers criticizing the MTX time schedule. Tekade claimed that it was "horrible", and LM Ericsson considered the minimum delivery time to be three years. However, there were also contradictory views, because STK, which previously had not developed MTX, estimated the development to take only 15-20 months instead of the previous prognosis of 18 months. The estimates made by the manufactures were directly reflected in the NMT time schedule, and the arrangements for acquiring the MTXs were brought forward to late 1976 instead of the summer of 1977. Because of this alteration, administrations, too, had to start thinking about issues related to budgeting and procurement.[268]

The extension of the MTX delivery time to a minimum of three years, combined with purchase procedures and system tests, meant that the implementation of NMT would be delayed more that the administrations considered acceptable. Thus the NMT Group prepared suitable methods for minimizing the implementation delay:[269]

- NMT Group to send continuous information about the work concerning specifications to selected manufacturers, showing their willingness to supply MTX.
- In July 1976, tender bids for MTX based on preliminary specifications to be sent to manufacturers, responses being required before September.
- The received information should give a rough view of the prices of exchanges concerning their sizes and number and the delivery times. The companies would have the opportunity to comment on the specifications and to suggest changes to them. The material is discussed with the companies, being used in the final documentation.
- At the beginning of 1977, each administration should send their tender bids. There should be as much as possible co-ordination on the Nordic level. The number of manufacturers can be restricted by an elimination round, responses to tender bids being limited to three months.

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267 NMT Report to 1975 Teleconference.
268 NMT # 17 Minutes (8.-12.9.1975), see also # 15 (2.-6.9.1974); NMT Report II-IX/1975.
269 NMT Rep X/1975-III/1976.

- Processing of the bids should be so coordinated on the Nordic level that each of the administrations can leave its order by mid-1977, with the requirement that the delivery time should not exceed 3 years.
- By the time the orders were made, the system test and documentation would probably not be completed, therefore the contracts should be made in a way to allow for modification of the system.
- The system will be operational by the start of 1981 after delivery, installation and test run.

Yet, even though it was obvious that the delivery of MTX would take longer than had expected, the NTAs considered in late 1976 that they wanted to have the NMT system operational in 1980. The only exception was the Finnish NTA, which was ready to postpone the opening of the network to the following year.[270]

2.2.3.2 Defining of system to enable purchase

2.2.3.2.1 Frequency planning and capacity estimates

After the 1975 Teleconference, three sub-groups were established under the NMT host. The Test System Group and the MTX Group were important in making the specifications, but also the Frequency Group had effects of far-reaching implications.

In May 1975 the Frequency Group was gathered together for the first time. Its intention was to outline frequency plans that would be ready by the same time of the following year. For the 1975 Teleconference, the NMT Group had already recommended the adding of 0,5 MHz (20 channels) to the band, which implied that NMT would, after the closing of the manual MTD system, have 180 channels. According to the original plans, it was intended that the reserved band be gradually taken into use. The knowledge available at the time implied that it would not be economically feasible to provide the terminals with 180 channels.[271] Attempts were being made to solve the problem with at the utmost the terminals being equipped with only 120 channels. The band would be divided into two sections, some of the terminals having 120 channels on the lower range; with more on the upper frequency range. The shared section would consist of 80 channels. The other alternative solution was the utilization of the length of 100 channels, but then the number of shared channels would have remained as few as 20.[272] The problem disappeared, when the manufacturers ultimately informed the groups that it was economically possible to provide the terminals with 180 channels.

As the criteria for the making of the frequency plan, it was required that the number of channels per base station was to be such that congestion would

270 NMT # 22 Minutes (16.-17.12.1976).
271 NMT Report to 1975 Teleconference.
272 NMT Frequency Sub-group # 1 (5.-6.5.1975), # 5 (5.-7.4.1976) Minutes, Report from # 1 and 2 meetings.

be 5 per cent at the most. During the summer of 1976, the Frequency Group had finished making the overall plan, and the Norwegians introduced a computer program that could be used in frequency planning. The program was used to make the frequency plans for the border-areas, and also for mapping the frequency plans for each of the countries.

The Frequency Group did not restrict its work only to the planning of frequency usage, because after the first meeting, it suggested a prognosis of subscriber numbers, as well as the division of traffic between the metropolitan and other parts of the country and on subscriber-based traffic. Dividing of the traffic locally was of significance for frequency planning, but it also influenced network structure. Right from the start, the Frequency Group considered it obvious that the big cities would require small-cell networks. The short-range base stations would enable the economical use of frequencies and thereby subscriber-capacity as massive as possible. The needed number of channels was first studied the area of Öresund (Copenhagen), because it was the most densely inhabited area in the Nordic countries. The studies involved various subscriber prognostications, traffic volumes, and, both small-cell and conventional sizes for the base stations. The most probable traffic was considered to be 0,01 Erlang. In this case, a capacity of 180 channels was deemed adequate only if the small-cell structure were to be used.[273] Equivalent studies were made also of the metropolitan areas in the other Nordic countries. On the basis of these studies, it was argued that the capacity of 180 channels[274] would be sufficient with conventional cell structure. According to various traffic scenarios, networks would clog up in 1992 if the traffic was not intense (0,005 E). On the other hand, with realistic resources (100 channels), the networks would be over-crowded as early as between 1983 and 1985 if the traffic was significantly heavier (0,02 E).[275]

TABLE 5 Estimation of clogging up of NMT-450 networks in the Nordic countries
Sources: NMT Frequency Sub-group, Report November 1976. Note: * = Finland 160; ** Finland 80 channels

CELL STRUCTURE	TRAFFIC DENSITY (ERLANGS)	WITH 180 (160)* CHANNELS	WITH 100 (80)** CHANNELS)
Normal	0,005	1992	1988-1992
	0,01	1991-1992	1985-1987
	0,02	1986-1988	1983-1985
Small-cell	0,01	1992	1990-1992
	0,02	1990-1992	1984-1985

The Frequency Group, however, made a hypothesis according to which Denmark, Norway and Sweden could need small-cell networks even earlier than estimated, 80 channels being reserved for the MTD-system. The subscriber-prognoses were based on the experiences obtained from the manual

273 NMT Frequency Sub-group # 6 Minutes (18-20.8.1976).
274 In Finland there would be only 160 channels available.
275 NMT Frequency Sub-group # 6; NMT Frequency Sub-group, Report November 1976.

systems, which did not apply to the automatic systems. Evidently, the negative decision of the Frequency Group, regarding the construction of small-cell networks, was affected by the view that with 180 channels and a volume of Erlang 0,01, the small-cell -network would not yield any essential advantage. This argument was, however, based on the assumption that the flow-in of the subscribers would not change significantly, and that the channels in use by the manual systems would be handed over to NMT.[276] Problems in the deployment of the NMT system were caused by (from the very beginning) the flow-in of the subscribers being more intense than was expected, and the channels reserved for the manual system not being, as yet, available for NMT use.

It is quite interesting to note that the NMT Group considered that it would be possible to use normal-sized base stations, but even in the 1978 traffic simulation utilized a mixed model of seven small cells surrounded by six normal cells.[277] The NMT Group had not made a formal decision to discard the small-cell structure altogether; and with the help of simulation information, the aim was to enable the definition of the network according to the small-cell construction. In practice, the networks were constructed on the basis of "normal cell" structure.

2.2.3.2.2 System tests

The system tests were divided into one carried out in the laboratory and one carried out in the field. An experiment was constructed for the field test to consist of an exchange controlled by a mini computer, three base stations and ten mobile stations. The experimental test network included a switch, connected to the network at subscriber level and three base stations (each of which had one calling and one traffic channel) divided between two traffic areas.[278]

The execution of the system tests was divided between the NTAs of Norway and Sweden. The acquisition of the mini computer and its programming was the responsibility of Norway. Sweden acquired the equipment excluding the computer and the carrying out of the experiment. Preparations were seen to simultaneously in both countries.[279]

The system tests began in May 1975. Norway set out the orders for bidding for the mini-computer and a Norwegian Nord 12 was chosen. The computer was delivered to the Research Institute of the Norwegian NTA (TF) by the end of the year. In addition to this, the Norwegian NTA bought itself a more efficient Nord 10 computer, which was program-compatible with the first one. Programming began at TF. The impulse logic of the exchange, the call decoder, the necessary interfaces, and the model replacing test equipment were all implemented in Stockholm. All of these were sent to TF in Norway, where the computer was being tested during winter 1975-1976. Sub-programs were

[276] NMT Frequency Sub-group Report November 1976.
[277] NMT # 32 Minutes (13.-16.6.1978); NMT Doc 304-1978.
[278] Test System Report 20.12.1977, Ö. Mäkitalo.
[279] Test System Report 20.12.1977, Ö. Mäkitalo.

tested during the spring of 1976, and the programming being finished by December of the same year when the computer and hardware were sent to the Swedish Radio laboratory.[280]

In the spring of 1976, the Swedish NTA sent tender bids for the modified 80 channel MTD terminals. Mitsubishi's Swedish agent Gadelius informed the NTA that it was able to deliver 12 terminals, provided with modified transmitting power, the required frequency and a duplex filter. During the year 1976, the Intelec 8/80 microprocessor was programmed as a logic unit. The intention was to use the Intel 8085 processor in the field test.[281]

The base stations were normal MTD units, modified by the Swedish NTA to meet the NMT requirements.[282] After the summer of 1977, calling and traffic channels, modem, transmitter equipment for evaluating the signal, and other maneuvering functions (Control Unit) and Supervisory Unit" (SU) became available.[283]

During the winter of 1977, a joint running of the MS and MTX programs started after the MTX test run . The field test took place in the summer of 1977. During the winter of 1977 there were problems with the signaling of the duplex, when the oscillator was used for both transmission and receiving. It was found impossible to separate data sent by MS and that received from BS. This had not been detected in the laboratory, because separate stations had been used for transmission and receiving. With the modification of the signaling fault, an overview was made of the signaling, and then the changes were found to be so significant that a new system specification NMT Doc1 1977 was made. The continuing of the system tests was not reasonable without updating, which was done during the summer and fall, and which delayed the tests by four months.[284]

The change of system specifications interrupted laboratory tests begun in the spring of 1977. These were re-launched in October 1977.[285] The delays were reflected in the other work, and during fall of 1977 the work of the System Test Group had to be divided in order to have the BS specifications ready by January 1978. The NMT Group was worried because the offer for the MTX expired at the end of August 1978, but while the exchange was being ordered, there had to be enough information on the test system to validate the functionality of the system. According to the labor allocation decided on, the Test Group (PS) prepared the parameters for use and maintenance as well as radio-technical details, while the MTX Group assumed responsibility for the system. The testing of the manual equipment along the lines of MS specifications was left to the administrations.[286]

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280 Test System Report 20.12.1977, Ö. Mäkitalo.
281 Test System Report 20.12.1977, Ö. Mäkitalo.
282 NMT Doc 313-1978.
283 Test System Report 20.12.1977, Ö. Mäkitalo.
284 Test System Report 20.12.1977, Ö. Mäkitalo.
285 Test System Report 20.12.1977, Ö. Mäkitalo.
286 NMT # 26 Minutes (24.-28.10.1977).

As the year 1977 drew to its close, it was noticed that traffic simulation was needed, because the mobility of subscribers and the coverage of the operating area caused peaks in traffic. The System Test Group (PS) recommended starting a simulation test, with the Norwegian company NTA expressing its willingness to arrange the test in Norske Regnecentral. The simulation test was carried out during the spring of 1978. The experiment costs were 200 000 NKr.[287]

In the summer of 1978, the field test had almost been completed. The participants tested the system by using three mobile stations and three base stations. Based on the test carried out during the summer, the NMT Group presented its report to the Nordic Radio Committee (NTR), suggesting that purchases for MTX and BS should be completed. The test system was not, however, closed down although it was considered in the fall of 1978 that the system test had fulfilled its primary task. The NMT Group recommended that the system test network should be used as much as possible.[288] Attempts were being made to persuade each administration to study proper running programs. During the fall, each of the administrations performed the actual field tests. Security regarding the transfer of digits was not sufficient when approaching the perimeter of the base stations, and dialing of numbers took too long. Because of this, specifications had to be altered and the dialing of numbers before sending (pre-seizure dialing) had to be tested. It was planned that these be done by the spring of 1979 and the rest of the alterations by the fall of the same year. Even after this, it was intended that the system could be used so that the manufacturers could utilize it in testing mobile stations.[289]

2.2.3.2.3 MTX specifications and procurement

LM Ericssons's AXE exchange was selected as the MTX in all Nordic countries. From a retrospective point of view it would be tempting to classify this decision as a tool of industrial policy, especially since the Swedish NTA developed AXE in conjunction with Ericsson, and its reception was as good as that of a mobile telephone exchange. This was, however, merely a pragmatic choice, and it was not the Swedish administration that was the most eager spokesman for Ericsson.

As early as in September 1972, the NMT Group made a summary of the types of exchanges, which were to be used on the fixed network in the 1980s. This was a pragmatic approach, because, at the time, it was thought possible to use both separate MTXs and exchanges integrated with PSTN in the NMT system.[290] Every member country intended to obtain LM Ericsson's AKE (SPC) exchanges for their fixed networks. The AKE exchange also became the

287 NMT Report X/1977-II/1978 and III-X/1978; NMT # 29 (20.-24.2.1978), # 30 (4.-6.4.1978), # 32 (13.-16.6.1978) Minutes; NMT Doc 313-1978.
288 NMT # 32 Minutes (13.-16.6.1978); NMT report III—X/1978.
289 Toivola 1992; NMT # 33 Minutes (24.8.1978); NMT Report X/1978-III/1979 and IV-X/1979.
290 NMT Report to 1973 Teleconference.

strongest candidate for MTX, but it was by no means the only alternative. After the 1973 Teleconference, the Nordic NTAs started to investigate the suitability of the exchanges for MTX use. The Danish were in touch with LM Ericsson (AKE-13 exchange), the Norwegians with STK (11B and 11C exchanges), the Finns with LM Ericsson (ARM exchange), and the Swedes with Teli (the manufacturing arm of the Swedish NTA).[291] The Swedish alternative differed from the rest in that its aim was to use a combination of Teli's A-205 exchange and mini computer (separate MTX instead of integrated PSTN). As long ago as in early 1975, Denmark made it clear that it wanted the "LM Ericsson solution" (AKE switch), unless there was a cheaper option. The Norwegians would have preferred to use AKE in the regions of Oslo and Östland, but separate MTXs for the sparsely inhabited parts of the country. Sweden was clearly in favor of separate exchanges, but Finland expressed no opinion on the subject.[292]

Although the NMT Group was dealing with the MTX issue, it was only having discussions, and it did not decide on any particular on some certain alternative.[293] This was strikingly different compared to the Nordic Data Network Group, in which all four NTAs had started cooperation related to use of AKE exchange even before the 1973 telecommunication conference.[294] The discussion within the NMT Group continued on a rather general level. During the fall of 1975, Denmark still regarded Ericsson as 'the natural choice', but the Norwegians thought that the purchase should be made without any references to nationality. However, even the Norwegians admitted that Ericsson or some other Nordic manufacturer would be a "good solution". The NMT Group was not about to commit itself to any certain exchange supplier because at least Tekade and STK expressed their interest in the discussions for the exchanges also.[295]

In September 1975, it was decided to make a rough draft for MTX specifications to be ready by May 1976. By this means, the number of potential partners could be limited to find those with the capacity to meet the demands. The specifications were sent in June to nearly twenty potential suppliers and they were asked to give their preliminary offers by October 15, 1976. At the beginning of May, a sub-group had prepared for the purchase and made a preliminary list containing the possible suppliers. The companies which were on the list were as follows: LM Ericsson, Sonab (Sweden); STK, EB (Norway); Storno (Denmark); Philips (Netherlands); Martin Marietta, Motorola, GE (United States); Nokia, Televa (Finland); Mitsubishi, Fujitsu, Hitachi (Japan); and Hasler (Switzerland) [296] The suppliers were given the opportunity of discussing the system and clearing up their misunderstandings in bi-lateral negotiations, which were held in August. Nokia, Televa, NEC, Marietta, Motorola, Ericsson, Mitsubishi, Siemens, Tekade and Hitachi attended these

291 NMT # 12 (8.-10.5.1973) and 13 (25.-27.9.1973) Minutes.
292 NMT Ad hoc Minutes (14.-16.1.1975).
293 Thomas Haug's interview.
294 Minutes of the 1973 Telecommunications conference (5.6.1973).
295 NMT # 17 Minutes (8.-12.9.1975).
296 NMT Report X/1975-III/1976 and IV-IX/1976; NMT "Little group" Minutes, Oslo (4.5.1976)

negotiations. Eight preliminary offers were submitted by the given expiry date.[297]

When these preliminary offers for MTX had been evaluated, it became evident that the smallest alternative for the exchange (1 000 - 7 000 subscribers) would be uneconomic. Other size categories (5 000 - 20 000 and 10 000 - 20 000) turned out to be economically more attractive. The prices of the exchanges varied considerably: between SEK 900 - 2 440 /subscriber for exchanges of 5 000 subscriber switches; SEK 540 - 900 /subscriber for exchanges with a capacity of 2 000, and SEK 450 - 730 /subscriber in exchanges with a capacity of 50 000. Norway had estimated that it would need at first one or two, Sweden two, Finland three to five, and Denmark one exchange depending on the capacity of the chosen exchanges.[298] In addition, it was proposed that during the years 1975-1990 Norway would need five, Sweden five, Finland six, and Denmark one exchange more. The price offers exceeded the expectations;[299] and thus the number of ordered exchanges diminished significantly, and this had a direct bearing on network structure.

Because the amount of received orders was considered to be high, and the variation in their quality wide, the MTX Group deemed it unnecessary to deal with all the given eight offers, and proposed that the administrations should limit their further evaluation to the four most favorable offers. The choice was perhaps easy to make, because one of the offers was considered as “not serious” (giving only the largest capacity alternative) and with three offers the delivery time exceeded the set limits of a three-year maximum. In practical terms, also controversial features were seen in the selection.[300] Tensions were thought to occur inside administrations in deciding which companies should belong to the group of four that would be asked to give their final offer for MTX.[301] This had already been given, by way of an example, within the parent NMT Group, because Norway and Finland supported restricting the number of potential MTX suppliers to four, whereas Denmark wanted to sent the bids to all eight manufacturers, and even to a larger group.[302]

The NTAs ultimately chose the final potential exchange suppliers, but “in some cases”[303] tender invitations were sent to wider group than the selected four candidates. The selected group consisted of five manufacturers instead of four, and included Ericsson, Motorola, NEC, C. Itoh, and Telefenno[304] (a joint venture of Televa and Nokia). Each administration sent out their tender

297 It is uncertain whether Nokia actually participated, at least NMT Group did not nominate a counterpart for Nokia; NMT “Little group” Minutes, Copenhagen (23.-27.8.1976).
298 NMT Report XI/1976-II/1977.
299 In Swedish MTD system the cost for an exchange was 500-600 Skr/subscriber
300 NMT # 21 Minutes (25.-29.10.1976).
301 The NMT Group was worrying about “what to say to manufacturers who would not get a tender invitation”. It was of the opinion that it had chosen a group of manufacturers, which it trusted the most; see NMT # 22 Minutes (16.-17.12.1976).
302 NMT # 22 Minutes (16.-17.12.1976).
303 Most likely this referred to the Danes, who did not like the idea of restricting the number of potential suppliers.
304 TN Norwegian NTA Styrmote 24 August 1978 Dok 126/78.

invitations on September 1, 1977, requiring the responses by December 1. By that date, only Ericsson, Motorola and NEC had submitted their bids.[305]

Although the procurement of MTX was, in principle, a matter for the administrations, it was considered suitable to have co-ordination and discussion concerning the further evaluation of the final offers. For the December meeting of the NMT Group, each was entitled to make a preliminary technical assessment of the offers. This commercial assessment was, already in advance, considered to be a difficult task, and due to this reason a special sub-group was established for the task. The NMT Group wanted to keep the sub-group within the range of its organization. This group had to turn to the administrations because of the confusion about the degree of coordination. These purchasing experts formed the MTXA Sub-group, which at first acted as an "unofficial committee", until the NTR confirmed its mandate in February 1978. The task of the group was to co-ordinate the evaluation of offers that was performed by NTAs.[306]

Because of the emergence of MTXA Group, the name of the old MTX Group was changed to MTXT. Its function was to make technical assessments. During the procurement phase, the MTXT Group was separated from the bidders and negotiations with manufacturers going through the apparatus of the commercial MTXA Group.[307]

Progress in both commercial and the technical evaluations was much slower than had been expected, and at the same time, the risk of delays in delivery was noted. Even before the end of 1977, a rough assessment had shown that there were shortcomings in Ericsson's offer, some of which were significant. Also Motorola's offer was deemed as to be incomplete, while that of NEC had only "some minor weaknesses".[308]

The MTXT Group had prepared a list of questions, because of uncertainties in the manufacturers' bids , this list being sent to the MTXA Group to proceed with the manufacturers.[309] Suddenly in April 1978, it was decided to start negotiations with Ericsson, because its offer had been left open in several issues, while it had, as regards technical assessment, received the highest score in each country. The commercial assessment was still unfinished and reliability assessment had only been started. Negotiations were not, however, considered to mean a commitment to this particular manufacturer.[310] In May 1978, a reliability assessment was finished in which NEC was found to be more reliable than Ericsson, but this did not alter the situation.[311]

The negotiations with Ericsson continued. In the first place, the negotiations had to be launched, probably because the assessment of the offers

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305 NMT # 26 Draft Minutes (24.-28.10.1977).
306 NMT # 26 Minutes (24.-28.10.1977); NMT Report X/1977-II/1978; NTR extra meeting (23.2.1978)
307 NMT # 27 Minutes (12.-15.12.1977).
308 NMT # 26 Draft Minutes (24.-28.10.1977); the NEC switch was an analog, computer-controlled electro-mechanical switch while the others were digital.
309 NMT # 29 Minutes (20.-24.2.1978).
310 NMT # 30 Minutes (4.-6.4.1978).
311 NMT # 31 Minutes (8.-11.15.1978).

was already delayed. However, it was not until September 1, 1978, that the NTAs could propose changes to the hardware of the exchange while proposed changes to software were delayed until the end of November. The system test was also delayed, and information from it was needed before making the decision to purchase. Furthermore, in May, the NMT Group decided to start negotiations related to additional and supplementary MTX specifications, even though the MTXT Group recommended waited until the supplier had been chosen.[312] By spring, Ericsson was already suggesting deviations from the NMT specifications, the most important of these being the automatic power control of mobile stations and the use of the standard CCITT modem instead of a specific NMT modem. Ericsson suggested that the power control of mobile station should be made by the base station, but this was held to be more expensive. Neither was changing the modem accepted.

As of the spring of 1978, estimates were made of the costs resulting from delays, and the wishes of the companies regarding the implementation of MTX were charted. According to the view expressed by the Swedish NTA, a delay of one year in the implementation of NMT would cause extra costs amounting to SEK 16 million[313], whereas in the case of Finland the coresponding figure would be FIM 5.6 million, and in Norway NOK 21.7 million.[314] All the companies wanted the first exchange to be in use by March 1 1981, but they were also satisfied with activities beginning on July 1, and they were even prepared to accept September 1 as the last starting point. All administrations desired a minimum time difference between the countries regarding the launching of the NMT system, and they expressed their solidarity in ensuring Nordic implementation, which, they felt, should take place as quickly as possible. Only three months later, in August 1978, it was revealed in the negotiations with Ericsson that the first exchange for Sweden would be delivered on May 1 1981, for Norway on July 1, for Denmark on September 1, and for Finland on November 1. The second exchange for Sweden and Norway would be delivered on March 1 1982 and roaming on June 1 1982.[315]

In August 1978, the NTR recommended that the companies should make a contract to buy MTX. The representatives of Denmark, Sweden and Norway in NTR thought that the contract should be made with Ericsson and that a letter of intent should be formulated before the expiry date. These NTAs signed a contract with Ericsson.[316] The Finnish administration did not consider itself to be in a position to make a contract in principle, because of the high price of the MTX.[317] It asked for supplementary offers from Ericsson and NEC.[318]

In the fall of 1978, project groups were formed in each of the countries. It was the wish of the NMT Group that their task be defined in a manner ensuring

312 NMT # 31 Minutes (8.-11.15.1978).
313 NMT # 32 Minutes (13.-16.6.1978).
314 NMT # 31 Minutes (8.-11.15.1978).
315 NMT # 31 Minutes (8.-11.15.1978).
316 NTR 14-10 Extra meeting (22.8.1978)
317 NMT # 33 Minutes 24.8.1978).
318 Toivola 1992.

good contacts with the MTX Group. The concern was justified, because national project groups had organized jointly-implemented type tests for MTX in Ericsson's plant without giving any information on it to the NMT Group. [319]

Even as late as in 1979, the NMT Group negotiated with Ericsson on the possibility of making changes to MTX specifications, but Ericsson did not accept the proposed changes unless the fines were postponed.[320]

2.2.3.2.4 MS specifications and type approval

The System Test Group made preliminary MS specifications during the fall of 1976. The administrations then outlined a list of manufacturers, to whom the specifications were sent at the end of October.[321] Feedback information from manufacturers was expected by the beginning of January, and a meeting was held in Stockholm in January 1977. Present at the meeting were mostly the manufacturers, who had been participated in joint ventures by 1974 or 1975 including Motorola, Sonab, AP Radiotelefon, SRA, Storno, Martin Marietta, and the newcomers Televa, Matsushita (Panasonic), Simonsen Elektro A/S, Salora, Mitsubishi, and NEC.[322] The manufacturers expressed "many valuable view points", showing great interest in NMT, without, however, proposing any fundamental changes. The second version of the MS specifications was completed during the summer of 1978, and the "final version" in late 1979, but modifications were made even after this. [323]

In the fall of 1978, the NTR had expressed its view that deviations from the CEPT recommendations (TR-17), while making specifications for MS, should be thoroughly justified. The Norwegian NTA had tested the MS specifications with the help of three manual UHF terminals, and a committee of experts had evaluated the results. According to them, the MS-specifications were not below the recommended CEPT norms.[324]

In fall 1978, the System Test Group suggested that the terminals should be equipped with 180 channels, if this could be done without significant extra costs. This requirement did not apply to duplex filters, in which the technology did not enable such a number of channels. The belief was that it could be easier to meet the requirement by merely changing the duplex filter.[325] Relying on the feedback from the manufacturers, the adding of a synthesizer to the equipment was considered reasonably economic, but changing the duplex-filters was problematic, because they were usually integrated with the system. [326] In January 1979, the Danes made contacts with equipment manufacturers Storno, AB Radiotelefon, Interphone, and Motorola as to whether it would be possible

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319 NR # 5 Minutes (29.2.1980); NR-5-3.
320 NMT Report IV-IX/1979.
321 NMT # 21 Minutes (25.-29.10.1975).
322 NMT ad hoc Minutes (17-21.1.1977).
323 NMT Report XI/1976-II/1977 and IV-IX/1979.
324 NMT # 26 Minutes (24.-28.10.1977).
325 NMT # 26 Minutes (24.-28.10.1977).
326 NMT # 27 Minutes (12.-15.12.1977).

to provide terminals with 180 channels as early as 1981. All of them confirmed this.[327]

In 1971, the Danes stated that they would prohibit portable terminals,[328] but the NMT Group did not make a joint common statement. In the spring of 1978, the NMT Group decided that the same specifications would apply to portable terminals as to the other kinds of mobile stations. The only exceptions were duplex filters and power-level. It was considered that the duplex problem could be resolved through a lowering of the requirements for the duplex filter, if it were used as an instrument in the signaling procedure. It did not, however, simplify the structure of the duplex. This could only have been remedied by lowering the transmission power. For this reason, it was decided that the portable terminals would have to meet the same requirements as the other kind of terminals.[329] Because simplex was used only when speaking, it did not cause a significant difference in toning-down compared to duplex; hence, in the spring of 1978, it was decided to removed the simplex feature from the entire system.[330]

At this point of time, also the issue of "draggable" stations was a focus of attention. Because it was not a realistic expectation that the customer would lower the transmission power, after stepping out of his auto, a decision was made to study the impact of power decrease by one level on channel interference. According to a study made by the Norwegian NTA, nothing of special importance occurred, the interference, even with the mobiles, being of extremely small significance.[331]

In addition to questions of a fundamental nature, the NMT Group had to tackle less important but, nevertheless, complicated problems. One of these was the debate in 1977-1978 regarding the location of the push-buttons and the number of push-buttons used.[332] Another irritating issue was related to the combined MTD-NMT terminals. Initially, the idea had emerged from the industry, but at the time it was not possible in practice.[333] By the end of the 1970s, it resurfaced. No other country showed interest in it, except Sweden, and even there it would not have been usable for more than a short period of time. In the NR Committee (formerly NTR), the Finns criticized the proposition harshly, claiming that it violated the principle of unity, exhibited protectionism, and was just an attempt by LM Ericsson to protect itself from the danger of being fined for delays.[334] Other manufacturers were not very enthusiastic about manufacturing combined MTD-NMT terminals, because it would have increased the cost of the terminal. At first, only SRA and Sonab would have

327 NMT # 28 Minutes (23.-27.1.1978)
328 NMT # 4 (5.-7.10.1970); NMT report to 1971 Teleconference.
329 NMT # 29 (20.-24.2.1978), # 30 (4.-6.4.1978) Minutes.
330 NMT # 31 Minutes (8.-11.5.1978).
331 NMT # 30 (4.-6.4.1978), # 31 (8.-11.5.1978) Minutes.
332 Myhre 1999; Hans Myhre's interview; Matti Makkonen's interview; e.g. NMT # 30 (4.-6.4.1978), # 31 (8.-11.5.1978) Minutes.
333 Thomas Haug's interview.
334 SA RD NR # 2 Draft Minutes (10.-11.12.1979), later this criticism was removed from the final version of the minutes.

been willing to start manufacturing it. Later, also Mobira announced that it was capable of manufacturing this equipment. Finally, the Swedish NTA decided, at the end of 1980, not to accept combined MTD-NMT terminals at all.[335]

By the end of 1978, attempts were made to avoid having to make changes soon after the implementation of the system. The NMT Group tried to persuade the manufacturers to recall the terminals and to make the necessary changes. Most of the manufacturers rejected this proposal outright (SRA, Storno, Sonab, NEC). Some of them would have agreed to the proposition, but with reservations. (AP Radiotelefon, Siemens, Mitsubishi). Most positively inclined were Simonsen, Motorola and Mobira. Due to rises in expenditure, the NMT Group was forced to cancel this plan.[336]

During 1975, the use of identical specifications was found to be possible in all of the countries, a move that simplified type approval. Approval in one country applied also to all the others.[337] At the end of 1977, the Frequency Group made a suggestion about the methods of type approval, also including maintenance and repair requirements. To even out the costs, the type approval for the terminals of different manufacturers was divided between the administrations in such a way that the products of a particular manufacturer were approved within one administration. In principle, a piece of equipment with its own type approval would only be accepted "on paper" in the other Nordic countries.[338] In practice, the administrations had suspicious attitudes towards each other during the early years, which meant that having an approval from the other countries was not merely a formality.[339]

The technical execution of the type approval was made possible by the use of a system simulator. Preliminary studies for the making of an adequate simulator were commissioned in 1979 from Storno, SRA, and Helsinki University of Technology (HUT). When the process slowed down, the Finnish Radio Department of the NTA placed an order for development work with HUT and it purchased the device for itself. While the other Nordic countries had difficulties acquiring simulators, the Radio Department organized cooperation between HUT and a company named Automaatiotoimisto Hakala, in order to facilitate export deliveries. The bidding competition involving Denmark, Norway and Sweden was won by Hakala. As a result, system simulators were delivered to the administrations as well as to some manufacturers including Storno, Motorola and Mobira. The purchase of a simulator reserved an option for Motorola to deliver an NMT system to Austria.[340]

The Frequency Group also planned the procedures for altering the specifications. These procedures were considered to be time-consuming, because experience showed that specifications were studied in a slightly

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335 NR # 4 Minutes (28.1.1980), # 6 Minutes (22.-23.9.1980).
336 NMT # 33 Minutes (24.8.1978); NMT Report X/1978-III/1979.
337 NMT Report II-IX/1975.
338 NMT # 27 Minutes (12.-15.12.1977); NMT Report III-X/1978.
339 Hans Myhre's interview.
340 Toivola 1992; Keijo Toivola's interview.

different way in different countries, and therefore coordination was deemed essential.

As late as in the summer of 1981, no terminal had yet been type-approved, but by October the number approved was six. The first terminals were approved with dispensers included.

2.2.3.2.5 BS specifications

Work on preliminary specifications for base stations (BS) commenced in the fall of 1976. It was planned to send them to manufacturers in April 1977, and feedback was expected by June of the same year.[341] Evidently the schedule did not hold, because the meetings with the manufacturers did not take place earlier than at the end of August and early September 1977. These meetings yielded "valuable information", but they made no decisions that would have caused any fundamental changes. The final specifications were expected to be ready by the beginning of 1978.[342]

The preliminary BS specifications were worked on jointly with the experts of the administrations, who had, initially been involved in drawing up of the specifications. The System Test Group suggested that single-channeled base stations would have to be eliminated from the specifications, thus omitting the need for storing a great number of crystals, and that MTX would control the selection of frequency for the BSs. The negotiations with the industry revealed that it was possible, both economically and technically, to equip the base stations with 180-channel synthesizers, which would yield advantages in equipment and maintenance.[343] The NMT Group decided to accept the proposition, at the end of October of 1978, and to prepare the final specifications for the January meeting, in order to have the specifications approved by the NTR. Evidently, for a while, the decision seemed a little hasty, since many of the manufacturers considered that the goal was unattainable within the schedule laid down by the NMT Group. The NMT Group regarded it as a risk to set requirements to which only one manufacturer responded, and a decision was made to demand the 180-channel base stations on the proviso that several of the manufacturers would be able to manufacture them.[344] However, the set requirement soon proved to be realistic, the specifications and the bidding material being approved at a telephone conference of the NTR on February 23, 1978, and in March the invitations for bids were sent to the manufacturers. Prior to this, the Finns had prepared requirements for the reliability and maintenance of the base stations. Even though the administrations launched the calls for bids, it was vital, simply for securing

341 NMT # 23 Minutes; NMT Report XI/1976-II/1977.
342 NMT # 26 Minutes (24-28.10.1977).
343 NMT # 26 Minutes . (24-28.10.1977).
344 NMT # 26 Minutes.

reliability, to arrange some coordination between the administrations, and the NMT Group was considered suitable for the task.[345]

Also, in the matter of acquiring of the base stations, the NMT Group was willing to adopt, along with coordinating, the role of controller. Even before the deadline for the bids had been reached, there had been, during the month of May, discussions on preparing for the possibility of an equipment manufacturer not meeting all the given requirements. Controlling the supplier was recommended; also securing the supply of sub-contractors, and the requirement of a production plan. It was further recommended that the base stations be bought from more than one manufacturer, if at all possible.[346]

By the deadline of the bidding competition on June 30, 1978, the administrations received 8 bids[347]. In addition to this, the Motorola bid was five weeks late in coming. Consequently, it was not accepted. The offers made came from the following manufacturers:[348]

- Salora-Nokia consortium (Finland)
- Magnetic (Sweden)
- Mitsubishi (Japan)
- Magnetic-Televa (Sweden-Finland)
- NEC (Japan)
- C. Itoh & Co Ltd (Japan)
- Tadiran (Israel)
- TeKaDe (FRG)
- Radiosystem (Sweden)

Of these, Magnetic submitted two bids which, however, were identical. One was made in cooperation with Televa, and directed to the Finnish market. It is striking how little interest was shown by Nordic manufacturers in the matter of supplying base stations. Japanese manufacturers, on the other hand, showed great interest in supplying base stations. Basically, all the offers were acceptable, but Radiosystem was able to supply only the channel equipment and antenna units.

At the end of the August, it was reported to the NMT Group that four of the bids had been selected for further consideration and that the technical evaluation was about to be completed, but the economic evaluation was to be started with. Again, it was the wish of the NMT Group that NTA enter into a contract with one manufacturer only.[349] Although the final candidates had been selected before the economic evaluation had been completed, the price level affected the decision of the ones to be singled out for further consideration, because the rejected ones were also the most expensive.[350] Those selected were initially Magnetic, Mitsubishi and NEC, but, on the Finnish initiative, also

345 NMT # 29, 30 Minutes; NMT Report X/1977-II/1978.
346 NMT # 31 Minutes (8.-11.5.1978).
347 NMT Report III-X/1978.
348 SA RD Memo Base station bids, M. Makkonen 21.11.1978.
349 NMT # 32 Minutes (13.-16.6.1978).
350 SA RD Memo Base station bids, M. Makkonen 21.11.1978; SA RD Memo Base station bids, M. Makkonen, K. Merontausta 4.12.1978.

Salora-Nokia and Radiosystem were included. According to the recommendations, orders for manufacturing were to be divided among them.[351] Sweden, Norway and Denmark came to an agreement with Magnetic, NEC and Mitsubishi; the finally contracts being made with Mitsubishi and Magnetic, which had already supplied the base stations for the MTD network. The order was divided in half, with the added proviso that Radiosystem manufacture the combiners for Mitsubishi's base stations.[352] In Finland, it was considered that the best alternative was for Salora-Nokia to supply the majority of the base stations and for Radiosystem to be responsible for their antenna combiners. NEC, which at that point was regarded as the most promising supplier of MTX, would have manufactured those of the base stations not requiring equipment for antenna combiners. Subsequently, after NEC had lost its opportunity as exchange supplier, it was decided to acquire all base stations from the Salora-Nokia consortium and the antenna combiners from Radiosystem.[353]

There were problems of standardization related to the bids for base stations, because the construction of the Japanese base stations did not meet the NMT requirements. Therefore, Radiosystem combiners were used in Mitsubishi base stations. In Finland, the physical depth of the containers of the base stations differed from that in the other Nordic countries, for which reason the placement of equipment was also different. This set different requirements for Finnish base stations, being one essential reason why most bids, including those of Swedish manufacturers, were ruled out.[354]

2.2.4 Implementation and further development

2.2.4.1 Construction of networks

The construction of an automatic cellular mobile telephone system as a country-wide service required heavy investments in Sweden, Norway and Finland. In terms of land area, these countries are the 3rd, 4th and 5th largest countries in Western Europe. Also, the population requirements for national services were good because these countries had small populations compared to other European countries, and they were also the most sparsely inhabited countries in the whole of Western Europe. On these criteria, Denmark differs from the other Nordic countries in the respect that it is a small land area but its density of population is of the level of the rest of Europe. In all the Nordic countries, the topography set special requirements for the construction of the base station network.

Factors related to demographics or topography were not the driving force behind the success of the NMT system. In the Nordic countries, the manual

351 SA RD Memo Base station bids, M. Makkonen 21.11.1978.
352 Mölleryd 1996; McKelvey et al 1997.
353 SA RD RD to PD 4.12.1978.
354 SA RD Memo Base station bids, M. Makkonen 21.11.1978; SA RD Memo Base station bids, M. Makkonen, K. Merontausta 4.12.1978.

networks had attracted a large number of subscribers and had given the operators much needed experience in handling great numbers of subscribers and in operating as well as maintaining a large network. Even in the mid-1960s, the Nordic countries did not differ from Western European countries as far as the popularity of land mobile telephone services was concerned. By the end of the 1970s, the situation had seen a drastic change, because the public networks of the Nordic countries had already 57 000 subscribers at the end of 1978 (see TABLE 6). It was most probably more than the total for the rest of Europe.

Manual networks affected the use of the NMT network in at least three ways. Firstly, the rise in the expenditure of the manual networks influenced the time schedule of the decision to construct the NMT networks, but it had no obvious effect on the rate at which the networks were built. Even before the MTXs were ordered, it had been noticed in Denmark that the capacity of the manual networks would be exhausted. This did not give even a theoretical opportunity to consider postponing the opening of the NMT network. However, when the orders for the MTXs were made, Denmark settled for a schedule that would not have it receive its exchange before the delivery of the first ones to Sweden and Norway. In the other countries, delay in opening the NMT network was estimated to have impact on expenditures only.[355] In Finland, at least, business with the manual ARP network proved to be increasingly unprofitable by the end of the 1970s, this trend, however, was corrected through pricing and rationalizing, while not affecting the speed with which the NMT network was built.[356] Secondly, in Denmark, Norway and Sweden, the manual MTD system, which had been intended as an interim solution with 80 channels, had to be later shifted to the NMT system. Before the closing of the MTD, the NMT in these countries had only 120 channels, a fact severely restricting its capacity. The Finnish NMT had 160 channels because the MTD system had not been used at all.[357] Thirdly, the subscribers for MTD networks were to be directed to NMT by 1987 when the former networks were closed. There were no such pressures in Finland, and it was not until after 1986 that the success enjoyed by the ARP system started to decline[358]

The success of the NMT system exceeded all expectations. Initially it had been planned that the system's capacity would be sufficient for the 1990s, but in Denmark, Norway and Sweden the maximum capacity that had been estimated as final had already been reached by 1986, while in Finland this capacity was reached in 1987. The rate of increase in the number of subscribers was more rapid than was expected. For example, in Denmark the number of subscribers exceeded the capacity reserved for the system's fixed parts by as early as the end of 1981, this capacity being double the estimated number of subscribers. In Norway and in Sweden, the number of subscribers exceeded the estimated volume of subscribers by as early as 1981, and rose to exceed the system's maximum capacity in 1982. In Finland, the flow-in was slower than in the other

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355 NMT # 31 (8.-.11.5.1978), # 32 (13.-16.6.1878), # 33 (24.8.1978) Minutes.
356 SA RD ARP Documents.
357 See p.
358 Interview of Matti Makkonen; Televiestintätilasto.

Nordic countries. It was not until 1984 that the rate of subscribers surpassed the estimate, also surpassing the maximum capacity the following year (see Figure 6 to 8).

Pricing controlled subscriber flow-in. In Finland at least, the NTA was effectively slowing down the stream of subscribers from ARP to NMT because the monthly NMT fee was three times higher.[359] The connection (access) fee was the same in both systems. In Norway, no connection fee was charged at all, the monthly fee for the manual and NMT service being exactly the same. The pricing structure was based on different approaches. In Norway and Finland, the threshold to NMT was kept low, whereas in Denmark as well as in Norway the monthly fee, too, was kept low. In these countries, the actual calling fees did not much differ from each other, but it was only in Finland that there was an attempt made to control the traffic in peak hours with the help of pricing.[360]

TABLE 6 Subscribers in manual networks and years of maximum capacity in Nordic countries
Explanations: NO = Capacity not used up; NI = System not implemented at all
Sources: GSM doc 18/83; ULA F4c-23 Swedish Telecommunication Administration 1.9.1983

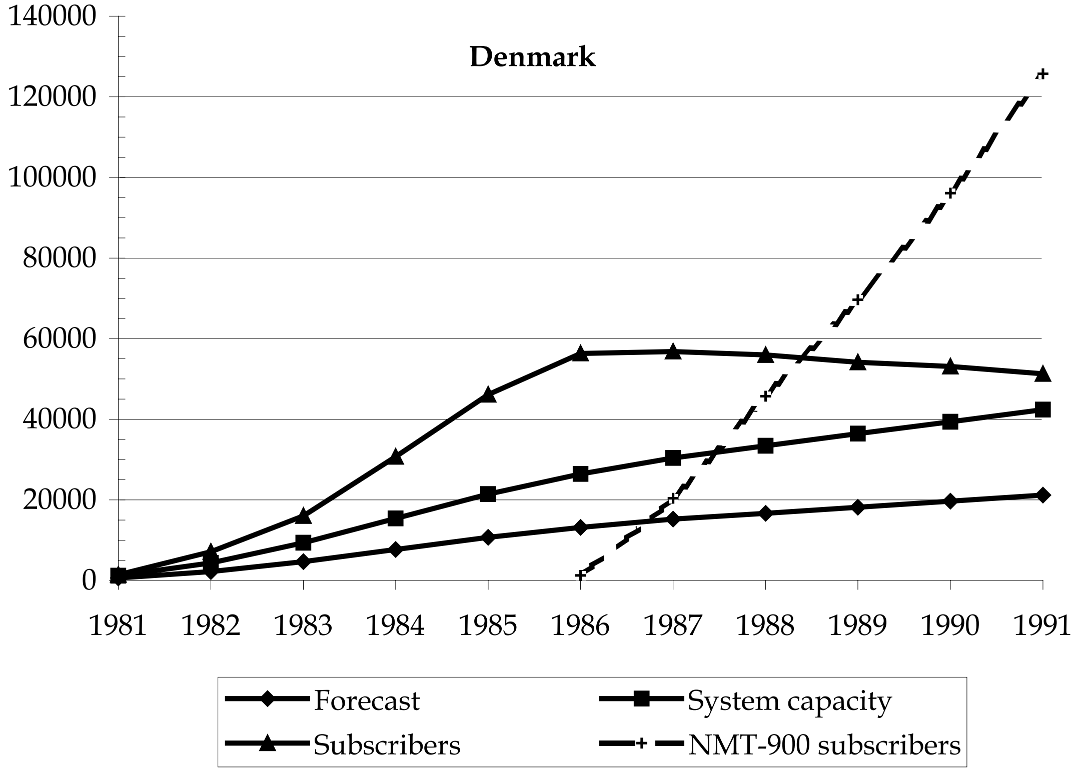
	SUBSCRIBERS, X1000		YEAR WHEN CAPACITY USED UP	
	1978	1983	VHF system	UHF system
Denmark	11	13	1974	1979
Finland	15	33	NO	NI
Norway	18	33	1983	1983
Sweden	13	14	NI	1980
Total	57	93		

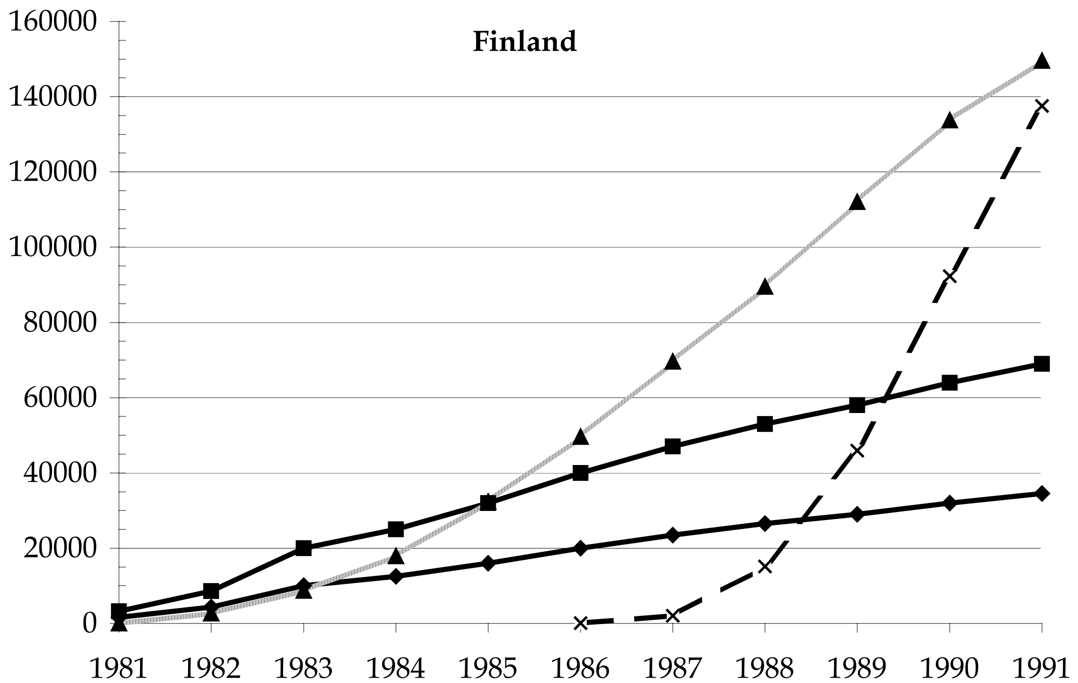
TABLE 7 MT-450 subscribers in the Nordic countries
Sources: NMT Reports

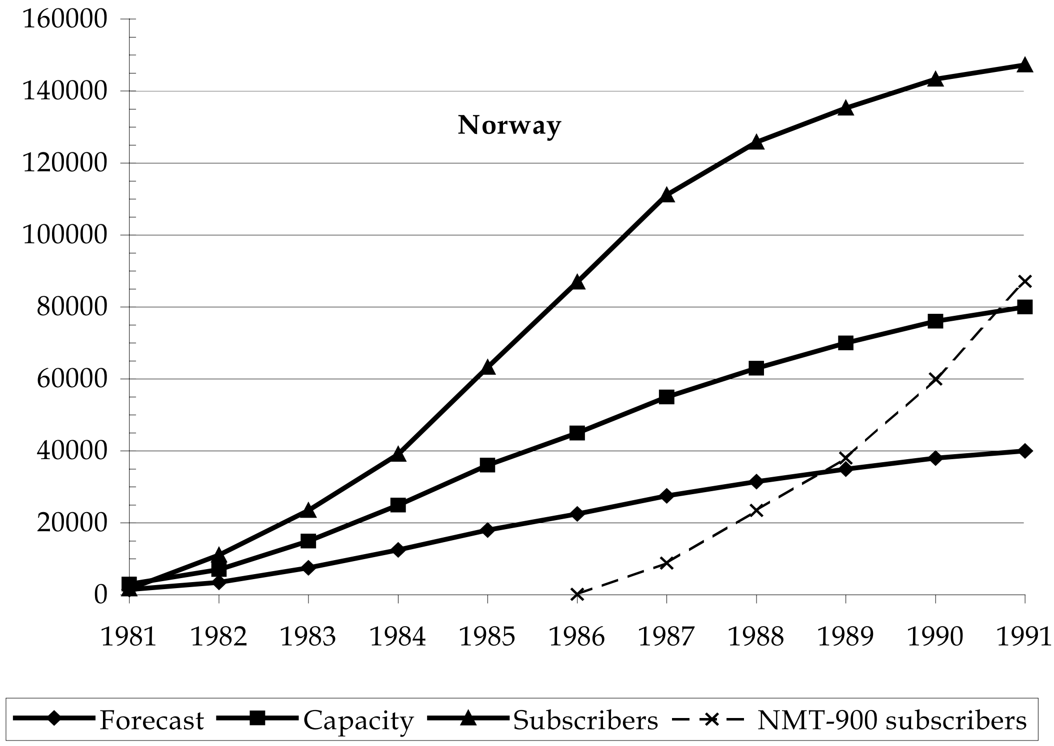
DATE (DD.MM.YYYY)	DENMARK	FINLAND	NORWAY	SWEDEN
System launched	Dec. 1981	March 1982	Nov 1981	Oct 1981
31.12.1981	1 400	0	1 670	1 344
1.9.1982	5 200	1 434	7 764	6 679
31.12.1982	7 150	2 648	11 059	11 084
1.3.1983	8 200	3 500	13 311	13 172
31.12.1983	16 058	8 655	23 473	27 118
31.12.1984	30 679	17 865	39 050	47 565
31.12.1985	46 089	32 309	63 185	75 998

359 Yet according to Matti Makkonen, this was not an intentional goal of the Finnish NTA in the first place. Pricing was based on estimated costs, see interview of Matti Makkonen
360 GSM Doc 33/83.

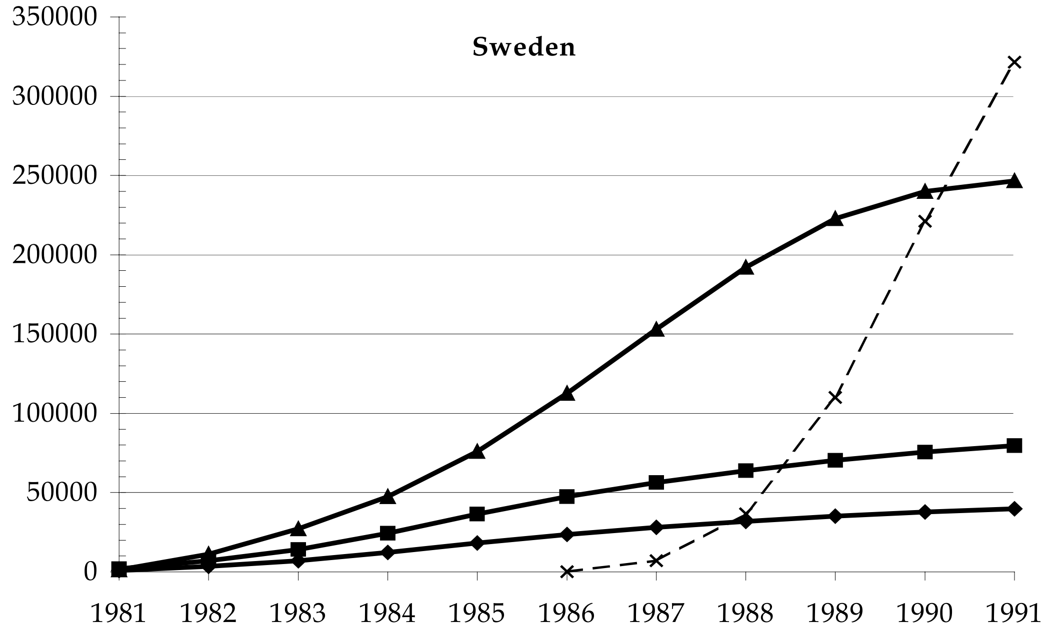
FIGURE 6, FIGURE 7, FIGURE 8 and FIGURE 9 Expectations regarding NMT and actual numbers of subscribers in Denmark, Finland, Norway and Sweden







Sources: Report from Ad hoc (Frequency) Group's 7th Meeting in November 1976; NMT Doc 1987-2108 and TN NMT Statistics



The prognoses regarding NMT-subscribers have subsequently been criticized, even though it has been admitted that similar ones elsewhere could no better predict this development. It has been claimed to be a "shortcoming" of the NMT system that its capacity became exhausted already by the mid-1980s. The reason for this was not, however, basically in the system itself, but in its applications.

In Denmark, Norway and Sweden only 120 channels were in use, while it was not until after the mid-1980s that the 80 channels used by the manual system were released for the NMT. According to the original calculations, the capacity of a small-cell network would have been sufficient for the realized volume of subscribers in Sweden until 1985, in Denmark and in Norway until 1986, and in Finland until 1988.

The problems with NMT-450 culminated in the abandoning of small-cell structure as of the beginning of the providing of the service. Although the problems of the capital cities had been acknowledged, the option of the small-cell had been left aside to be implemented later. A paradox in the development was that the marketing studies done in Finland before the implementation of NMT had revealed that the customers appreciated a network covering large areas and the possibility of pan-Nordic use. However, in practice, as much as 25-40 per cent of the traffic was concentrated to the metropolitan area. NMT-450 could not solve this equation with the aid of a reduced number of channels nor with "normal-sized" base stations.[361] For example, in Helsinki and its surrounds, there were, in February 1983, only 28 channels and, a year later, 59 channels. The first small-cell base station was already being used in 1982, but the actual small-cell network was not implemented until as late as 1985, at which point 280 channels were used. During the years 1987-1990, as many as 420 channels were being used. Further reduction in cell size would have required the implementation of a third power level within mobile stations. This property had been specified into the system as early as in 1985, but the program was not modified for the MTXs until 1990. At that point, some 800 channels were implemented in the Helsinki area.[362]

The problem with capacities could not be totally attributed to weaknesses in the system. The densest population concentration was in the area of Öresund (Copenhagen in Denmark), but the NMT system was also soon to meet severe problems in Olso, in Norway. In the first place, it was an outgrowth of Oslo's topography, this limiting the NMT system's capacity.[363] Furthermore, there were other explanations. The Norwegian NTA had adopted the most customer-friendly policy in the Nordic countries, favoring subscriber-flow through a combination of low pricing and a free connection (access) fee policy.

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361 NMT Traffic reports.

362 Toivola, 38-39; SA RD NMT Traffic Report February 1983- February 1984; According to Toivola, the blockage of the Finnish NMT network did not result purely from there having had been an insufficient number of radio-channels, but also due to the shortage of channels for long-distance networks, because MTX had been located in Lahti, 60 miles from the Finnish capital city, Helsinki. Therefore, each phone call from Helsinki to Helsinki took up two long-distance connections.

363 Hans Myhre's interview.

Furthermore, a special strategy was employed in the construction of the network. Norway built the greatest number of base stations, concentrating on coverage of the network instead of its capacity. This, in fact, showed that in Norway the number of subscribers per radio channel was considerably smaller than in the other Nordic countries.[364]

The experiences gained during the first five months changed the Swedish plans to the extent where the time schedule for building the NMT network was accelerated by the period of one year to have a coverage equivalent to the MTD system by as early as 1982.[365] The Swedish decision was possibly influenced by Comvic, the competing operator, it having introduced an automatic system to the markets just before the opening of the NMT system.[366] Even in Sweden, however, priorities had to be shifted in favor of constructing sufficient capacity instead of putting the emphasis on coverage. After the mid-1980s, the Swedish NTA was able to focus on expanding coverage.

In Denmark, Finland and Norway, the administrations continued constructing the network according to schedule. In these countries the competition did not threaten construction of the network. In Denmark, due to the small size of the land area, the base station network was completed rapidly, but it was not until the small-cell stations were implemented that the number of base stations started to rise. The best capacity was in the Danish network, because as early as the end of 1983, each base station had an average of 10 channels , whereas the other countries had but half this number.[367] The original intention of the Finnish NTA was to cover the area of southern Finland during the first phase, the network thus being built step by step along the main routes leading from Helsinki to other cities. During the following stages the process would continue from these cities towards the northern and eastern parts of Finland, in such a way that by the 1990s as much as 99 per cent of the public routes would be covered.[368] The construction went according to schedule, but since 1984, construction work focused on urban areas and the vicinity of airports, these being more profitable than remote rural areas.[369]

Operating experiences indicated that once a user connection had been acquired, subscribers set heavy requirements on both channel capacity and radio coverage. The most severe restrictions on the process of expanding the NMT network were the following features:[370]

-Establishment of fixed connections between exchanges and base stations
- Deliveries of exchange interfaces for coupling fixed connections
- Establishment of connections between mobile exchanges and trunk exchanges in the fixed network frequencies
- Deliveries of base stations

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364 See Appendix 5.
365 NMT Report X/1981-II/1982.
366 See Karlsson 1998; Comvic was not originally a cellular system, because it lacked handover.
367 See appendix 5.
368 SA RD Vice General Director of PTT Decision # 1722. Schedule for construction of automatic radio-telephone network.
369 Toivola 1992.
370 Magnusson 1985.

One of the most significant features associated with the implementation of NMT was the number of MTXs, because long distances slowed down traffic. Furthermore, the Swedish Radio division of the NTA had to pay the full market-priced rent, from using the fixed network, this being the biggest part of the costs for the NMT system in Sweden.[371] In the spring of 1982, both Swedish and Norwegian NTAs acquired their second MTX. The third MTX was installed in Norway in1984 and in Sweden in 1983. It was not until 1985 that the second Danish MTX and 1986 the Finnish one were commissioned.[372]

2.2.4.2 Services and development of utilization openings

The development of the NMT system was based on the idea of providing sophisticated services for the customers. The system was considered to be able to offer services that fixed networks were giving in the 1980s. Yet it was the radio part of the NMT system that was responsible for handover, the most essential feature, and partly also for roaming. Particularly after small-cell structure was adopted, the handover facility became an insuperable feature. Roaming was a feature not offered by other automatic systems at the time. According to a market study carried out by the Finnish NTA, the customers put a very high value on inter-Nordic roaming.

The facilities of the system included the ability (i) to take a call from the fixed network and relay it to a mobile station and vice versa, (ii) to take calls between mobile stations and hand them over during a call between base stations, and (iii) to automatically allocate mobile stations according to the traffic area. The principle of billing was a very important feature, because only the A subscriber paid for the call. Before the spring of 1982, each country had only one MTX and traffic area, but in 1982, Sweden and Norway acquired their second exchange. Inter-Nordic roaming was introduced in October 1982.

There were other facilities in the system that the operators were able to offer to subscribers against a possible surcharge. These included:[373]

- - Call transfer to another telephone (“follow me“)
- - Restriction of long distance calls
- - Programmable intercom dialing
- - Displaying of the dialed number

A call transfer could be used either as an immediate call transfer or as a call diversion in cases where a phone call was not answered.[374]

Along with the services related to the NMT system, the operators naturally provided essential services, such as subscriber catalogues and number inquiries. No specific alternatives for subscriber connections were tailored for the customers until these were adopted by Sweden in 1991.[375]

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371 Magnusson 1985.
372 NMT Reports.
373 SA RD Short description of NMT system. User manual.
374 SA RD Short description of NMT system. User manual.
375 Hulten and Mölleryd 1995; Mölleryd 1996.

NTAs also provided service subscription. There was also a quick way of becoming a subscriber. For example in Finland, the customer had to visit the local NTA Telecommunication Service Office, which, upon receiving an application would contact the Traffic Section of the Radio Department by phone or telex, giving it the subscription number, the identification data of the applicant and billing address. The Traffic Section would up-date the information for the MTX and for the computer in charge of billing. After updating, the information would be fed back to the office, which would inform the subscriber that his phone was now usable. The office would then send the application by post to the Radio Department, which would then pass on the user license and the written document confirming the subscriber relationship. In less urgent cases, the same would be carried out completely in writing, [376]

An obstacle to the diffusion of the NMT system as a "household tool" was at first the price, around SEK 20 000, and also by it being attached to an automobile. It was a common thing for terminals to be expensive investments in the early 1980s. No attempt was made, however, to turn the NMT system into a luxury item. On the contrary; the Swedish NTA initially marketed the NMT as a useful tool, trying to avoid the impression of luxury. The NMT-450 was clearly as much a tool as a product, because its largest user group consisted of people working in the transport business. Of all the users, the proportion of NMT-450 users was 15% in Sweden and 20% in Denmark.[377]

TABLE 8 The price of NMT terminals in Swedish crowns (SEK)
Source: Adopted from Hulten and Mölleryd 1995

YEAR	CAR-BASED PHONES	HAND-HELD PHONES
1981	20 000	-
1987	18 000	30 000
1988	15 000	25 000
1991	10 000	..
1992	7 000	..
1993	..	9 000 - 11 000

NMT-450 was originally intended to serve as a car-installed radio telephone, this being the basis for the network. However, by the 1971 Teleconference it had been proposed that temporary maritime use would be allowed.[378] At the time, its usage was not restricted to concern any specific system, but in 1970s the using of the NMT system at sea was brought up. Later on, the Norwegians proposed a plan concerning the NMT as a replacement or complementary system, in place of the VHF system currently used at sea, while also planning and constructing a totally separate coastal network to serve oil rigs.[379]

376 SA RD 18.2.1980 Subscriber issues of ARPA network (NMT).
377 Magnusson 1985; GSM Doc 35/84
378 NMTReport to 1971 Teleconference.
379 Hans Myhre's interview; The Norwegian NTA had a coastal NMT network serving oil rigs. It included only three base stations with directional antennas. These base stations were located at different points along the Norwegian coast.

New considerations were being made to use NMT as a communicative system with small airplanes, but the CEPT project postponed the Nordic plan and buried it with that of the CEPT project.

The NMT network was also applied in specific cases, such as terminals with priority status, payphones, and extra devices connected to the terminals. Preparations for devising specifications for the above had already been made at the end of the 1970s, but the implementation of the system, type approvals, and other concerns delayed the planning of the specifications. After the system had been made operational, the resources were directed, at first to the monitoring, and then later to R&D for the NMT-900 system.[380]

2.2.4.3 Hardware

The first NMT terminals were quite heavy, although weight was not the most essential issue, because the terminals were installed in automobiles. The lightest terminals weighed around 10 kg, and the heaviest phones were really heavy. The first to introduce a relatively light transportable terminal was the Norwegian manufacturer Simonsen.[381] Mobira also made a version of its first NMT terminal (Senator) which could be transferred from one car to another. In the spring of 1984, Mobira introduced a really portable model, Mobira Talkman, weighing less than 5 kg, a model that became an instant success. The size was reduced to such an extent that it could be carried in a briefcase.[382]

TABLE 9 Evolution of handheld mobile phones 1987-1993
Sources: Hulten and Mölleryd 1995

YEAR	WEIGHT IN GRAMS	SPEECH TIME IN MINUTES	MANUFACTURER
1987	750	180	Mobira (Nokia)
1988	650	120	Ericsson
1989	500	80	Philips
1990	350	90	Motorola
1992	300	180	Nokia
1993	265	90	Motorola

TABLE 10 Physical dimensions of NMT base stations (BS) and mobile telephone exchanges (MTX) in 1980 and in 1999
Sources: Myhre 1999

DIMENSION	BS		MTX	
	1980	1999	1980	1999
Volume (cubic meters)	7,75	0,5	..	..
Weight (kilograms)	2 240	220	..	..
Required area (sq. m)	..	..	150	10

The portable models were designed for the NMT-450 network, but they were not allowed, whereas the NMT-900 network used the portable option as an

380 NMT Minutes.
381 Hans Myhre's interview.
382 Koivusalo 1995; Pulkkinen 1997.

incentive. Portable NMT-900 models were introduced in 1987. The Mobira Cityman model weighed a mere 750 grams, its speech time being 3 hours. In just three years, the weight was halved.[383] (see Table 9).

The infrastructure equipment also faced the phenomena of shrinking, although it was less dramatic than it was for the terminals. In the early 1980s, the base stations were heavy. Base stations also required considerably large racks. With the building of more channels, shortage of room became a problem, and this caused extra expenses. The development of technology and miniaturization was visible with the MTX also (Table 10). Whereas the earliest MTX originally required room the size of a house, it fitted in a kitchen twenty years later.[384]

2.2.4.4 Development strategy

After the implementation of the system, the inner cohesion of the NMT Group began to wane. This was caused by the fact that the group did not have the resources to continue with the development of the system, working under the authority of the NTAs.[385] In practice, more and more was being focused on properties adding to user comfort, without affecting the system itself. This development work was under the auspices of the manufacturers, frustrated by their disagreement with the development philosophy of the NMT Group.[386] According to the Finnish ironic interpretation, everything not specifically allowed, was prohibited. Conflicts occurred, because some administrations approved of certain properties, which others would not. Basically it was a question of ground rules. The Swedish NTA was often willing to give dispensation, with the Finnish NTA arguing that the property should be documented as a specification, if it did not affect any other facilities. According to one Finnish interpretation, the stiff policy of the NMT Group was leading to a situation, where manufacturers would no longer be interested in developing their products. This in turn would cause the essential unchangeability of the product, regardless of its manufacturer. It was claimed bitterly that only then could the color of the terminal vary. Another grim possibility was the ultimate situation of a monopoly by one equipment manufacturer.[387]

The controversy related to the development philosophy of the NMT system, was intensified at the end of 1983, when the NMT Group refused to approve Mobira's "scratch pad"[388]. The issue had been tossed about for a long time, and when NMT Group slowed down the decision process, the Finnish delegation stated that they would accept the function on a national level. This caused massive arguments against it, interpreted by the Finns as being of

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383 Hulten and Mölleryd 1995.
384 Myhre 1999; Matti Makkonen's interview.
385 See NMT Report III/1984-VIII/1984.
386 SA RD Memo, M. Makkonen 14.3.1983.
387 SA RD Memo, K. Sappinen 21.2.1983.
388 This facility made it possible to program the "zero" push-button during a call in process.

emotional nature, especially when the Finns compared it to the positive reception given to Motorola's "voice operated hands free" function. The Finnish members regarded it as "illegal", especially with Motorola trying to get a patent for it.[389]

In Finland, attempts were made to see the problem of Mobira's facility in a larger perspective, with Mobira continuously complaining about difficulties, which it had encountered in other countries with delays in getting type approvals for new models.[390] This was taken to mean that type approvals for Mobira's new product were being deliberately delayed, in order to get the national product to the market. This schism had also a positive consequence. The Finns planned to have cuts in the mandate of the NMT Group, and suggested working procedures for similar situations in the future.[391] The NMT Group did not want to accept this new philosophy, but ultimately it had to start altering its policy during the spring of 1984. The incentive behind the change was not the Finnish complaint, but that made by the Danish company, Storno. At the time, the chairperson of the Nordic Radio Committee (NR) was a Dane, and the NR committee took the Storno initiative into consideration right away, urging the NMT to adopt a new policy.[392] The NR decision resulted in the NMT Group adopting a more liberal policy, a policy which was to become totally liberal in the late 1980s.

2.2.4.5 Reasons for the development of the NMT-900 system

Even as early as at the 1975 Teleconference, the NMT Group suggested that the Nordic administrations should reserve a considerable number of channels from 470 MHz upwards, e.g. from the frequency range of 800 MHz. This suggestion was very broad-lined, and the group did not do anything to further the issue.[393] The report made by the Swedish NTA reveals that this was more a wish for a long-term procedure than a concrete directive. The frequency band in question had not officially been reserved for mobile services by CEPT, and even if this had been done, it would have taken a long time before the frequencies would have been freed from their current use.[394]

The NMT Group made no initiatives for applying the NMT system to the 900 MHz frequency, not even after WARC-79, in conjunction with which it was decided to reserve the band for the use of land-based mobile telephones. This passive behavior is understandable, because it was thought that the NMT system's capacity would be sufficient up to the 1990s, and that the capacity problem was to be solved by the small-cell structure. In the future, once the NMT had exhausted its capacities, it would be replaced by the digital "NMT-2",

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389 SA RD Memo from NMT # 62, M. Makkonen 11.10.1983; Memo M. Makkonen 18.11.1983
390 SA RD Memo, K. Sappinen 21.2.1983.
391 SA RD Memo “Procedures for accepting extra facilities”, M. Makkonen 21.10.1983.
392 NR # 19 Minutes (26-27.3.1984).
393 NMT Report to 1975 Teleconference.
394 MTC Report 1975.

subsequently termed FMK (Framtidens mobila kommunikation, or 'Mobile Communication of the Future'). The NMT-2 Group was established in the spring of 1981, commencing its operation in December of the same year.[395]

The application of NMT to the 900 MHz frequency band started from initiatives made by British and French NTAs. In April 1982, they made it known that, as of 1985, they would be needing a system operating on the frequencies 890-915/935-960 MHz, currently reserved by the CEPT, and that this system would be utilizing the signaling and control structure used by the NMT system. The administrations of France and the United Kingdom had decided to specify a joint system, offering it as a possibility for other countries as well. Invitations were sent to the Nordic countries, and also to the NTAs of the Netherlands, Belgium, Luxembourg, Switzerland, Spain, Germany, and Italy. The proposition was discussed at the meeting in London, June 23 - 24, 1982. The situation changed radically before the meeting commenced. The Netherlands stated that it would be recommending to the June meeting of Telecom mission that the CEPT should start procedures leading to the construction of the pan-European automatic mobile telephone service on the 900 MHz band. Although the initiative of the Netherlands meant that the system would be implemented in the future, it had its effect on the project proposed by British and French, because they planned to use the same frequency range. None of the other countries, excluding the United Kingdom and France, had as acute a need to start using the "interim solution" of 900 MHz.[396]

Even before the London meeting, the Norwegian NTA sent a representative to the United Kingdom for a week "to teach NMT". At the second meeting held in Oslo in July 1982, between the Nordic countries, the United Kingdom and France, where changes were needed in the NMT systems, were also represented. The Nordic countries were uniform on the point that the NMT Group should not be opened up to outsiders, but that the Nordic representatives would still participate in the cooperative project of France and the United Kingdom. The Nordic countries, especially Sweden and Norway, presented themselves as eager supporters of the development of the new interim NMT shared by the aforementioned European and Nordic countries. Sweden said that it would seriously consider the implementation of the NMT on the 900 MHz band as an interim solution before the FMK, and Norway concurred, on the condition that the issue concerning the use of the frequencies between the interim and the future solutions would be solved. Finland was the most reserved of the Nordic countries, because it considered itself as having no need for an interim system.[397]

The project advanced further and the French administration invited the Nordic representatives to a meeting held in October of 1982 in Paris, where a joint group would be established. The goal was to be the preparation of specifications for the interim system.[398] The situation was, however, changing

395 NR # 9 Minutes (31.3.-1.4.1981); SA RD ISMOC (FMK) # 1 Minutes (1.-2.12.1981).
396 SA RD Swedish NTA, Travel report (Tv RD Rml 7751, Reseraport) 8.6.1982.
397 SA RD Memo from Oslo Meeting (4.6.1982), Matti Makkonen 10.6.1982.
398 SA RD Record Books 104/227 1982.

rapidly in the United Kingdom, because it had been decided that competition was to be included in the area of mobile telephony as well, which meant choosing a system from among several alternatives, including the NMT-900, the AMPS, the NTT, the MATS-E, and the S-900.

In January of 1983, the NMT Group suggested that development work on the NMT-900 be started. At the time, it was not yet known that, due to reasons of trade policy, the United Kingdom had decided to choose a modified AMPS system, which came to be called "TACS". The core of the argument for its development was that it was only in Finland that there was adequate NMT capacity at the beginning of the 1990s, whereas in other countries the capacity would probably have been exhausted by 1986, and every country had need for a complementary system for areas of heavy traffic. It also became evident from the proposal that the NMT-900 would be a temporary system, operating until FMK/GSM came into use.[399]

Although the NMT Group had outlined its suggestion for developing the NMT-900 even before the selection of the system for the United Kingdom, the NMT Group made no reference to international interests. This was, however understandable, because the Nordic NTAs did not directly profit from marketing the system abroad. An indirect benefit would be the lowering of prices. The decision to develop the NMT-900 was "marketed" to the NR, based on the impending shortage of capacity, even to the point of distorting the real situation, because the NR was told that the capacity for 180 channels of NMT-450 would be exhausted by 1985-1986. In truth, this was merely a question of ordering the pace of the proceedings. The NMT-450 system did not at that time utilize 180 channels, because the intention was to close down the manual MTD system in 1987 to release its 80 channels for the NMT system. Nothing was mentioned about the intention to solve the capacity problems of the NMT-450 system with the help of the small-cell network structure.

The NR dealt with the NMT suggestion on the NMT-900 project in March 1983. The foundering of Nordic cooperation with the United Kingdom and France had been brought up earlier during the same meeting. According to the chief of the Finnish Radio Department, K. Toivola, there was still a possibility of reaching a joint system solution in Europe, despite the British decision. Therefore, the openings for the NMT system on the world market and its basic philosophy needed to be thought out in the light of future requirements for systems and their services. According to K. Toivola, both FMK and GSM Groups should direct their work with an eye to reaching an early solution for a joint system in Europe. However, the NR was not in favor of the suggestion, because the NR thought that systems such as the NMT-900, the MATS-E or the C-900 were not future-oriented enough, and none of these could form a base for the future system (the GSM system). All in all, the NR expressed skepticism on the potential of the NMT system, because Germany and France had begun cooperation, and the NR thought that there would not be much chance of the

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399 NMT assembled on 12.1.1983 and made these recommendations for NR; see NR #14 Minutes (24.-25.3. March 1983).

NMT becoming the shared system of these countries.[400] However, only a month later, the Norwegian chairperson of the NR, J.R. Vaestad, offered cooperation on an interim system for the NTAs of France and Germany, because a stronger technological base for Europe would be provided, along with the optimizing of the frequencies, a move considered vital for the future systems. In was thought that the cooperation would have benefited the NMT system to the extent where there would have been possibilities for harmonizing the specifications for at least some parts of the system. A joint meeting between the delegations of the Nordic countries, France, and Germany was held in the summer of 1983, but the shared intention was to wait until France and Germany had specified their system. Eventually, this led to the collaboration effort being buried.[401]

The differences between the views of the NR's member countries did not, in fact, relate to the possibilities of the NMT system on the world market, but rather to its development philosophy. Especially the approach of the Swedes was based on the idea that only some minor changes should be made to the NMT, whereas the Finns urged that the principal weakness of the NMT system be recognized and fixed. What lay behind the opposing views was perhaps not only the question as to when the new NMT-900 systems should be needed by the administrations. According to the Finnish interpretation, Sweden was not willing to jeopardize the extensive export efforts of LM Ericsson. Finland had barely taken the first steps towards enabling the delivery of the infrastructure of the whole system. As early as the end of December 1982, the Finnish Radio Department had entered in to a contract with Mobira regarding the construction of an experimental network to operate on the 900 MHz band. This decision was made before the NMT Group had even suggested that NMT system should be applied to the 900 MHz frequency band. The decision related to the 900 MHz experimental network was not in accordance with the view expressed by the Finnish NTA only a couple of months earlier, because it had been emphasized that the Finnish NTA had no need for the interim system on 900 MHz. Mobira saw in NMT-900 the possibility of becoming an European system, and it had "intensively participated" in the discussions regarding the British choice of system. It had also started export efforts with the British private operator candidates Sectel and Racal.[402]

The joint EMCR experimental network of Finnish Radio Department and Mobira was used to study the NMT signaling on the 900 MHz band, optimizing selection criteria for the channels and applicability to small-cell networks as well as the realization of base stations. The Radio department amassed valuable and basic information for the development of the coming NMT-900 system.[403] However, the experimental network did not turn out to be as significant as was originally expected, because NMT-900 did not gain the position of a pan-

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400 NR # 14 Minutes (24.-25.3. March 1983).
401 NR-15 J.R. Vaestad's letter 26th of April 1983, NR # 16 Minutes (17.-18.8. 1983), NR # 17 Minutes (23.-24.1.1984).
402 NMT Doc 1983-893, 1983-897.
403 Toivola 1992.

European system.[404] Still, Mobira probably gained an advantage compared to the other Nordic manufacturers, because the other NTAs lacked similar experiments.[405]

The primus motor in the line of action for the Finnish Radio Department was not, however, primarily the support of Mobira's export efforts. In a mapping of the strategies made in September 1983, grave concern was expressed by the Radio Department regarding the future development of the NMT-900.[406] This anxiety was increased by the controversy going on within the NMT Group, related to the orthodox development philosophy of the NMT system in general. The Finnish NTA was even seriously considering leaving the Nordic cooperative venture, and continuing to develop the NMT system nationally.[407] Yet this option was kept secret, not being presented as an official alternative, since there was no documentation,[408] nor were any hints given to the NMT Group.[409] According to the official strategic plans of the Finnish NTA, the NMT-450 system would be temporarily sufficient, if during 1985 a "refined modern technology" would be implemented and the small-cell network would be adopted in 1986. At that point, there would be two basic alternative lines of action. Acccording to the first, everything possible would be squeezed out of the NMT-450, implementation of the system for 900 MHz being postponed to 1988, at which time there would be options for choosing either the NMT-900 or the S-900[410]. The other possibility, based on the further development of the NMT system, claimed that the only realistic option was to adopt the NMT system, and adopt the NMT-900 and small-cell technology simultaneously in 1986. The advantage would come in the form of pricing as a method of directing subscribers to the NMT-900, while, at the same time, keeping NMT-450 operational. The soundness of the solution would become questionable if NMT-900 could not be improved. Thus, in 1986, the NMT-900 system would have to be launched as a temporary solution in the condition it was in at the time, reserving some 200 channels for it. By the year 1988 enough information would have become available to decide about the rest of the channels, resulting in the implementation of either S-900 or NMT-based "N-900", with this being an improved version of NMT-900, and it could be NMT-900 system-compatible, a system launched in 1986.[411]

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404 Matti Makkonen's interview; It seems that the experimental networks was a manifestation of Mobira's export effort in a first place, and willingness of Finnish NTA to support it.
405 Hans Myhre's interview.
406 SA RD Memo System selection, M. Makkonen 20.9.1983.
407 Interview of Matti Makkonen.
408 The Radio Department files do not any contain any references to this plan, but the archives are fragmental.
409 The NMT chairperson Hans Myhre was not aware of this plan. The very first time he heard of it was in 2000 from the author of this study.
410 The S-900 system most probably referred to the joint Franco-German (analog) system.
411 SA RD Memo System selection, M. Makkonen 20.9.1983.

2.2.4.6 Developing NMT-900

Contrary to former practices, the NMT Group wished for a "flying start" to the development of the NMT-900. For this reason, the NMT Group was, at the same time, preparing arguments for commencing the development of NMT-900, a time schedule for the procedures, the requirements to be set for the system, a letter of information to manufacturers, and a modification of NMT Group's mandate. When, in March 1983, the NR decided to accept the development of the new NMT-900 system, it also approved of, with minor changes, all other procedures aiming at the launch of the project. A rapid start to the project was also helped by a new group not having been formed, but instead the task description of the expert NMT Group simply being modified. This was justified, because the development of the NMT(-450) system also affected the development and properties of NMT-900. There was also a negative impact as issues connected to NMT-450 were delayed, resources having been directed at a new project.[412]

The requirements set for the new NMT-900 system focused on applications of the already existing technological knowledge, with minor adjustments, and on the beneficial use of existing resources. In principle the requirements differed from those previously set for NMT-450 in that a preliminary solution had already been found for the frequency dimension. The new system would be based on the NMT-450 technology, the frequency band being changed, but, at the same time, coordinating the frequency needs of the future systems operating on the same band. The requirements set for NMT-900 were:[413]

- - It would be based on a system solution of NMT-450. Existing know-how and technology should be used as much as possible, because of factors relating to time and expenditure. Adjusting to the new frequency band and making simple changes in order to maximize the interim solution could be inevitable.
- - For the system to implement 890-915/935-960 MHz ("The CEPT band") and to have a sufficient number of channels. The optimal allocation of channels should be taken into consideration, since also other systems, e.g. FMK/GSM, would be using the same band in the future.
- - In the initial phase, NMT-900 would be constructed for heavy traffic areas to supplement NMT-450. The system should have the roaming function.
- - There should be improvements to the system, in comparison to the NMT-450, such as handheld phones and the network having small-cell structure.
- - The system should be ready as soon as possible with capacity sufficient up to the 1990s.

The Nordic Radio Committee (NR) did not accept the restrictions proposed by the NMT Group, i.e. that the new system would be targeted only for areas with heaviest traffic in the first phase, and that it would be a system complementary

[412] NR # 14 Minutes (24.-25.3. March 1983).
[413] NMT Doc 1983-895.

to NMT-450. All references to the phrase "interim system" in the group's proposal were deleted. A very tight working schedule was set, especially for the initial phase. The decision related to the system would be made in the spring of 1983, and the issue of the frequency band would be resolved by September, when also the preliminary specifications were to be finalized. Subsequently the specifications would be sent to the manufacturers for their comments. At the same time, work on the final specification was to begin. The feedback from manufacturers concerning preliminary specifications would be received during meetings to be held in November. These would enable the completion of specifications in the first half of January, 1984. Next, the tender invitations would be sent, with the replies being due in May, at which point the orders would be placed. Production would begin in the summer of 1984, and deliveries would begin by late summer in 1985. The launching of the system would be timed to coincide with the end of the year 1985 and the beginning of 1986, commercial activity taking place during the winter and spring of 1986.[414]

The starting point for the resolution of the frequency question was that the system would be able to use 1000 channels, meeting the CEPT Recommendation T/R 75-2.[415] In practice, the NMT Group followed the GSM Committee's recommendation, also accepted by CEPT in the spring of 1984. According to the recommendation, the band of 15 MHz would be reserved for interim solutions and 10 MHz for GSM.

The frequency issue was no longer an internal issue for the NMT Group, as it had been during the 1970s. Instead, the decision required co-ordination with international plans, on top of the Nordic internal dimension. This was a reason for establishing a mandate for the ad hoc group, which was a sub-group of an independent NR-F, Frequency Group. According to its mandate, the task of the ad hoc group was as follows:[416]

- - To sort out the advantages and disadvantages of interleaving channels
- - To study the need for frequencies
- - To work on a proposal regarding a method of designing the use of frequencies
- - To develop pan-Nordic computer programs for the devising of frequencies
- - To give reports to NR-F Group and to send copies to the NMT Group.

Initially, the Frequency Group NF-F supported the use of band 890-905/935-950 MHz according to the recommendations of CEPT. In principle, the ad hoc sub-group accepted this stand, but at first 400 channels (10 MHz) was thought to be sufficient up to 1995. This meant reserving the 890-900/935-945 MHz band for the NMT system and the 905-915/950-960 MHz band for digital systems. [417]It was intended to keep the 5 MHz intermediary band in reserve until 1995, until

414 NR # 14 Minutes (24.-25.3. March 1983)

415 NMT Doc 1983-896 (Information letter January 12, 1983, to manufacturers); The requirement of being able to use the entire band of 25 MHz (1000 channels) was vital, because the future of the GSM or Nordic FMK projects was uncertain, Hans Myhre's interview.

416 NR # 17 Minutes (23.-24.11.1983)

417 NR-19-21 NR Report IV/1983-III/1984.

there were new developments in the field of mobile phones. These principles were accepted by the NR in September 1984.[418]

The work on specifications did not keep to the schedule. The preliminary specifications had to be sent to the manufacturers by the beginning of September, but by that time it was only the system specifications and MS specifications that could be sent. The sending of the preliminary specifications was delayed until 1984. The meetings with manufacturers were held in summer 1984. The MS specifications were sent to 80 addresses (manufacturers and others interested in them) and BS specifications to 30 addresses. By the summer of 1985, the first base stations had already been delivered and development work on mobile stations had begun.[419]

The schedule failed totally in making the MTX specifications, because it was not until the end of 1984 that the first versions were outlined to be sent to manufacturers in the spring of 1985. LM Ericsson had expressed, even before the summer of 1984, that it would be permissible to use old MTXs in the initial stages.

2.3 The Nordic model

2.3.1 Working principles

The work of the NMT Group was influenced by two closely related principles: pragmatics and flexibility. These were already to be seen in the organization of NMT and its internal composition. NMT brought expertise from various fields together. Here, just as in the official CEPT standardization process, responsibilities were divided thematically between several different groups, each of which concentrated solely on their own sector

When the NMT Group was founded, the organization for permanent Nordic cooperation in the telecommunication field was only just about to assume an organized form, the organization being restricted by only little regulation and a minimum of bureaucracy. The most time-consuming singular task was reporting. In practice, the group was at liberty in deciding on its working modes as long as it reported to a higher level of organization.

Characteristic for Nordic cooperation was its style of making decisions based on a consensus principle. This defined limits and practices for work. Consensus required that all participants should share similar views and hold fast with the objectives. In order to achieve consensus there would be negotiation-defying problems and striving for compromises. In cases where consensus was not reached, the only alternative left was to shift the issue to a higher organizational level.

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418 NR # 20 Minutes (4.-5.9.1984).
419 NMT Reports III-VIII/1984; IX/1984-III/1985; III/1984-III/1985.

Especially during the standard-setting phase of NMT, the issues were not made to seem national. Thomas Haug, secretary for the group and chairperson from 1978 on, claimed that there were no national conflicts at all, just differing points of view caused by individuals, with strong opinions.[420] Naturally, working was not without its problems, because different countries had different preferences, due to their specific historical background and differences in operator structure.

The working of the group was assisted by the fact that the chairperson and the secretary were from the same country. In the election of the chairperson, candidates were nominated from Sweden and Denmark.[421] The man elected to the post was Håkan Bokstam from Sweden. At first it was thought that the chairpersonship would rotate, but after a year the issue was postponed, first because of the coming Teleconference. Subsequently, it was abandoned altogether because the Danes were unwilling to accept the laborious post due to a shortage of resources.[422] Rotation of the chairpersonship was by no means normal practice in Nordic cooperation in the field of telecommunications.[423]

TABLE 11 Chairpersons and secretaries of the NMT Group
Sources: Myhre 1999 (chairpersons); NMT Minutes (secretaries)

CHAIRPERSON	HOST COUNTRY	TERM OF OFFICE	SECRETARY	HOST COUNTRY	TERM OF OFFICE
Håkan Bokstam	S	1970-1978	Thomas Haug	S	1970-1978
Thomas Haug	S	1978-1982	Rune Björkmyr	S	1978-1982
Kåre Gustad	N	1982-1984		N	
Hans Myhre	N	1984-1993	Arild Börensen	N	
Ole Poulsen	Dk	1993-1995		D	
Frey Holmström	FIN	1995-1999	Seppo Tiainen	FIN	1995-1999

In the choice of chairperson for the sub-groups, the posts were not allocated on a national basis, but on competence and availability, instead. The leadership of the sub-groups was also a matter of resources, because the same persons had their own responsibilities within their own administrations.[424]

Initially, the NMT Group functioned as a unified group, meetings being held only 2-3 times a year. For the interim period the participants were given “home assignments" , which needed preparation. The principle of “cell multiplication” was adopted as the working mode, especially at later stages, when the group could be divided into groups of two or three people. The same principle had been applied to the NMT organization itself, “unofficial committees” (utskott) being formed for short periods for the purpose of solving special problems. These could subsequently be evolved into sub-groups,[425] with their own mandate and defined tasks. Sub-groups, too, could be temporarily

420 Interview of Thomas Haug interview.
421 SA RD Memo from NMT # 1 (14.-15.1.1970).
422 NMT #1 (14.-15.1.1970), # 7 (2.-4.11.1971) Minutes.
423 This did not include chairpersonship of harmonizing committees, such as the Nordic Radio Committee (NTR/NR)
424 Thomas Haug’s interview; Hans Myhre’s interview; Matti Makkonen’s interview.
425 Like MTXA Group, which was, established late 19977, but which got the official mandate in February 1978.

divided, when opposing participants were unable to reach consensus. The NMT Group also organized so-called "boarding school meetings", in which the group assembled in middle of nowhere, and worked from early morning to late night without breaks, just to make sure that the given task was fulfilled.[426]

The NMT Group co-coordinated and made decisions based on the suggestion of the sub-groups. The NMT Group was the actual working instance until 1975, when sub-groups were founded and given mandates. These groups dealt with test systems (PS), frequencies and exchanges (MTX) . The MTX and System Test Group in particular had a significant role in the making of the final specifications. At a later point, when these groups had had completed their primary tasks, they were united to form the System Group (NMT SG). In establishing sub-groups, the principle of flexibility was emphasized. A sub-group could be operational for some time as an informal committee, being given their mandates at some later stage.[427] The task of a sub group could be changed at some later stage.

TABLE 12 Organization of NMT Group between 1975-1982
Sources: NMT Minutes
Explanation: Dk (Denmark),N (Norway) and S (Sweden)

SUB-GROUP	ESTABLISHED	CEASED	CHAIRPERSON	NTA	PERIOD
PS, Test system	1975	1979	Ö. Mäkitalo	S	1979-1979
Frequency	1975	1981	K. Björnsjö	S	1975-1981
MTX, Mobile telephone exchange; (split to MTXT and MTXA sub-groups)	1975	2/1978	P. Aagaard	Dk	1975-1978
MTXT, Technical evaluation of MTX bids	1978	1978	P. Aagaard	Dk	1978
MTXA, Commercial evaluation of MTX bids	1978	1978	C.J. Wiezell	S	1978
SG, System Group	1979		P. Aagaard H. Myhre	Dk N	1979-1979 1980-

The NMT Group was easily manageable, because during the first years there were only 10-12 participants at the meetings, whereas at the end of the 1970s the number varied between 14-25. Especially during the first years, the group did not require heavy material resources or a large staff. An exception was the Swedish delegation, because the posts of chairperson and secretary demanded financial resources, but, in addition, the Swedes also typically had 2-3 members present at the meetings. During the early years, the Swedish members represented permanence, because the turnover was greater among the other Nordic members.[428] Along with its compact nature, the NMT Group had clear a vision in keeping almost all activities within its own rule, and no task being easily delegated to external working parties.

426 NMT Minutes; Thomas Haug's, Hans Myhre's and Matti Makkonen's interviews.
427 E.g. MTXA sub-group was operational before it had official status (mandate).
428 See Appendix 3.

The NMT Group was by no means infallible. It "wasted" some time for discussion on the lay-out of push-buttons, even attempting tried to outline and determine the physical appearance of the NMT terminal.[429] In all, these were minor faults, and with little impact on the development process. While making all the major decisions of economic importance, the NMT Group rejected civil-servant-like, bureaucratic mind-setting, making decisions that were relevant and appropriate.

There was some criticism directed against the NMT Group. It was thought to require too many resources, but this criticism came from outside the group.[430] Probably because of this criticism, there have been claims that NMT was developed in spite of the higher levels of the NTAs. These claims relied on the claim that the group's activities were somewhat of an exception due to the long time span[431] of the operations, a fact leading to internal criticism regarding limitations to the resources. The group had the blessing of the chiefs of the NTAs.[432] The superior levels of hierarchy did not interfere in the work of the NMT Group, which was left in peace to carry out the given task.[433]

2.3.2 Cooperation between the NMT Group and the manufacturers

NMT opened connections to the industry at a very early stage, an information meeting being held for potential manufacturers as early as November 1971. It was evident from the start that the "domestic" manufacturers were not the only alternative. The meeting was attended by representatives of the Nordic subsidiaries of the important European manufacturers Siemens, Philips, and Brown Boveri, and also by those of Mtsubishi and NEC and Motorola (of Sweden and Germany). The Nordic representation included the Danish companies Storno and AP Radiotelefon; the Swedish LM Ericsson, Sonab, AGA and SRA; the Finnish companies Salora and Televa, and the Norwegian Nera, Standard Telefon og Kabelfabrik and Elektrisk Bureau. Altogether 39 persons attended, representing 21 different equipment manufacturers.[434]

The intention of the information meeting was to introduce problems related to radio and telephone technology before the actual discussions began.

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429 Myhre 1999.
430 Interview of Hans Myhre; Interview of Matti Makkonen; Knuuttila 1997.
431 Some would have it that the acronym NMT meant "Never Mobile Telephone", see Toivola 1992.
432 It should be remembered that in Finland, for example, where the NTA staff had difficulties in getting money for international activities, there were no obstacles to Nordic cooperation.
433 This is confirmed by documents and interviews (e.g. Thomas Haug, Hans Myhre)
434 NMT Doc Information meeting with the industry ("Informationsmöte med radioindustrin) 3.11.1971; Usually (e.g. Gerdes 1991, Mölleryd 1996, Mölleryd 1999, Lehenkari and Miettinen 1999) it was erroneously claimed that almost 40 companies attended the meeting. The wrong figures are based on faulty data from NMT, which should have indicated the number of persons attending instead of the companies; see Minutes of the 7th Meeting of NMT. -Actually 25 companies were present at the information meeting, but some manufacturers had also subsidiaries present. In addition to the companies already mentioned, the meeting was also attended by representatives of Zodiac Sv AB, Securitas, Mikeva Ind El AB and SATT Elektronik AB.

It was obvious, even before the meeting, that, generally speaking, the NMT Group had to be careful not to let information leak from one manufacturer to another. [435] The desired discussion was a failure, because in at a joint function, with all present, the companies were reluctant to divulge semi-confidential information in the presence of their potential competitors. The NMT Group was forced to change procedure, all meetings being subsequently held with one manufacturer at a time. This meant that each meeting took from two to three days, but the NMT Group soon managed to establish a confidential, man-to-man relationship with the manufacturers, the latter noticing that the NMT Group was able to maintain classified information private.[436]

Even before the information meeting, the NMT Group adopted a procedure that secured the inner cohesion and transparency of the group. According to this principal decision, each administration was allowed to suggest manufacturers with whom negotiations were to take place. This principle was also followed when tender bids were sent for the signaling studies. At that point, a second procedure was adopted, later to become regular practice, of arranging meeting after an inquiry or preliminary order, where the manufacturers could ask for more detailed information. The companies that came to discuss the tenders for signaling were AGA, AP Radiotelefon, Storno, STK, Sonab and Lehmkuhl jointly, Philips and Tekade jointly , and SRA and Tvt/Ur (Development section of Swedish NTA) jointly. LM Ericsson did not even respond to the tender.[437] The bids made by STK, Storno and SRA were subjected to closer scrutiny, and they were given grades based on the competence in various fields. SRA received a negative evaluation from the NMT Group, which claimed that the company lacked interest in cooperation.[438] Storno was given the highest grades and was consequently given the order. Also subsequent orders for industry, only two in number, were given directly to Storno for its previous activity in developing the interim manual system.

During the early years of NMT development, the leading Nordic manufacturers attempted at first to offer ready-made solutions to the NMT Group, which they were able to deliver. [439] The companies were initially reluctant towards the tailor-made requests of the NMT Group, because it was feared that the Japanese would conquer the market. The Japanese manufacturers responded positively to the wishes of the NMT Group allowing many of the planned features to be put into practice.[440] Yet it is not fair to claim that the Japanese manufacturers were constantly the driving force.[441]

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435 NMT # 7 Minutes (2.-4.11.1971).
436 Thomas Haug's interview.
437 NMT # 9 Minutes (30.5.1972) and Draft Minutes; NMT Doc Swedish NTA's bid for study (Televerkets anbusinfordran) 15.5.1972.
438 NMT # 9 Draft Minutes (30.5.1972).
439 For example Storno exhibited its system 1970 and Ericsson presented its joint venture in Australia; see NMT # 4 (5.-7.10.1970), # 5 (20.-22.1.1971) Minutes.
440 Thomas Haug's interview; Hans Myhre's interview; Mölleryd 1997.
441 In early 1978, the Japanese NEC was not willing to manufacture terminals with 180 channels from the beginning. Instead it recommended providing terminals with 120 channels. Storno, A.P. Radiotelefon, Interphone and Motorola were willing to provide terminals with 180 channels without any major additional cost (Motorola's estimation was 1% extra cost,

The group of manufacturers that had participated in the cooperation ventures in 1974, was small and limited to the Nordic manufacturers plus Tekade from Germany. The meetings were attended by Sonab, STK, Storno, Tekade, AGA, SRA, LM Ericsson and, AP Radiotelefon. The same group participated the next year, but there were also two newcomers: Martin Marietta and Motorola.[442] The timing the entrance of Japanese companies is problematic due to the nature of the sources.[443] Most likely it took place in August, 1976, when a meeting was held with potential MTX suppliers. Participating manufacturers included NEC, Mitsubishi and. Hitachi, and non-Japanese companies Nokia, Televa, Marietta, Motorola, Siemens and Tekade. Potential terminal suppliers were invited to the next meeting, in which preliminary MS specifications were discussed[444] This meeting, held in January 1977, was attended by the Japanese companies Matsushita (Panasonic), Mitsubishi, NEC, and also by newcomers such as the Finnish Salora and the Norwegian Nera. Companies that had already participated in the cooperative work and that came to the meeting were Motorola, Sonab, AP Radiotelefon, SRA, Storno and Martin Marietta.[445]

Early participation in the NMT projects was not an essential advantage for a manufacturer, and late joining did not place a manufacturer in an unfavorable position. This was a result of the focus of work, because before 1976, the direction of the benefit to be had from the cooperation was from the companies to the NMT Group. The companies were asked information regarding costs and delivery schedules. Information regarding the progress of work was also given to other manufacturers, because the 1973 and 1975 Teleconference reports were circulated throughout the industry.

The role of the industry became more pronounced and the direction of flow of information had been stabilized, when preliminary specifications began to be adjusted using feedback obtained from the manufacturing industry. In order to specify and refine the feedback of manufacturers, meetings were organized in August 1976 (MTX meeting), in January 1977 (MS meeting) and in August-September 1977 (BS meeting).[446]

Even before the preparation of preliminary specifications, several manufacturers had expressed their interest in manufacturing terminals, because a common standard was going to form a larger market. The lack of interest of Nordic companies in manufacturing base stations is surprising, because the

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whereas NEC considered that the rise would be 10%; see the NEC telex dated 6.2.1978, that of Motorola dated 17.2.1978; Danish NTA to NMT Group 27.1.1978.

442 NMT Minutes of the Little group 20.-21.5.1974, NMT # 15 Draft Minutes (2.-6.9.1974), NMT #17th Draft Minutes (8.-12.9.1975); Report to 1975 Teleconference.

443 NMT Group was not keeping record books on letters sent and received, the letters, in practice being sent by NTAs.

444 In 1974, enquiries were made from a number of manufacturers regarding the price level of terminals , but apparently Mitsubishi did not respond and there were no Japanese representatives at the meetings held during 1974-1975. They were present at the information meeting of 1971, but there is no evidence of their subsequent participation.

445 The meeting was also attended by the Finnish Televa; but, in Martin Marietta's words, it did not begin to produce NMT terminals; NMT Minutes of Ad Hoc Meeting 17.-21.1.1977

446 NMT Minutes 23.-27.8.1976, 17.-21.1.1977 and NMT Report III-IX/1977.

leading radio communication companies in Sweden (SRA), in Denmark (Storno, AP Radiotelefon) and in Finland (Salora) did not make an offer.[447]

Since, from the beginning, the NMT Group had chosen a path of cooperation with all manufacturers interested in the development of the NMT system, manufacturers were not given favored status due to their nationalities during development phase. There was absolute no sense in favoring any or some manufacturers, because the strategy of NMT Group was based on flexible negotiation. The aim of the NMT Group was to communicate with a large group of suppliers. This procedure made it possible to "bargain" with the manufacturers. If some manufacturer was unwilling to satisfy the needs and requirements set by the NMT Group, it was possible to negotiate with others. If some manufacturers estimated that requirements were economically and technically feasible at a certain point of time, the NMT Group was able to come to a positive decision, even though all manufacturers were not compliant.[448]

The procurement of equipment was functionally connected to the development phase, because specifications had, as yet, not been frozen. The NMT Group participated as co-ordinator and adviser in the MTX and BS purchases. Especially the BS acquisitions, avoided a commitment to a sole manufacturer.[449] The price was an essential selection criterion, because the bids were categorized according to their prices, the most economical ones being selected for evaluation as potential suppliers. The Swedish manufacturer Magnetic made its bid more alluring by tying the price to the joint Nordic purchase. Price comparisons were difficult, because some Japanese bids were formally the least expensive, but they did not include indirect expenditure, some parts (combiners) not being in line with the specifications.[450]

The Japanese NEC made the lowest bid for the exchanges, but the context of evaluation of the bids, made by intermediary experts from different administrations, was the fixed network and the associated adjustments to MTX. Evidently, the application of AXE into the Nordic data network had a positive impact on the evaluators, even though this was not emphasized. Also, the fact that the administrations were not familiar with the Japanese manufacturers, the cultural differences and great distances involved, largely affected the evaluations of MTX bids, which showed in the assessment of the indirect expenditure (programming, and its developing, maintenance and education). Ericsson had an important advantage, because all Nordic NTAs used Ericsson exchanges in the PSTN. Even in the early 1970s, all Nordic NTAs had plans to use Ericsson's AKE exchange as an integrated exchange.[451] Especially Denmark

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447 According to invitation of bids, the Finnish NTA did not receive bids from the mentioned Nordic manufacturers. Even Salora was unwilling to participate, and only after pressing by Finnish Radio Department, did Salora become involved in a joint bid with Nokia.

448 Thomas Haug's and Hans Myhre's interviews; The documents do not argue with this statement.

449 See NMT # 31 Minutes (8-11.5.1978).

450 SA RD Memo Base station bids, M. Makkonen, K. Merontausta 4.12.1978, Memo Base station bids, M. Makkonen 21.11.1978.

451 In conjunction with this, the Danes and the Finns negotiated with Ericsson on the grounds of different alternatives, whereas the Norwegians turned to STK and the Swedish with

supported Ericsson as a supplier in general, without reference to any particular type of exchange.

Formal equality began to deteriorate during the last stages of MTX bid assessments, this however being the result of the following four factors: the NMT Group fearing that the schedule would fail; the consequences of delays in selecting a supplier for MTXs; the threat of the expiry of the bids and, fourthly, the experiences already gained, regarding the results of delays in the purchase of switches for the data network.

The manufacturers indicated their willingness to enter the opening markets by making economically reasonable bids. The entry to the markets turned out to be a good opportunity for the manufacturers that got the orders. Even the NMT Group was trying to avoid a situation, where the NTAs would be depending on one supplier, Ericsson achieved monopoly status as supplier of MTXs in the Nordic countries up till 1986.[452] Also, the suppliers of base stations received further orders and, consequently, a solid position in the market until the mid 1980's, when purchases were made also from others than the original supplier.

After the implementation of the NMT system, the relations with the equipment manufacturers changed, because the NTAs had their own industrial objectives, reflected in the working of the NMT Group as disagreement with the developmental suggestions made by the manufacturers, regarding the production of terminals. The NMT Group no longer had the resources to maintain its role as vanguard in development-work, the manufacturers having a greater interest in emphasizing this work, because, thanks to this development work, they could improve their own market position.

2.3.3 The significance of the NMT standard to the leading equipment manufacturers

2.3.3.1 The general importance of the NMT standard

The NMT standard was initially important for terminal manufacturers, because it was the first commercially successful cellular standard, and until 1984 its subscriber volume increased faster than other standards. Even by 1983, the NMT's share of the world's total number of subscribers for the cellular systems was 58 per cent, but two years later it had dropped to 20 per cent.[453]

Televerket's Teli.

452 MTX bids were evaluated by switching experts, who were not willing to adopt a totally new switch, in addition to the fact that the supplier would be totally unfamiliar with the Nordic NTA fixed networks. This was natural, because a new switch (and supplier) would increase expenses for the Telephone/Telegraph departments responsible for PSTN. On the other hand, it seems that, compared to the radio experts, the switching experts totally underestimated the scale of demand for mobile services. Even the radio experts could not foresee the magnitude of mobile services, but at least they did not consider that the MTXs would not remain the sole examples.

453 Pulkkinen 1996, 1997.

When the NMT system entered the market, it conquered the place of the leading cellular standard, rapidly surpassing the Japanese NTT system. It took up to 1985 for the AMPS system to become the leading standard in terms of the number of subscribers.[454] With regard to base stations, the NMT's share of the market was overpowering. In August 1983, of all the world's base stations connected to cellular networks 75 per cent were NMT-based. At the time, -the Nordic countries had 381 base stations on their NMT networks whereas the Japanese NTT system had a mere 97.[455] This was a distinct advantage for manufactures involved with the NMT system. As late as February, 1986 the Japanese NTT system had only 508 base stations. This was certainly not a mass market to be proud of, because at the same time the Nordic NMT systems had 923 base stations.[456]

In the Nordic NMT terminal market, the biggest market share was obtained initially by Ericsson. In the summer of 1983, its market share was nearly 20 per cent (excluding Norway), the others following it being Mobira, Storno, AP Radiotelefon, all exceeding 15 per cent, and, with a little less, Siemens. Below 10 per cent were Panasonic, Mitsubishi, NEC and Motorola.[457] During 1983, Mobira became the leader of the market with its share of 20 per cent, and next in line were Ericsson, AP Radiotelefon and Siemens.[458]

TABLE 13 Type approved NMT terminals on February 21, 1983
Sources: NMT Documents

MANUFACTURER	NATIONALITY (OWNER)	NUMBER OF APPROVED TERMINALS	
		According approved types	According marketing names
AP Radiotelefon A/S	Denmark (Philips, Holland)	2	2
Matsushita	Japan	2	2
Mitsubishi Electric	Japan	1	1
Mobira Oy	Finland	3	9
Motorola Inc.	United States	2	1
Siemens A/S	Germany	4	0
Storno A/S	Denmark (GE, United States)	3	1
SRA	Sweden (LM Ericsson, Sweden)	2	3
Sonab Ab	Sweden (LM Ericsson, Sweden)	1	0

The "invasion" of the Japanese manufacturers, which was feared in advance, did not happen. Also, the market share of Motorola was left meager. Even though Nordic manufacturers got a strong hold on the NMT market, and the NMT was an object of interest also for foreign manufacturers and the markets were competed, because eight equipment manufacturers had managed to obtain type approval for their mobile phones, at the beginning of the 1983. These included

454 Paetsch 1993.
455 Personal Communications September-October 1983
456 TN NMT statistics; NMT Doc 1765-1987; - The aforementioned figures do not include exported systems, but inclusive of these, the ratio would increase because of the NMT alone.
457 ULA Swedish Telecommunications Administration 83.09.01 (Presentation in English).
458 Koivusalo 1995.

the Danish manufacturers AP Radiotelefon, Storno; the Finnish manufacturer Mobira, the Swedish LM Ericsson (SRA and Sonab), the German Siemens, the American Motorola, and the Japanese Matsushita and Mitsubishi. Later, the markets were entered by the Japanese NEC, the Norwegian Simonsen, and the Danish Dancall.

The Nordic market for terminals was totally open, from the start, to all manufacturers, both in theory and in practice, which differed from those of the other cellular systems. In August 1983 there were ten manufacturers supplying NMT terminals for the Nordic market, whereas in Japan the market was shared by the domestic manufacturers NEC and Matsushita (Panasonic). In the United States, terminals were manufactured for the ATT experimental system in Chicago by the Japanese OKI, and the domestic companies E.F. Johnson and Motorola; the system in Washington/Baltimore was totally dependent on Motorola products.[459] The systems in Australia, Hong Kong, Mexico and Singapore were completely based on monopoly. The principality of the Nordic solution is emphasized by the fact that the NMT system in Saudi Arabia was entirely dependent on deliveries by Ericsson and Philips, and Spain received its NMT terminals only from LM Ericsson.[460]

2.3.3.2 The specific importance of NMT for Ericsson and Nokia

The NMT was the only alternative and opportunity to non-Japanese manufacturers[461] before the AMPS system started commercial operation in the fall of 1983. Furthermore, the NMT was of special significance to the Swedish manufacturer Ericsson and the Finnish manufacturer Nokia. In their own strongholds, Ericsson and Nokia-Mobira obtained a significant position.

Ericsson became the leading supplier of cellular systems, a success story based on the digital AXE exchange. Ericsson's share of the market for cellular systems was 45 per cent in 1987.[462] Conversely, the success as a system supplier meant that, until the introduction of GSM, the company did not manufacture terminals to standards other than the NMT. The decline of the position held by the NMT in the world's market for terminals in 1984 paralleled the decline in Ericsson's share as a manufacturer of terminals.[463]

Mobira was among the world's five leading manufacturers of mobile phones up to 1985, rising to the position of leader between the years 1986 and 1988, and subsequently competing for the position with Motorola.[464] Mobira also wanted to expand its activities to the market for base stations. Mobira was actually manufacturing base stations, but initially their only buyer was the

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459 When the AMPS system commenced commercial operation in late 1983, the terminal market became the subject of heavy competition, especially by Japanese manufacturers.
460 Personal Communications September-October 1983; on the other hand, only the markets of the Nordic countries and those of Japan had any economic importance at the time
461 Because the Japanese market was closed for foreign manufacturers.
462 McKelvey et al 1997.
463 See Pulkkinen 1997.
464 Pulkkinen 1997.

Finnish NTA. By 1984, the model of base stations was revised, a more aggressive pricing policy subsequently being adopted. In conjunction with this the market opened up, initially to Belgium, then to Norway and Sweden. Mobira-Nokia became a significant manufacturer of NMT base stations. Up to 1989, Nokia's competitors in the NMT base station market were Mitsubishi, Ericsson, Philips and Hans Damm, but by 1994 Nokia had only one competitor left. [465]

As far as resources were concerned, Ericsson had a good starting-point, because in 1986 it was the world's 8th largest telecom manufacturer in; whereas Mobira's parent company Nokia did not even fit into the Top 15. In 1991, Ericsson was 6th and Nokia 14th largest.[466] Yet the success of Ericsson and Nokia cannot be explained by the scale of resources alone. The rise of Ericsson and Nokia cannot be understood without observing how they managed to get to this position. It can be studied by focusing on how both companies created competencies, adopted the idea of supplying the whole infrastructure, and expanded to other standards.

Both Ericsson and Nokia created competencies by pooling their resources on the national level, this feature distinguishing them from the other manufacturers. The Ericsson strategy included buying companies with specific competencies, whereas Nokia concentrated on establishing joint companies and later carrying out mergers. The parent company of Ericsson prepared for the supply of MTXs, while its affiliate, SRA prepared for the production of terminals. In addition to this, Ericsson had to make a contract with Magnetic and Radiosystems for the first deliveries to Saudi Arabia.[467]

In the consortium formed around Nokia, the organizational capacity for systems delivery was initially better than for Ericsson, but only theoretically. The Nokia-Salora consortium prepared to manufacture base stations and terminals; while particularly Televa and also Nokia to some extent showed interest in the MTX. Due to the establishing of the joint corporation Telefenno,[468] and the unfinished ADS project (DX-200), however, the MTX project was cancelled.[469] This decision of Telefenno to withdraw from the final MTX bid was not insignificant, because Telefenno had been accepted for the final round of five manufacturers.[470] The Finnish Radio Department was very pleased with the Telefenno bid, because the price was competitive and the basic concept of the exchange was progressive due to the use of microprocessors and modular structure.[471] Telefenno's decision to withdraw from the development

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465 Koivusalo 1995.
466 Dyson 1990; Mäenpää-Luukkainen 1994.
467 Mölleryd 1996; MacKelvey et al 1997.
468 Telefenno was a joint venture of Nokia and Televa.
469 Koivusalo 1995; Palmberg 1997.
470 Televa's bid was accepted for further evaluation, only because the Finnish NTA insisted. Other NTAs considered the bid too optimistic and superficial. Hans Myhre's interview.
471 SA RD Memo Common Nordic Radio telephone network in Finland, March 1977; Finnish NTA was favoring joint purchase from one MTX supplier

of MTX caused five years' delay to Nokia's entry into the business of mobile switching.[472]

Networking was quite a natural strategy for Nokia, because in Finland the manufacturing industry started to engage in networking not only to supply infrastructure, but also on the level of components. In 1976 Insele Oy[473] was established to produce duplex filters in response to orders from Salora. Nokia bought the majority of its shares in 1985, becoming the largest manufacturer of duplex filters in Europe during the 1990s. Also, the production of ASIC circuits commenced. In 1980, Nokia, Salora and ASPO established Micronas Oy, which acquired its technological skills from Micro Power Systems in the United States, the development process starting in 1984, leading to production two years later.[474]

Networking, in the Finnish context, extended even to the institutional level. Most likely this was a consequence of limited resources and the novelty of this line of industry. In conducting research, there were close relationships between manufacturers and the VTT (State Technical Research Center). The VTT Radio Technical Laboratory had as its board a consultative committee of representatives of equipment manufacturers (such as Nokia and Televa), the Radio and Telegraph departments of the NTA, the Helsinki Telephone Association (HPY), The Finnish Broadcasting Service (Yleisradio), and the Finnish Radio Technical Association, and of course, the representatives of VTT. The consultative committee directed the activities of the laboratory, making significant propositions, at the end of the 1960s, of profiling the activities in such a way as to make them serve industrial needs, the laboratory functioning on a commercial basis. Up to that period, its principal customer had been the Finnish Army.[475] VTT had close relations also with the institutions of higher education, because up to the 1960s, the VTT and the Helsinki University of Technology (HUT) had not been administratively separated. Even after this stage, the same personnel worked in both establishments[476] The central role in the whole communication business was occupied in the 1960s, by the

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472 Actually this was more or less a theoretical delay, because in 1978 the DX-200 was still on the drawing board, the prototype not being available until 1980. It should be also remembered that the DX-200 itself was competing with DX-100 (Alcatel’s E-10) technology, the Finnish NTA at first being interested in ordering one MTX!

473 Insele was established because Salora needed duplex filters for manufacturing radios to be used on train locomotives. The locomotive radio project developed by Salora served as a springboard to further development. As an offshoot of this, a terminal that was equipped with a synthesizer was developed. In Insele, Lauri Kuokkanen, who had been influential in the commencement of the duplex production, purchased the company's duplex production line in 1978, the company becoming known as Lauri Kuokkanen Oy. Nokia itself manufactured the filters before purchasing the majority of the company's shares.

474 Koivusalo 1995.

475 SA RD VTT Radio Technical Laboratory (RTL) Annual reports and the Minutes of the RTL Consultative Committee (especially October 5th 1967 andDecember 14th 1967). The staff of the laboratory consisted of 85 members in 1965. An inclination to move towards the civilian sector was further emphasized by the inclusion of HPY (HTA) in the Consultative committee of the RTL at the beginning of the 1968. The significance of the army was decisive, because in the turnover of 1966 its share was 61%, and of the laboratory's Radio Department as large as 93%!

476 Michelsen 1993.

Consultative Committee in the Field of Communications (CCFC) established in 1963, the function of which was to consider the needs of the society in conjunction with the plans for the communications networks.[477]

Neither of the consortia, Ericsson nor Nokia, had in their core organizations any systematic plan for the supply of all the parts of the system. System deliveries had not in themselves a decisive significance on the success of the manufacturers in the very first years of 1980s,[478] but anyhow it implies that the possibilities provided by the NMT were being understood. Outright paradoxical was Ericsson's reluctance in offering AXE exchange as MTX for the Nordic countries and for a first-export delivery.[479] Nokia did not express any great interest in manufacturing terminals, because it had not even attended the meeting, where the specifications were discussed. Even Salora was not concerned in the least with the manufacturing of base stations.[480]

Inside the Ericsson's consortium, its subsidiary, SRA, had a central part in bringing Ericsson into the mobile phone business as a system supplier. SRA persuaded Ericsson to offer the NMT system to Saudi-Arabia, which bought the system, even before any of the Nordic countries started to use it. At that time, base stations had to be ordered as sub-constructions from Magnetic and Radiosystem. In 1982, however, the leading manufacturer of the NMT base stations, Magnetic, was bought by SRA, being annexed directly to the Ericsson organization in early 1983. A decision in principle was made in 1982, when the Netherlands expressed its willingness to purchase only the AXE-MTX without base stations, but Ericsson decided to offer the whole infrastructure or nothing. This decision was the result of "heavy pressure" from SRA.[481] By 1983, Ericsson had reached a position where it delivered all of the Nordic MTXs, up to 1986, as well as those exported elsewhere, Austria possibly excluded. After its purchase of Magnetic, Ericsson's status was firm also as a manufacturer of base stations, having received half of the orders made by Denmark, Norway and Sweden, and having also received additional orders. Radiosystem started to deliver base stations, instead of components by the mid 1980s, receiving significant orders, due to its aggressive price policy. Ericsson acquired Magnetic and merged it in 1988.[482]

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477 PT 4/1973; FCC (VANK) had as participants the Army, the NTA and the Association of Private Telephone Operators (Puhelinlaitosten liitto), and it had a central role in making decisions regarding the ARP network.

478 In total opposition, Kåre Gustad, chairperson of the NMT Group, claimed in 1983 that Ericsson's AXE was chosen because Ericsson was the only manufacturer, who could deliver all the parts of the system (Personal Communications September-October 1983). This is an erroneous claim. The criteria for the choice procedure were different, and the NMT Group did not intend to see to the procurement of the whole system, only that of its components. Ericsson itself did not even have ability to manufacture all of the system components of the system, when the Nordic countries made their first orders. It was only the Japanese NEC that had this ability.

479 See Chapter 2.3.3.3.

480 See Chapter 2.2.3.2.5.

481 McKelvey et al 1997.

482 McKelvey et al 1997.

Also within Nokia the idea of supplying the whole infrastructure started with the division responsible for radio communications. Mobira attempted, from 1982 on, to persuade the Nokia exchange manufacturing unit, Telenokia, to develop MTX. In 1983, Nokia's marketing section studied the issue; and in 1984 Telenokia made a reluctant decision to this effect. At the end of the same year, Telenokia received a preliminary order from the Finnish NTA. Mobira shared the MTX development costs.[483] Thus, Telenokia developed MTX based on the DX-200 exchange for the NMT-900-system, the first exchange being delivered to Turkey in 1986. Although Telenokia was the first to accomplish MTX fitting the requirements of the NMT-900 , difficulties were encountered in exports. At first, only the NMT-450 system was sold to China to operate on an oil field, to be followed by another network. Also at organization level, Nokia was preparing for deliveries of the systems in 1988 by shifting a PMR unit, which had also been responsible for the marketing of the systems, to Nokia Cellular Systems. The manufacturing plant for base stations, formerly part of Mobira was also transferred to Nokia Cellular Systems. The move finally opening the market was the pact with Alcatel[484] regarding the development of GSM. During 1988 and 1989, Nokia delivered 26 exchanges and over 300 base stations for the French SFR. This was the NMT-900 system which, however, operated on the frequency 450 MHz, the partner being Alcatel-Thomson Radiotelephone. Subseqently, the NMT systems were ordered from two former colonies of France: Algeria and Thailand. The actual ascendancy did not, however occur until 1991, when the markets for East-Europe and the former Soviet Union were opened for the NMT-450 system.[485]

It has been assumed that the break-through in Nokia's mobile phone production started when NMT had created the market for it.[486] This view is based on a market-focused approach, which does not take into account building up of competence, experience and the process going on at the time. Nokia did not emerge to the markets from a vacuum, its break-through being based on export that had begun as early as 1975. This was based on Salora's innovative product development,[487] which opened up exports to the Nordic countries, where Salora attained the status of market leader with terminals for the manual systems in 1978. The export was also supported by Salora's marketing channels, not solely on the products. Salora had experience in the production of consumer electronics, production methods and marketing to Western Europe. Salora and Nokia started cooperation in marketing in 1975. In addition to the Nordic countries, terminals were exported to the United Kingdom, which, together with the Nordic countries was one of the central marketing targets for Salora televisions. Export of terminals to the United Kingdom started from 1978 onwards. By way of exception, the British markets were at first reached by

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483 Palmberg 1997; see also Koivusalo 1995
484 Alcatel, Nokia and AEG jointly formed the ECR consortium, aiming to develop and market the GSM system.
485 Koivusalo 1995
486 Pulkkinen 1996, 1997
487 For further details of Salora's R&D work, see Palmberg 1997

Nokia products, that, however, were soon to be replaced by those of Salora.[488] A processor-equipped telephone was developed for the automatic System 4 network in he United Kingdom later to be further developed into a NMT terminal.[489]

Cooperation in the marketing field between Salora and Nokia deepened into a joint enterprise, Mobira, established in 1979, but even before the founding of Mobira both companies had together made a joint bid for the NMT base stations the previous year. Combining resources was essential, not only in the production of terminals and base stations, but in order to carry the line of business over the period of technological transition. Televa did not even begin to develop the NMT-terminal,[490] nor had Nokia shown any particular interest in manufacturing terminals. Salora had run into economic difficulties, beginning from the oil crisis of the early 1970s, which at first halted the expansion of the of television set exports, until the whole business was faced with problems in 1977. Salora was one-sidedly dependent on the sales of television units, an area constituting 80% of its business income. A meager 5% came from radio phone sales, even though from the beginning of the decade it had been decided to expand activities on this sector.[491] The demise of Salora came when the company had also to tackle taxation-related problems, and, as a consequence, it was sold to shipbuilding company Hollming. This helped in establishing Mobira. On the other hand, Nokia could compensate for the shortcomings of Salora. Nokia had sufficient resources and a long-term commitment. The electronics department of Nokia had been unprofitable for 15 years, but as it was oriented to the market of the Soviet Union, the rise in the price of oil increased its export volume, due to the bilateral trade agreement between Finland and the Soviet Union.[492]

It was the spirit of Salora that inspired Mobira well to up to the mid 1980s, even though Nokia bought up majority of the Salora shares between 1982-1984.[493] It is obvious that the early success of Mobira was based on the spirit of Salora.[494] Yet Mobira did not rest on its laurels. Quite the contrary. Several notable decisions were made in order to secure business success. SMT (surface-mounting technology) was adopted, as the first in Europe, and Mobira Talkman, weighing 5 kg, was developed during the years 1981-1983. A hand

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488 Koivusalo 1995; see also Kalpa 1977.

489 Koivusalo 1995.

490 Terminals with the Televa brand name were on the market, but they were actually developed by Mobira.

491 Salora 50 vuotta; TT 3/1972.

492 Mäkinen 1975.

493 In the summer of 1982, Nokia purchased the 50% share that had belonged to Salora and Hollming.

494 In addition to the competence gained, one essential factor in this success might have been the spirit of solidarity in Mobira, where all the staff was one big family. CEO Jorma Nieminen was even chief editor of the staff bulletin "Mobiralainen", writing several interesting articles (Later this bulletin came to be more like the typical staff bulletin containing articles related to union issues etc. Solidarity spirit was also boosted by organizing special evening parties (NMT parties for NMT employees, TACS parties for TACS employees etc), see Mobiralainen 1980-1985.

phone, Mobira Cityman, was developed in the period 1982-1985, which was among the first of its kind, after the one made by Motorola.[495] Networking was a prerequisite for the development work for Mobira, the VTT electronics laboratory having developed the processor part and the software for Mobira's first microprocessor-equipped phone. Mobira had no previous experience in applying processors to mobile phones, therefore the role of VTT was decisive in the process of developing of the product. VTT has, also after that point, developed software and methods for testing them; its various laboratories have participated in developing modem circuits, guiding computers and their software, senders and transmitters and silicon technology for different standards and equipment generations.[496]

To ensure success neither Ericsson nor Nokia relied on one standard alone, expanding their marketing instead to other standards, from an early period. In 1983, Ericsson was granted the first contract to supply an AMPS system to the United States, and later a TACS system to Vodafone in the United Kingdom.[497] Mobira began also manufacturing TACS terminals for the British market, following Manual Systems 3 and 4.[498] AMPS-terminals were delivered to the United States in 1985, and RC-2000 terminals to France in 1986. In addition Mobira also produced terminals for the German C-450 system (Netz-C), opened in 1985. Mobira (Nokia) was, in addition to Motorola, the sole manufacturer to have in its capacity equipment of five significant standards, its market areas being Europe, the Middle East, Asia and North America.[499]

In the 1980s, telecommunications was clearly divided into two sections: switching and radio communications. This was to be seen in the organizational structure of manufacturers and operators, in addition to the fact that the division into two sectors was also a mental watershed. Radio companies could react impulsively[500], whereas switching companies had to build long-term reliability.[501] As mobile telephony was commercially in its infancy in the early 1980s, switching companies were not particularly interested in mobile telephony, whereas radio companies, in cases such as SRA and Salora, were willing to take risks and promote the mobile telephony industry generally. This was particularly clear in the Swedish case, where SRA was pushing Ericsson forward. It has been stated that this was possible because of the loose ties

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495 Koivusalo 1995; Pulkkinen 1997.

496 Lemola 1992.

497 McKelvey et al 1997.

498 The continuation is accentuated by the fact that as early as the end of 1982 Mobira marketed NMT to England. After systems selection, TACS terminals were purchased by the operator Racal from Mobira.

499 Pulkkinen 1997.

500 SRA was even starting development of MTX, though it had no experience in switching (McKelvey 1997), or "Mobira madness", referring to intentional risks taking (Pulkkinen 1996).

501 Per Björndahl's interview: according to Björndahl, a switching company cannot afford to make bids which later turn out to be unrealistic, because on the next occasion the operator could instantly neglect bids from that company. Mobile switching was also of minor importance compared to PSTN in the 1980s, development of both NMT and GSM systems starting from the supposition that major changes to PSTN could not be effected.(PSTN defined the development of a mobile system).

between SRA and Ericsson, ties giving SRA freedom of action.[502] A similar organizational structure prevailed with Nokia and Mobira and in the role of Mobira as promoter of cellular telephony within its parent company Nokia.[503]

Yet even though the vision of cellular telephony was personified by radio communications companies, they needed the cooperation and competence of switching companies. This was specially true in the NMT case, NMT having been developed primarily as a switching system on the presupposition of a fixed network. Companies with limited competence in switching had severe shortcomings in their plans to solve switching in the NMT system. This was very clear in the case of Motorola, because the company aimed at solving its capacity limits of exchange simply by placing several small switches side by side.[504] Companies with strong competence in switching, such as Ericsson and Telefenno (Nokia), could offer exchanges that represented the most modern digital technology. As Ericsson and Nokia had built up competences over a wide area, they could more easily understand the whole system.[505]

The evolution of the NMT standard had an impact on manufacturers, even though it is quite difficult to evaluate because the major part of the impact was mental, relating to the attitudes of the manufacturers. Several manufacturers participated in cooperation with the NMT Group, but all were not willing to adopt the spirit. It has been stated that Motorola was willing to follow the path it had selected, because it was the market leader and knew everything about the field, whereas Ericsson and Nokia adopted a customer-oriented approach.[506] Then again, it has been claimed that the Japanese manufacturers were the most customer oriented, even to the extent that their main aim was just to please the customer, even though they were giving unrealistic promises.[507] Thus customer friendliness could not be the only criteria in evaluating the outcome of the NMT standardization process and particularly of whether a manufacturer had it or not. This observation is supported by another claim, arguing that before the mid-1980s, at least, the Finnish NTA considered that Ericsson was no longer willing to meet the suggested requirements, because it had attained monopoly status in supplying MTXs. From this point of view, it was a great favor for Ericsson, that Nokia had developed an MTX of its own and started to compete with Ericsson.[508] A logical result of this chain would be that the spirit of

502 McKelvey et al 1997.

503 It was Mobira that persuaded Telenokia (Nokia) to start development of MTX (see Toivola 1992, Koivusalo 1995; Palmberg 1997). In summer 1983 Mobira (particularly its CEO J. Nieminen) spoke for commencing studies related to GSM. Nieminen considered the future (the digital system or GSM) as "big business" and extremely important for Finland, see SA RD State Research Centre (VTT). Memo Digital Radio communications Project, Meeting with VTT, NTA, Mobira and Ministry of Trade and Industry, 6.6.1983.

504 Interview of Hans Myhre.

505 Hans Myhre stated that Japanese companies were swift to react to demands set by the NMT Group and to start production with very short time delay, but they had difficulties in understanding the NMT system. This observation is supported by the fact, that Japanese companies focused on terminals, and actually only NEC achieved some success in the infrastructure of non-domestic standards.

506 Interview of Hans Myhre.

507 Interview of Per Björndah.l

508 Interview of Matti Makkonen.

cooperation was an outcome of the learning process, especially since the Ericsson radio subsidiary (SRA) did not show willingness for cooperation at all in the very early 1970s and Nokia's predecessors did not actually participate in NMT standardization before the mid-1970s. As most major manufacturers were involved with the NMT standardization process, the result cannot be explained by the participation alone. While Ericsson and Nokia, in particular, in introducing the NMT standard, the cause for their success must have been in something specific to just them both. Both Ericsson and Nokia had know-how in a wide area of cellular telephony containing the radio and telephone fields. Yet as this know-how itself resulted from something, an explanation had to be sought from corporation strategy or unique ties with the most important customer: the NTA.

From the present perspective, the position of Ericsson and Nokia in the field of telecommunications seems obvious, but one can not claim that Ericsson and Nokia could have foreseen future developments to focus solely on cellular telephony in the early 1980s. In actual fact, their position on the cellular market was jeopardized by decisions made on the corporate level during the 1980s. As far as their organizational core was concerned, both companies had specialized in electronics for professionals, when they decided to move to consumer electronics where there were higher profits to be made. In 1983, Ericsson established a new division, Ericsson Information Systems, investing a significant sum of money in corporation purchases. The vision behind this was the integration of telecommunications and office work, the paperless office, for which purpose computers began to be produced. Focusing on the U.S. market was not, however, successful and the division had not made sufficient profit by 1988, at which time it was sold to Nokia. As a result Ericsson re-focused on telecommunications.[509] Nokia followed suit, although the details were different. In 1984, Nokia became the leading manufacturer in the Nordic countries of color televisions and computers, after having purchased Salora and the Swedish Luxor. As a consequence, the company began expanding into a "multi-domestic small giant" of the electronics field. The company stressed the importance of expansion and globalization strategy, for which reason resources were directed to television production during 1987-1988 by purchasing its European competitors. This headed Nokia into financial trouble. In order to gather new strength, it was decided in 1992 to give up manufacturing television units and a majority of other activities in favor of telecommunications.[510]

509 McKelvey et al 1997.
510 Nokia decided to give up television manufacture as early as in 1990, but this decision was not published; see Ruottu 1996.

2.3.3.3 The intervention of the National Telecom Administrations in the plans of equipment manufacturers

The NMT Group could not and did not favor any of the manufacturers during the development phase of the NMT system, because its principle was equality for all. Therefore it was not in a position to orivude deliberate help to the aims of any one country as regards its industrial policy.[511] At the later stages of the development, the purchase of MTXs and BSs became a significant issue for NTAs, NMT Group and manufacturers alike. Even though the technical evaluation was carried out by the experts of each NTA, the work was organized under the supervision of NMT, which co-ordinated it and also attempted to direct the methods and also to give suggestions even for the actual purchases. Yet, in the final analysis, the procurement decisions were made independently by the NTAs, and they could have an influence on which manufacturers were selected to the group for further evaluation. In principle, the NTAs had a dual dole, because during the NMT standard definition the NTAs were doing their utmost to avoid to breaking the spirit of cooperation among the members of the NMT Group. During the procurement process, the NTA had to heed their own interests specifically, and with the commercialization of the standard, they also adopted a more selfish role in the NMT Group simply as participants.

The NTAs had the biggest interest in influencing the purchase of infrastructure, because they were to be using the equipment. The Swedish and the Finnish administrations were the most active in intervening in the activities of the manufacturers. The Swedish administration interfered with development of MTX, when Ericsson showed reluctance in starting to develop a newly completed AXE into an MTX, while being willing to offer AKE[512] exchange. The Swedish NTA said that in such a case it would purchase the exchange from another equipment manufacturer. The AXE-MTX was not directly profitable for the Swedish administration, even though it had been participating in the development and production of AXE, because Ericsson manufactured the MTX and the NTA's manufacturing arm Teli manufactured exchanges for the sole use of Swedish NTA, nor did it export.[513]

The activity of the Swedish NTA was not limited to a role of godfather for the AXE-MTX, and it adopted a role of patron for the NMT system. The Swedish NTA considered it essential, from the start, to gain export markets for the NMT system because it was thought that exports would increase the interest of the manufacturers in developing the system and the equipment. Because of this, NMT was often being spoken for in several different situations, other operators being advised to select NMT.[514] In fact, the Swedish NTA

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511 Thomas Haugh's interview; for example the NMT Group did not do business with Ellemtel which had developed the AXE, but with Ericsson instead.

512 If AXE had not been offered as a choice for MTX, then the most obvious choice would have been the NEC exchange, which, in the evaluation, was AXE's strongest competitor. Also, in the beginning of the 1980's, NEC and Ericsson were the most general exchange suppliers for cellular systems; see Personal Communications September-October 1983.

513 Mölleryd 1996; Mölleryd 1999; McKelvey 1997.

514 Mölleryd 1997.

served as a kind of mail-box, through which operators from different parts of the world asked for information regarding the properties of the NMT.[515] At least the NMT delivery to Netherlands resulted from a close cooperation between the NTAs of the Netherlands and Sweden.[516]The cooperation of Ericsson with the domestic NTA for promoting the export took place on a very practical level, and foreign delegations were jointly taken care of.

The export markets of the NMT has not been systematically studied. The Swedish NTA probably had a significant role in making NMT widely known; and it could have been easier for other operators to turn to a colleague than to a manufacturer. The actual making of the deals was naturally the responsibility of the manufacturers. It has to be remembered, too, that in the first exports of the NMT system, NMT followed the market tracks opened by AXE exchanges for the fixed network, at least in the Nordic countries, Saudi Arabia, the Netherlands and Spain.[517]

The principal beneficiary of the NMT system exports was LM Ericsson. With Ericsson practically having a monopoly status in supplying the whole system infrastructure, this was interpreted as attempts by the Swedish NTA to support Ericsson's export efforts. However this was natural, and was accepted by other Nordic NTAs. It would have been most peculiar, if the Swedish NTA had not supported the export drive, because it had heavily resourced the developing of the NMT.

Controversially also Ericsson attempted to influence the decisions of the domestic NTA. During 1984-1985, when the decision was being made for the implementation of the NMT-900 network; Åke Lundqvist, CEO for the Radio division of L M Ericsson, tried to persuade the Swedish NTA to acquire an already existing system, either AMPS or TACS, because these systems would have larger terminal market. Also the general director to Ericsson, Lars Ramqvist, tried to influence the general director of the Swedish NTA, Tony Hagström, that the Swedish NTA should choose AMPS system. Ericsson was reluctant to start developing a new system; and it was intended to exploit the development work already in existence .[518] Ericsson's attempts received a serious response in the Swedish NTA, with the general director of the NTA sending a memo to other general directors of Nordic NTAs at the beginning of 1985.[519]

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515 E.g. India and New Zealand were interested, see Replies of Swedish NTA 31.5.1983 and 20.10.1983.

516 In 1981 Dutch and Swedish NTA had discussion on possible cooperation regarding mobile telephony already in 1981, see SA RD Netherlands PTT (Mobile radio Dept.) 11.8.1981 to Swedish NTA.

517 In these countries AXE switches were already adopted for a fixed network (PSTN or Data network) before NMT system was purchased.

518 Mölleryd 1996.

519 SA RD Swedish NTA Memo ”Confidental” (Televerket “Förtrolig PM”) 15.2.1985. The memo compared the properties of NMT-900, AMPS and TACS. Besides technological differences the using of NMT was emphasized from the point of view of the administrating frequencies and operator, because the traffic capacity/MHz of NMT was estimated to be 50-150 per cent better than that of the TACS system, and AMPS was even below TACS.

In Finland, more than in Sweden, the NTA affected the central decisions of industry, even on the political level no priority had been given to the field of mobile telephony. There was interest at the political level, but it was focused on consumer electronics as, for instance, in Sweden and many other European countries. The ultimate result of political activity led to the establishing of the television manufacturing company Valco in 1976. It was planned to merge the resources of two state-owned companies, Valmet and Televa.[520] However, this plan fortunately failed. The result was something which was not expected, because Televa did not react positively to this idea,[521] which helped the formation of, Telefenno, the joint-corporation of Televa and the private-enterprise Nokia.

It has been claimed that the Finnish NTA did not have a systematic policy regarding mobile telephony.[522] This is quite a valid statement, but mainly for organizational reasons. The Telegraph Department responsible for fixed network was jealously watching over its territory whereas the Radio Department logically was keen on promoting mobile communications. It is also apparent that the procurements of the Radio Department was much more systematic than it had been previously assumed . It had been falsely claimed that the procurement of the first base stations for the ARP mobile telephony network was a decision to favor domestic industry, because Televa utilized "tubes" in base stations.[523] Televa, however, got a share of the order, because it made the most aggressive bid, and technically its partially transistorized base station did not differ from most of the others in the bidding. The main part of the order went to the Danish Storno, which also succeeded in the bidding because of its price and technical features.[524]

Already with the procurement of ARP base stations, the Radio Department's motive was saving costs in the long run. Therefore, domestic product development and manufacturing was considered to be necessary. The same phenomena recurred with the procurement of the NMT base stations. Not much priority was given to such issues as employment-effect, domesticity and state-owned companies as such, because a bid given jointly by Magnetic-Televa, was rejected by the Finnish NTA. The joint bid would have been economically tempting, but product development would have stayed in Sweden. The Radio Department meant to secure the position of Salora-Nokia, which had already been achieved in the Nordic market for equipment. This was also used as an argument, but partially it may have been merely rhetoric and extra argument, because it was more emphasized in documents, which were pointed to higher level of NTA hierarchy.[525] But it is a fact that the Radio Department acted vigorously to cause the starting of Salora-Nokia's production of base stations.

520 Ruottu 1996.
521 Televa 1945-1980.
522 Palmberg 1997 A.
523 Toivola 1992
524 SA RD ”ARP File”.
525 SA RD Memo Base station bids, M. Makkonen 21.11.1978; SA RD Memo Base station bids, M. Makkonen, K. Merontausta 4.12.1978; SA RD Memo Constructing of inter-Nordic radio telephone network, 7.12.1978.

The director of the Radio Department, Keijo Toivola, pressured Salora to at least submit a bid.[526] During the evaluation of bids, the Radio Department brought Salora-Nokia and Radiosystem together, in order to make combined manufacturing possible.[527] In addition to this, the Finnish representatives influenced the NMT Group to accept the joint bid of Salora-Nokia and Radiosystem to a final group of four, from which the orders were made.[528] The Radio Department thus also influenced the rise of the Radiosystem, because the company had made only bids for combiners. At that moment the legal disposition of the company was still unclear, because it had just recently diverged from Magnetic.

In the context of procurement of base stations and MTX for NMT network, the most essential motive of the Finnish Radio Department seems to have been the lowering of total costs, in order to enable the financing of the construction of the network.[529] The Radio Department even planned combine the purchases of MTX and base stations, at least to some extent. It would have wanted the NEC exchange, which was considerably cheaper than Ericsson's AXE. In addition, NEC would have delivered some of the base stations not requiring combiners, this lowering total expenditure even more. The Telegraph Department, however, primarily preferred the AXE exchange. Alternatively, if AXE was to be considered too expensive, it suggested that Telefenno[530] would have to be persuaded to present a new bid, even though it did not participate with any more final bids. This time Telefenno should be asked to develop DX-100 (Alcatel's E-10) to MTX usage. The Radio Department regarded this as the worst possible option, because it would, even in optimal cases, have delayed the implementation of the NMT for a year. The Radio Department got this proposition knocked down, and finally it accepted AXE, after the total price was lowered by calculator means.[531]

The director of the Finnish Radio Department, Keijo Toivola, created an atmosphere among engineers subordinate to him, that it would be positive to support domestic industry and its export efforts.[532] Yet this did not reflect visible on work of Finnish representatives in the NMT Group during the

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526 Koivusalo 1995; Palmberg 1997; - According to Jorma Nieminen (interview), base station did not fit to Salora’s business idea.

527 Miettinen-Lehenkari 1999: according to the original bid Magnetic would have sub-contracted combiners for base station manufactured by the Salora-Nokia consortium. This raised the price level beyond consideration. On the other hand, Radiosystem made a bid for combiners only. While the Finnish Radio Department brought Salora-Nokia and Radiosystem together, it killed two birds with one stone, because the prize level was lowered essentially to be competitive, and Finnish manufacturers later acquired competence to manufacture combiners, see interview of Matti Makkonen and SA RD Memo Base station bids, M. Makkonen, K. Merontausta 4.12.1978.

528 SA RD Memo Base station bids, M. Makkonen 21.11.1978.

529 This claim is supported by the fact that the Radio Department was eager to construct as wide a coverage as possible, even at the cost of capacity. The aim was to provide credible service for the customers, see interview of Matti Makkonen.

530 Telefenno was a joint enterprise of Nokia and Televa.

531 SA RD Memo Unofficial meeting 20.10.1978, M. Makkonen 24.10.1978; TD Memo Procurement of MTX 30.11.1978; RD Letter 4.12.1978 to PD.

532 Interview of Matti Makkonen.

development phase of NMT standard. The relationship between the Finnish NTA and manufacturers, and the role of Finland within NMT cooperation started to change from 1982 onwards.[533] The Finnish Radio Department started actively support export efforts of Mobira. At first, the Radio Department lent unofficially personal for Mobira to boost attempt to sell NMT system to the United Kingdom.[534] Secondly, quite surprisingly Mobira took the lead role in export efforts to the United Kingdom in the latter part of 1982. Even more extraordinary was the role of the Finnish Radio Department. In summer 1982 it stated that it would not need an interim NMT-900 system at all, but in December an agreement was signed by Radio Department and Mobira, regarding the construction of experimental network on the 900 MHz band. The contract was made before the Nordic countries had officially decided to start development of the NMT-900.[535]

The procurement policy of the Radio department of the Finnish NTA had far-reaching consequences for the possibilities of Nokia becoming a system supplier. The pre-requisite was the manufacturing of the base stations, but Mobira did not manage to sell them anywhere else except to the Finnish NTA. Even though Mobira got more orders from the Finnish NTA, it did not start further development of the construction of the base stations; the order for the first base stations for small-cell networks thus being presented to the Swedish Magnetic.[536] The Radio Department was not pleased with the quality of Nokia's base stations in comparison to Magnetic. The other goal was to increase competition, or actually introduce competition, because the Radio Department was not pleased with the Nokia’s prices.[537] In this situation, Mobira had to develop a totally new construct for the base station, this opening possibilities also for export.

Even though the joint experimental network of the Finnish NTA and Mobira did not turn out to be as important as it was supposed,[538] it was a clear signal for expansion to the competence of Mobira. The decisive steps towards competence to supply the whole infrastructure were soon taken. In truth, it was Mobira that had the idea of resuming development of the MTX, but the development order for the Finnish NTA was of pivotal importance.[539] The

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[533] Also other governmental bodies, mainly Ministry of Foreign Trade, started to support export efforts, although they were not successful.

[534] Interview of Matti Makkonen.

[535] SA RD Memo from Oslo Meeting (4.6.1982), Matti Makkonen 10.6.1982; NMT Doc 83-893, 83-897.

[536] The better quality of Swedish (Magnetic’s) base stations was an objective fact in the early 1980s, but not all of the criticism was fair. It was the Finnish NTA itself that had requested a different physical size for the base stations that differed from other Nordic countries used.

[537] SA RD Memo Procurement of small-cell base stations 29.3.1984

[538] Matti Makkonen's interview.

[539] Toivola 1992 and Palmberg 1997 A claim that the MTX order was a manipulation carried out by the Procurement department of Finnish PTT, because in the preliminary order there was no mention whether it should be in accordance with the NMT-450 or the NMT-900 system. In practice, however, it was an order for development work, because Nokia had the option of deciding whether it was supplying an NMT-450 or NMT-900 exchange. The first exchange ordered by Finnish NTA was actually was sold to Turkey by Nokia with the aid of state officials.

contract left Nokia totally free hands to choose the exchange it wanted to deliver to NTA, even though the NTA clearly wanted to have an exchange for an NMT-900 system. The contract was not actually a major risk for the Finnish NTA, because in the case of total disaster, it could buy an exchange from Ericsson. On the other hand, the Finnish NTA (particularly the Radio Department) wanted to diminish dependency on one supplier, Ericsson, because it was not happy with delivery times, price and attitude towards cooperation.[540] Secondarily, the Finnish NTA was supporting Nokia's export, a fact soon evident. Even the first exchange ordered by the Finnish NTA was delivered to Turkey. The construction for the Turkish network was formally made by the consulting company Telecon, the main shareholders were NTA and Association for Telephone Companies, but in practice it was constructed by the personnel of NTA.[541] Also the Ministry for Foreign Affairs participated in organizing the export.[542]

The supposition that the Finnish NTA was attempting to materialize the intentions of industrial policy would seem obvious, on the grounds of the many-sided intervention of governmental authorities. The primary motivation for the Radio Department, however, was the needs of the field, because it was evidently aiming to end its dependency solely on Ericsson. Ericsson's AXE-MTX exchanges were expensive and their delivery took a great deal of time. On this occasion, the Radio Department's arguments were not in conflict with a division of its own administration, the Telegraph Department or "switching world", because Nokia's "revolutionary"[543] DX-200 exchange had become extremely popular among Finnish operators.

The active pressure of Swedish and Finnish NTAs had crucial importance for Ericsson and Nokia respectively. Without the clear vision of the Swedish NTA, Ericsson would not have developed the MTX based on the modern digital technology represented by AXE. Since cellular telephony turned out to be much more popular than had been expected, a flexible and large-capacity AXE exchange gave Ericsson the competitive advantage. Without the firm stand by the Finnish NTA, and particularly the Radio Department, Nokia (Mobira) most likely would not have entered the market for NMT base stations, this stand providing a vital impulse for Mobira to improve its technology. The NTA also provided extremely favorable conditions for the development of the MTX for the NMT-900 system. Furthermore, wide support was given by state officials to Nokia to promote exports, even though, in practice, this merely demonstrated preference for Nokia.[544]

The close relation of the NTAs of Sweden and Finland to the "domestic" manufacturers LM Ericsson and Nokia has invoked a general interpretation that

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540 Interview of Matti Makkonen.
541 Toivola 1992
542 Toivola 1992; Knuuttila 1997.
543 Televa/Telefenno/ did not start to develop the processor, but it implemented microprocessors.
544 The actual success in export was based on a cooperation agreement between Nokia and Alcatel that formed basis for the breakthrough.

these administrations aiming for idustrial political goals and ensuring the possibilities for the industry of their countries. Such an interpretation has been made on the grounds of the final outcome. However, viewed from the process aspect, the picture thus constructed is different, because both of the administrations were heading primarily in the directions desired by the field of activity itself. The lack of existence of any early industrial political goals is supported by the fact that the NTAs did not actually especially support terminal manufacturing of domestic industry.[545]

It was not for motives of industrial policy that the Swedish and Finnish NTAs meant to create national champion. They were, instead, fostering the interests of the NTA itself for practical reasons. Originally the relationship between Swedish and Finnish NTAs with their domestic manufacturers was not especially warm, because in the early 1970s, the SRA was not interested in the NMT project, and the Finnish Radio Department was skeptical towards Nokia's procedures in developing the first base stations for the NMT-450 network.[546] The supply of equipment for the further orders for the NMT network tightened ties to the domestic NTA, and widened Ericsson's cooperation several other NTAs. Nokia followed the same type of path a few years later. What was special in this process was the NMT standard was not one to which any particular company had the exclusive rights. The development of the standard was, instead, clearly being conducted by the NTA in cooperation with the manufacturers. The NMT standard required much more cooperation than one owned by some company.

2.4 The success of NMT revised

National issues have steered the studies on NMT, though the NMT Group itself was a multi-national body. Secondly, the focus of studies had reflected the changes in telecommunications, although there has been a considerable lag. The studies concerning the NMT were primarily of Swedish origin, because the Swedish NTA had the central role in the development of the NMT system. The success of the NMT is often explained on the grounds of Swedish factors. This

545 The NTAs bought a small number of terminals from several manufacturers to boost type approvals, this move, however, being motivated by practical need. It seems that only the Norwegian NTA was actually giving preference to a domestic supplier, making a development contract in 1978 with Simons Electro A/S. This project was funded by the NTA and by the Development Fund, see TN Meeting (Sty mote) 24.8.1978 Dock 125/78. As earlier stated Swedish NTA was planning to have only two terminal manufacturers, but it was negotiating with Motorola, this implying that the motive was not to support domestic industry in the first place, this plan consequently being rejected.

546 SA RD Files related to Development of base stations: At this phase it was Mobira (the joint Salora-Nokia venture) that developed these base stations, the actual work being done in the Nokia manufacturing plant in Oulu. The internal memos of Finnish radio Department reveal that the department relied on Salora, but felt a certain mistrust towards "Nokia's procedures". The Radio Department considered that Salora should have done the work, because it had more experience and the spirit required to work with NTA.

seems alluring, because Sweden was the first in the world to start using an automatic radio telephone system as early as in the 1950s, taking the initiative in the development of the NMT. Due to these factors, because the Swedish manufacturers had attained a position of importance.

Attempts have been made to explain Swedish developments in the field of mobile telephony on the grounds of the interaction between the market and technical factors.[547] The research has also focused on the origins of the telecommunication business in Sweden and the process of acquiring of competence related to the field.[548] These studies explain the Swedish development, but they tend to leave open the questions why NMT was realized as an inter-Nordic project, why the cooperation succeeded and why the "Swedish model" was not applied here, in connection to the implementation of the system and in many issues with administrative nature. To answer these questions, the operations of the NMT Group must be viewed from the perspective related to its most obvious dimension: cooperation of the Nordic NTAs in telecommunications.

The rise of the Nordic manufacturers to the world market, and the shift in emphasis between manufacturers transferred the interest from Ericsson to Nokia,[549] and to the role of the Finnish NTA-related breakthrough of the industry.[550] This has been scrutinized from the point of view of the operational qualities of the NMT Group, emphasizing that the group gathered together the Nordic competence and , administrations favoring domestic manufacturers in order to achieve the goals connected with the technology policies of the countries.[551] These approaches divulge information regarding the manufacturers' product development, the purchasing policy of NTAs and the relationships between the different participants during the development process. These explanations leave open issues regarding the motives, their implementations, specifically, the relation between the NMT Group and the NTAs.

The elaboration of the NMT standard in the Nordic context, and the commercial break-through of the standard as a first of the cellular systems, has encouraged the views based on the Nordic standardization practice and the conditions applying only to the Nordic countries. It has been claimed that the most essential factors were as follows:[552]

- Incremental evolutionary approach to technological innovation and distribution
- Environmental factors prevailed in the Nordic countries
- The unique and flexible organization implementing the process

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547 Hulten and Mölleryd 1995.
548 For example McKelvey et al 1997; Mölleryd 1996; Mölleryd 1999.
549 See for example Lemola and Lovio 1996; Pulkkinen 1997.
550 See for example Palmberg 1997 and Palmberg 1997 A.
551 Miettinen and Lehenkari 1999.
552 Knuuttila 1997; Knuuttila and Lyytinen and King 1997.

- The creation and mobilization of all technological core-competencies, required for designing, manufacturing and operating of mobile telecommunication networks
- Innovative features of mobile telephones and services.

This approach defines the features of the Nordic cooperation in general, but leaves unexplained the reasons for the failure of other projects and also the unique features of the NMT.

Many of the previous studies have emphasized the flexibility of the NMT organization in the development procedures and the organizing of the work. Experts from various fields were gathered together, some with experience in switching, others in radio, with help also being given by occasional sources of expertise in different areas. In addition, it has been maintained that the engineers participating formed a relatively unified group of the same generation. This "Radio Gang"[553] was enthusiastic; and despite the different nationalities, there were no cultural barriers between them, which assisted cooperation. In fact, the Norwegians, the Swedes and the Danes almost share a common language, the Finns having Swedish as their second official language.[554]

The combining of the competencies of different NTAs helped the development process of NMT, but it cannot be regarded as a the most vital condition for the success of the work. The most important feature of the cooperation was that the decisions were not made on a national basis. Instead, a variety of views on the applicability of several possible solutions were encouraged by the different practices, experiences and views of the various administrations concerned. This showed in far-reaching decisions of great importance. Although the Swedish NTA had the expertise, knowledge and abundance of resources for the NMT project, the practices adopted by the Swedes, however, did not apply to the maintenance of large networks servicing an extensive number of subscriber. When the ownership of the terminals was being decided, the Swedes were reluctant to relinquish operator ownership of the terminals. The liberalization of terminal ownership and sales was a prerequisite for the creation of the inter-Nordic market for equipment, and it had far-reaching consequences for the development of the Nordic manufacturers. In general, it is obvious that the NMT would not have become what it turned out to be, if it had been developed by just one NTA (see TABLE 14).

Even though multi-national cooperation on an equal basis was an absolute pre-requisite for success, it is doubtful that the NMT project would have been launched and carried out underdifferent circumstances. First of all, the

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553 The phrase "Radio Gang" is actually misleading. Although the Radio Departments of NTAs had essential role as well as radio divisions of enterprises, many vital experts had expertise in switching or some other field.

554 Knuuttila 1997. - In practice, however, there was a language barrier between the Finns and Scandinavian representatives, excluding the Finns who spoke Swedish as their mother language, Hans Myhre's and Matti Makkonen's interviews (Scandinavians could not understand Finnish, a long period of time also being needed for new persons joining the NMT Group to understand Danish or Norwegian.

elaboration of the NMT project occurred at a point in time, when conditions could not have been more beneficial. The economic integration process formed an exceptionally advantageous environment and conditions, the trend of the traffic policy provided for the rationale of constructing the Nordic network, and the solid organization of Nordic cooperation in the field of telecommunications presented fitting structures for the process. On the other hand, neither of these became a burden. No shared industrial policy was formed. The temporary manual MTD system satisfied the need for communications between Sweden, Norway and Denmark, while Finland had its national system. Nordic NTAs started several projects in the beginning of the 1970s in telecommunications, thus the NMT Group did by no means, turn out a freak of nature, something that arousing attention unwelcome and startling at the same time. And secondly, industrial policy did not interfere with the standard-setting process. This was not self-evident, especially since the Swedish NTA had the major share of investments in resources and funding. Yet it was logical, because the goal of a common system would benefit all participating countries, the economic incentive of mobile telephony, on the other hand, being small compared to expenses.

TABLE 14 The roles of Nordic NTAs during the standardization of NMT
Sources: compiled from NMT Minutes, interviews and literature

DELEGATION	POSITIVE ROLE	NEGATIVE ROLE
Denmark	• early counter-balance to Swedish NTA • godfather in solution of frequency issue • strongest support for liberalization of terminal trade	• opposition to hand-held terminals • push-button "incident" • "faded away", although physically present in mid-1970s
Finland	• became more active in the late 1970s • NTA organized development and sales of system simulator • most eager support for liberalizing the terminal user interface • increased competition in base stations (and exchanges also) • foresaw defects of signaling (test system)	• "invisible" during the early 1970s • Finnish interpretation of cooperation (strictly on national terms) • Alleged Japanese-like behavior (negative or positive, depending on perspective)
Norway	• second to Sweden up to early 1980s • took the role of leader in 1982	• together with Sweden (anti-liberal attitude towards user interface)
Sweden	• leading role up to early 1980s • capable, this notwithstanding to cooperate on equal terms! • had the vision of a 10-year development period • investments in resources and studies	• less experience in managing nation-wide networks • weakest (and latest) in supporting liberalization of terminal trade • anti-liberal attitude towards user interface • not willing to admit shortcomings of NMT-450

The role of industrial policy, as far as the development of NMT is concerned, has been evaluated on shaky grounds, if by industrial policy we mean something connected with the national promotion of a domestic manufacturer. The multinational NMT Group could not support the position of a particular manufacturer in the event of all participants being included in the project, the group intending to function as successfully as possible. On the national level, there may have been some attempts at supporting the interests of national industry. The NMT Group, however, acted as a filter of sorts between propositions coming from the outside and those interests of the group itself. The most important of these was possibly the intention of Swedish origin, stating that no more than two manufacturers be selected for the production of terminals, and that the ownership of the terminals be left to the operator. In principle, there was basically an opportunity to mix the goals, the NMT Group participants were experts in their field and members of the domestic NTA at the same time. However, the dual role did not cause any major inconvenience during the standard-setting phase, mainly for two reasons. Firstly, the NMT Group put first preference on the common interest (the joint Nordic service). Secondly, it was accepted that each NTA intercourse with domestic manufacturers as a normal procedure.

The NMT Group did not adopt the status and role of a typical standard forum, intervening, instead, even in equipment procurement, giving recommendations on methods, coordination of procurements, and eliminated the problems connected with the implementation procedures. On top of these, the NMT Group had to work actively in the context of procurement, however, even though the concerns here were of a pragmatic nature, aimed at securing the implementation of the system despite delays in schedule.

The NMT Group was the most dominant player during standard-setting process. Political level was totally absent and administrative level took quite a passive role. The Nordic Radio Committee (NTR/NR), which was superior body to the NMT Group merely accepted and confirmed measures of the NMT Group. There was no need to act as a guardian, because working groups (like NMT) were intentionally given nearly free hands to operate. The NMT Group also implemented very flexible working procedures and managed to do that successfully. Only after the NMT system was already operational the NMT Group was not any more able to cope with the situation: it was becoming a hindrance for further development of NMT standard and the NR had to intervene in order to liberalize the philosophy of maintaining the standard.

The relationship between manufacturers and the NTAs was quite close, especially in Sweden and in Finland, where the NTAs were participating in the development of digital exchanges, whereas in the area of radio communications there were no such relations. There was no need for it. This did not imply that the administrations of Sweden and Finland would have remained in a passive role. On the contrary, they exerted a direct influence on the manufacturers to focus on the field of mobile telephony. The interest of the manufacturers was quite limited, because the larger market was connected with the equipment production for fixed networks. By their intervention the NTAs decisively improved the success of manufacturers on the field of cellular telephony. The interests of the administrations and the companies were connected also in the international diffusion of the NMT system. By opening the field to exports, namely, the prices for the equipment could be pushed lower.

The NTAs made a decision of critical importance in creating a Nordic market for terminals.[555] The selling of manual terminals was completely deregulated, with Sweden, in 1971, being the last to give up its operator ownership of the equipment. This increased the interest of the Nordic manufacturers. Foreign manufacturers, however, were unwilling to enter the Nordic market, even though this market had become the largest in Europe, as far as manual systems were concerned. When NMT networks started operating, they could not attain a strong market position. Participating in development work before the presentation of the final specifications did not bring any major advantage to the manufacturers. From the early phase of the development of the NMT system, also foreign manufacturers were enticed, with some success, to participate in the project. But it was not until the specifications stage that the Japanese companies and the Finnish manufacturer Salora, which was Nokia Mobile Phone's predecessor, started to participate actively.

The prerequisite for the success of the NMT project was a vision of the kind of mobile telephone system needed in the 1980s. Very early prepared basic requirements concentrated on defining the perceived needs for services, while technological concerns were left aside, other than by presupposing that the system would be automatic. The Swedes had two essential visions. The first one was related to automaticity, which was considered the trend of the future. This was concomitant with another vision related to the time schedule. It was estimated that the development process would take 10 years. During the period technology would develop and price levels go down. The perceived features were viewed with the serious intent of being materialized, for which reason a remarkably long period was reserved for the development phase. The NMT Group stayed with its vision, although it was precisely at itskey points that manufacturers directed their criticism. The group had a considerably longer time-perspective than the manufacturers, this being seen in such matters as to whether some solutions were realizable in practical or economic terms. In this dialogue, the NMT Group was helped by the fact that a great number of manufacturers were brought to the project, allowing the perceived requirements to be maintained. The NMT Group's steadfastness was also assisted by its not being a typical development project, it was, however, to undergo gradual progress until 1975. And thereafter attempts were made to ensure the required functions, a step-by-step model for the productions being chosen. When the NMT entered the market it was the only cellular system with a roaming function fit in economically into the construction of large networks.

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555 The Norwegian and Danish NTAs had liberalized the terminal trade in the 1960s, the Finnish NTA made a similar decision in the late 1960s, and the Swedish NTA in 1971.

The starting point for the NMT Group was the harmonizing of the Nordic services for mobile telephony, so the technical questions were but one part of the issue. The group prepared or also solved administrative questions, keeping almost all the service's activities under its authority. In fact, it helped to create the Nordic "operator policy", because it intervened in the whole process chain: numbering, pricing, charging, type approvals, maintenance, frequencies. It was also a notable feature that the group could function without any outside intervention.

The solving of the frequency issue was the most important of the administrative questions, being the prerequisite for the whole process of. In choosing the frequency range not many alternatives were on offer, because a band had to be found, that would be suitable for all the Nordic countries, and would be concerned with the Danish requirements for co-ordination of frequencies with West Germany. The frequency question was purely pragmatic, and the purpose of its solution was to reserve a technically usable number of frequencies. The intention was to make the system effective as regards the economy of its frequency use, for which reason the resolving method for the calling channel was considered as being of high importance. With the private operators the sparseness of the frequencies was solved by applying for more frequencies, but the administrative operator intended the frequencies to be used economically.

The NMT project was developed in the same socio-cultural environment as the other joint projects of the Nordic NTAs. Only the NMT, however, became a commercial success outside the Nordic countries. The timing was a decisive factor for the NMT. When projects for the paging and data networks were initiated, they were by no means the most advanced, the forming of the groups following the activity of CEPT. When these products came on the market in the late 1970s, they could not offer anything new to distinguish them from the rest. Especially the paging project was a coalescence of unfavorable actions, because it was connected to the interests of industrial policy; the system being based on the use of broadcast company networks, in which the Finnish NTA had no say.

In the early 1980s, the NMT-450 became an unexpected international commercial success. During the first two years of its commercial implementation, the system was adopted by six countries, and a similar number of countries were seriously considering adopting it. The rapid success of the NMT system can be explained by a combination of three factors related to timing, cost and features of the system.

Timing was perhaps the most essential factor, because the NMT system was the second cellular system to enter commercial service after the Japanese NTT. Furthermore, NMT was the first cellular system to operate on the 450 MHz band. Before the summer of 1985 other systems, including the Japanese NTT, the US AMPS and the British TACS, used the 900 MHz band, which was not allocated for land mobile usage until 1979 in Regions 1 (Europe-Africa) and 2 (the Americas). Subsequently, systems such as the French RC 2000, the Italian

RTMS and the German C-450 used the 450 MHz band, but they were too late coming on the market.[556]

The cost factor was also decisive. From the beginning the NMT Group aimed to control the costs of both the infrastructure and the terminals. This set limits for development. On the other hand, however, the most essential features were carried out, the price level having sunk at the moment when construction of the equipment started.[557] It was also managed to keep the costs under control, and subsequently even lower them, several manufacturers having begun production of equipment.

The NMT system had also some features that others could not offer. The most essential was that of roaming.[558] In addition to that, the 450 MHz band was well suited for the construction of nation-wide networks, due to the relatively small number of base stations required. This had a direct effect on the cost of the network.

One feature of a successful product is its ability to expand its life span. The NMT-450 system provided a foundation for further development work. The advantage of the NMT had been the possibility of offering an alternative for the construction of a country-wide system operating on the frequency of 450 MHz. The selection of frequency band was originally an asset, but it became a hindrance to further development work. Yet this was not a technical disadvantage, but rather a "failure" in decision making. No initiative to use the 900 MHz band was made in the Nordic countries, because the CEPT had not, before WARC 1979, reserved a mobile band from the 900 MHz frequency. Even in 1975 the NMT Group had presented the need to use the 900 MHz band in the future. On the other hand, there was no perceived need for it before 1982 when the United Kingdom and France informed the Nordic countries that they would need a system based on NMT, to operate on the 900 MHz. At that point, immediate needs could not be met, and NMT being delayed in the international market for systems operating on the 900 MHz band. The expansion of NMT abroad was not assisted by the insistence of the NMT Group on keeping the United Kingdom and Netherlands outside the group, although they expressed interest in joining. By the end of 1980s, the NMT Group finally opened its doors to non-Nordic countries. Iceland had already joined the NMT Group earlier.

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556 In addition to the fact that the abovementioned RC 2000, RTMS and C-450 systems were more or less proprietary, they had peculiar features not advantageous from the diffusion point of view. The RC 2000 was not actually a true cellular system, because it lacked the handover (it could not transfer a call from one base station area to another), RTNS had serious security problems and C-450 systems were prohibitively expensive.

557 The AMPS system, for instance, used expensive technologies for the location of a mobile station, but it lacked roaming, whereas the German C-450 system used the SIM card, a very sophisticated feature at that time, though hardly worth the huge rise in costs during the era of auto-installed phones.

558 The Japanese NTT system, for instance, was not originally provided with the roaming feature. In the early 1980s roaming was possible the most wanted feature within European NTAs, according to the Paris meeting of 1980. It was ranked first in order of preference by French and British NTAs, SA RD Memo from Paris Meeting 8.-10.10.1980, K. Teräsvuo 21.10.1980 and Memo by Ö. Makitalo et al 3.11.1980.

The success of the NMT was due to several factors, but there was one eminently predominant factor. If this factor had not prevailed the basic essence of the NMT would have failed. It was the idea of a socially-shaped mobile telephony. Nation-wide networks were considered to be important for society in general through the infrastructure they provided. Nordic cooperation in telecommunications gave extra impetus to this idea, promoting compatible services, not requiring compatible systems at first. With increased economic cooperation and land transportation increasing the importance of inter-Nordic mobile telephone service, the requirement regarding roaming became especially important. But it was not just a matter of emphasizing just one facility. In general, the NMT Group put services first in their order of preference, leaving technology implementations open. It was even willing to implement the required services in a limited or simplified way initially, just to secure the introduction of services. The group was not blinded by technical features, not considered to be of primary importance. The exception was the cost of technology, the intention being to keep this low.

3 ELABORATION OF THE GSM STANDARD

3.1 Background

3.1.1 Political context

3.1.1.1 Economic integration

The European Economic Community (EEC) was founded in 1957 with the signing of the Treaty of Rome, its aim being to form a single European market. In order to achieve this goal, the EEC tried to create conditions for economic growth in Europe and to foster political integration. The integration process was slow, and there is, in fact, a notable difference between the European Community of the early 1980s and the European Union[559] of the 1990s in their authority and width of membership.

The integration process of European Community had two dimensions. The original members comprised only Belgium, France, Luxembourg, Italy, West Germany, and the Netherlands. They were joined by United Kingdom, Ireland and Denmark in January 1973, and Greece in January 1981. The last extension before the birth of European Union occurred in January 1986 when Portugal and Spain became members.

Horizontally, the integration process was even slower than it had been vertically. At the Paris summit of 1972, The Heads of Government declared as their overall goal a European union, yet it was not until the mid-1980s that the process started to roll on. In December 1982, a special Council of Ministers was established to promote the establishment of the internal market. In 1985, an EC Commission white paper "Completing the Internal Market" opened a new era. The next step was taken with the resolution of an intergovernmental conference in Luxembourg to consider the possible reform of the relevant Community treaties. These decisions were assumed into legal document status with the signing in February 1986 of the Single European Act (SEA), a treaty that came into force in July 1987. According to the treaty, a single market was to be established at the end of January 1992. This act was the first major revision of the Treaties of Rome since 1957.[560] A notable feature was in the fact that the reform of the treaties clearly took on the characteristics of a package, linking the creation of a single market with the development of new Community policies and institutional changes.[561]

The Single Europe Act and in particular the Maastricht Treaty were major passage points in the growing authority of the EC because they broadened the

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559 European Union was established by the Maastricht Treaty, signed in December 1991. It came into force in November 1993.

560 Schneider and Werle 1990; Hurwitz and Lequesne 1991.

561 Hurwitz and Lequesne 1991.

scope and variety of policy issues subject to the influence of the EC. Up until 1987, EC decision-making involved mainly relations between the Commission and the Council relationship with the European Parliament making increasing efforts to become involved. The Maastricht Reform introduced a new cooperation procedure by giving Parliament the right of veto in certain cases. A reform of the Treaties also radically changed the decision-making process. Before the Single Europe Act, the bulk of decisions required unanimity, but the Single Act introduced simple majority voting in important areas such as internal market legislation. The Maastricht Treaty extended this procedure to new areas.[562]

Even though the SEA was disappointment for those who favored more efficient and democratic integration, some even thinking that it was a step backwards, the mood changed rapidly between 1986 and 1989. The new procedures of the SEA were now seen as an opportunity. The possibility of majority voting was generally perceived as a strong whip for member states to adapt more flexible strategies early in the decision-making process, thus enabling faster decision-making. The SEA or Project 1992 became a widely-used slogan, generating hope inside Europe and suspicion outside Europe.[563]

The integration process was not merely a matter of internal European Community authority. In 1989-1990, the European Community prepared negotiations with the European Free Trade Association (EFTA) with the aim of extending the Single Market to EFTA countries. This idea was named the European Economic Area (EEA), an idea of great economic value, since the EEA countries would have a total population of 370 million inhabitants, accounting for more than 40 per cent of world trade. As a bloc, EFTA was the EC's largest trading partner. In 1989, exports to EFTA countries comprised 26 per cent of EC exports. As a matter fact, most the economies of the EFTA countries were more closely integrated with the EC than were those of the new members of the EC, such as Spain or Greece.[564]

In order to get access to the Single Market, EFTA countries had to adopt the relevant Community legislation. The EFTA countries were afraid of being left outside the Single Market, because they were much more dependent on the EC than the EC was on them. At the end of the 1980s, around 61 per cent of EFTA imports came from the EC with 55 per cent of its exports going to the EC. Originally neutral EFTA countries considered the EEA a convenient way to accelerate economic integration in the Single Market without being a full member of the EC. The political elite assumed a positive attitude towards the EC between 1989-1990, with several EFTA countries starting to consider applications for EC membership.[565] Just a year after the EAA Treaty came into force in January 1994, Austria, Finland and Sweden became members of the European Union.

562 Andersen and Eliassen 1993.
563 Wessels 1991.
564 Schwok 1991.
565 Schwok 1991.

3.1.1.2 Origins of the European Community's Telecommunications policy

Since the early 1970s, the European Commission had been urging for the opening of telecommunications to public procurement as a major prerequisite for the future development of the sector. The resistance of member states was insuperable and telecommunications was one of the three sectors excluded from the application of the 1976 directive on opening public procurement supply contracts.[566] This was understandable, because it was generally considered that the Treaty of Rome did not provide the EC with any powers in telecommunications. Almost all attempts by the EC to enter the telecommunications policy arena were associated with trade policy issues. A gradual change in the attitudes towards telecommunications policy can be observed to have taken place since the mid-1970s . In addition to trade policy considerations, the telecommunications sector was deemed relevant for industrial policy. [567]

The first reaction to merger of telecommunications, data processing and the audio-visual sector was the Commission's report of 1979, which for the first time emphasized the industrial policy dimension of information and communication technologies and their closer interconnections. The report emphasizes the contrast between Europe's weakness in information technology and its strength in telecommunications.[568] Telecommunications was seen as a part of the information technology industry, encompassing microelectronics, computers, consumer electronics, professional electronics and telecommunications. The Commission was concerned because European firms were losing ground in information technology and communication policy was discovered as being a relevant factor determining the industrial competitiveness of Europe vis-à-vis the United States and Japan. Inspired by the Japanese experience with inter-firm research consortia and empowered by the Treaty of Rome to promote the competitiveness of European industry, Etienne Davignon, the Commissioner of Industry, invited Europe's twelve largest information technology firms in 1980 to draw up a work program for the industry.[569] The outcome was The European Strategic Program for Research and Development in Information technology (ESPRIT), which was aimed at promoting intra-European industrial cooperation in R&D in the five main IT areas (microelectronics, software technology, advanced information processing, office systems and computer integrated manufacture); to furnish European industry with the basic technologies that it needed to bolster its competitiveness through the 1990s; and to develop European standards. The pilot phase

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566 Ungerer 1990.

567 Schneider and Werle 1990.

568 Schneider and Werle 1990.

569 In January 1984 twelve major European IT companies clearly indicated their support for a standardization policy based on harmonized implementation of international OSI standards and committed to using them.

commenced in 1983, followed by primary phases in 1984, 1984 and 1986 respectively.[570]

The intervention of the European Commission in telecommunications was carried out by applying at least three different approaches. First, an incremental approach aimed at harmonizing and standardizing new services and equipment at the European level. Short-term goals, related mainly to telematics, failed because the France, the United Kingdom and Germany were not ready to harmonize their telematic equipment (mainly videotex), no market being opened for videotex services around the world. Secondly, a federative approach was aiming at constructing a Europe-wide telecommunications network. The Euronet/Diana network was created in 1982, and the CADDIA and INSIS programs were launched the same year. And thirdly, a legal approach through legal actions against interpretations of limits were related to monopoly rights of PTTs. Even though European institutions, and particularly the European Commission, were active in trying to influence the development of telecommunications in Europe, the initiatives had only limited success. The result was inevitable because actions lacked coordination, there was no clear vision of what the European telecommunications policy should be, the instruments of actions were limited in scope.[571]

In the early 1980s, the EC relationship with the telecommunications sector changed, and within a few years the political weight of the EC in the national telecommunications sector increased considerably. A major impetus was given by the deregulation and liberalization of the telecommunications markets in the United States. After the divestiture of AT&T,[572] AT&T entered the European markets through joint ventures with Philips and Olivetti. Since IBM had started to diversify into telecommunications, it was feared that US multinationals, in addition to their hegemony in information technology, would also conquer Europe's communications market. In response to the threat, a Special Task Force was created in 1983 and it achieved its goals of creating an awareness of the new sectored policy domain. Awareness strategy was oriented to three goals: legitimatising EC action in telecommunications vis-à-vis the hostile national PTTs; creating a coalition of supporters by mobilizing those positively affected by community action; and stimulating and coordinating the various initiatives taken by the Commission. During the period 1983 - 1986, which could be labeled as the support-seeking or awareness phase, the Special Task Force launched a series of studies by consulting firms showing that Europe was losing ground in telecommunication and that coordinated action was necessary.[573]

The basis for EC activity was in forming a cohesive telecommunications policy instead of unconnected actions. In the mid-1983 the Commission became active, taking the offensive in this field. In June a note signed by M. Davignon, Commissioner for Industry, strongly emphasized the need for a common

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[570] Mytelka 1991.
[571] Dang-Nguyen, Schneider and Werle 1993.
[572] The decision to break AT&T was made in 1982, and it came into force in early 1984.
[573] Dang-Nguyen, Schneider and Werle 1993.

telecommunications market. This note has been seen as a definitive breakthrough of an EC telecommunications policy. with the Commission reacting in September and outlining six lines of action for a common telecommunications policy:

- Setting medium- and long-term goals;
- Defining and implementing a research and development program;
- Expanding the market for terminal equipment by mutual recognition of registration standards;
- Cooperating closely to create the telecommunications infrastructure of the future;
- Using fully modern telecommunications technologies in underdeveloped regions within the EC;
- Opening up protected procurement markets.

The Commission established a group of experts, which between November 1983 and March 1984 formulated an action program, which was forwarded to the Council of Ministers in May 1984.[574]

The most important goals of the Telecommunications action program were related to the creation of a Community-wide market for telecommunications equipment and to improving the development of advanced telecommunications networks and services. The intention was to fulfil the former goal implementing common standards derived from international standards; progressive application of procedures for the mutual recognition of type approval for terminals; and opening of access to public telecommunication contracts. The tool for the latter goal included the implementation of joint infrastructure projects; launching a development program for the future wide-band network; and setting-up a wide-communications system to link the various political authorities in the Community.[575]

Within a relatively short period, the EC proceeded to implement an action plan for telecommunications (see TABLE 15). By June 1985, the pilot phase of RACE program (R&D in Advanced Communications Technologies for Europe) had been launched lasting 18 months and bringing thirty major European telecommunications manufacturers together with the ultimate aim of introducing Community-wide integrated broad-band networks by 1995.[576] The EC also originated measures to open major procurement of telecommunications and to harmonize type-approval, these being essential requirements for the fostering of a joint industrial policy. The relationship between the EC and standardization is complex, though it had been seen as being a straightforward trail. In the spring of 1985, the EC adopted a policy usually called "The New Approach" to harmonization and standards. According to the most extreme view, the new policy was implemented because there were more and more conflicts between the EC and CEPT, and "*producing standards often took so long that [many of them..] were already out of date once agreement on them could be*

574 Schneider and Werle 1990.
575 Ungerer 1990.
576 The original goal of introducing IBC was year 2000.

reached".[577] But in the light of the actions that took place, it is very difficult to see this kind of sharp confrontation, because CEPT accepted the desires of the EC with astonishing rapidity. In any case, the most important frontline was between EC and national governments, because the EC primarily considered standards barriers of trade, endeavoring to prevent establishment of national barriers and to increase authority over national governments. The EC was aiming to make the standards binding for all Member States. The practical standard-setting process was left to specific outside bodies, such as the CEPT.[578]

Parallel to the expansion of EC activities in telecommunications, the Internal Market process began to unfold giving support to the EC telecommunications policy. In order to establish guidelines for European telecommunications policy in the context of the 1992 Internal Market and to urge on deregulation and liberalization, the Commission issued a Green Paper on telecommunications in the summer of 1987.

The Green Paper received wide recognition and support from most of the parties involved. This was seen as a direct consequence of the awareness-building policy of the Commission and significant changes in the international policy environment. Only a year after the divestiture of AT&T in 1983, the British privatized British Telecom and licensed a competitor (Mercury)[579]. The Japanese privatized NTT, opening up competition in 1985.[580] The Dutch, the French and the Germans were preparing reforms at the time. The Green Paper was aiming for deregulation and an increase in competition. The provisions of the network infrastructures and basic services were to remain unchallenged, but as far as enhanced services and terminal equipment were concerned, the Green Paper called for radical liberalization, in addition to urging for separation of the regulatory and operational activities of the PTTs. After publication in June 1987, the Green Paper was sent to the Council, the European Parliament, and the Economic and Social Committee. In June 1988, the Council supported acceptance of the major policy objectives in the Green Paper, several directives being passed in 1989 in line with the Green Paper platform. [581]

Though there is no reason to undermine the value of the Green Paper, its importance should be seen in the context of EC internal development, and mainly as a manifestation of EC over national governments. From the actual impact-relationship point of view, it was not an omnipotent magic wand. By early 1992, only the United Kingdom, Finland, Norway, Sweden and Switzerland had created regulatory bodies separate from the ministry in charge of telecommunications, and only the United Kingdom was a members of the EC, having established separate regulatory body (OFTEL) three years before the

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577 Bekkers and Liotard 1999, 111, quoting Schreiber 1991, 99. Actually this quotation of Bekkers and Liotard is false, because Schreiber was referring to harmonizing the activity of EC by directives, not to standard-setting of specific standardization bodies.

578 See e.g. COM (87) 290 (Green Paper), 100.

579 On the mobile sector pne competing operator (Vodafone) got its license already in 1982, although operations started in early 1985.

580 On the mobile sector, the monopoly of NTT was broken in 1988, and the operation of competitors started in 1989.

581 Dang-Nguyen, Schneider and Werle 1993.

TABLE 15 Initial implementation (before 1987) of Telecommunication Program of 1984
Sources: Ungerer 1990; COM (87) 290.

R&D	STANDARDIZATION	MARKET LIBERALIZATION
Council Decision of 25 July 1985 on a definition phase for an R&D programme in advanced communications technologies for Europe (RACE) (85/372/EEC).	A Memorandum of Understanding establishing a framework for cooperation between the Community and CEPT was signed in July 1984	Council Recommendation of 12 November 1984 concerning the first phase of opening up access to public telecommunications contracts (84/550/EEC).
Proposal and workplan for RACE main phase (COM 86/547)	In line with the CEPT-Commission agreement, working programmes of CEPT regarding standardization have been agreed since 1985 with the Commission. The CEPT has reached a similar agreement with EFTA	On 29 March 1985 the European Court adopted its ruling on the "British Telecom case" which turned out to be a cornerstonc for future case-law on telecommunications in the Community
	CEPT decided - at the request of the Commission - on the working out of a "family" of specifications which could be made binding on its members. These are known as NETs (Normes Européennes des Télécommunications - European Telecommunications Standards). To	Council Directive of 24 July 1986 on the initial stage of the mutual recognition of type approval for telecommunications terminal equipment (86/361/EEC).
	Council Directive of 3 November 1986 on adoption of common technical specification of the MAC/packet family of standards for direct satellite television broadcasting (86/529 EEC)	
	Council Recommendation of 22 December 1986 on coordinated introduction of ISDN in the European Community (86/659/EEC)	
Telecommunications action program; Commissions Communication, COM (84) 277, 18 May 1984; approved by Council 17 December 1984		

Green Paper. Neither did the other goal, introducing competition, proceed swiftly, because, for example, data communication was a monopoly service in all the other countries except the United Kingdom, Finland and Sweden.[582] One major objective of the Green Paper was the establishment of an independent European standardization body. This aim did not encounter any resistance worth mentioning within CEPT, which gave all Technical Committees working under the supervision of the Co-ordination Committee for Harmonization to the newly-established ETSI. CEPT accepted the establishment of ETSI as early as the beginning of 1988.[583] It is paradoxical that it was much easier for the EC to get its agenda accepted by subjects or organizations independent of supervision by the EC, than by Member States.[584]

3.1.2 Adapting the idea of the pan-European mobile communications system

The World Administrative Radio Conference of 1979 (WARC –79) was a major prerequisite for the diffusion of public cellular systems. The status of land-based mobile radio had been low. Still land-based mobile services were not considered to be an international service requiring agreement on a three-region basis, decisions being made regionally. In Region 3 of the ITU (Asia), there was no change in allocation, this band was already being implemented for mobile radio in Japan. In Region 1 (the Americas) the 806-890 MHz and 890-960 MHz bands became allocated primarily for mobile use, although in the United States the FCC had already nationally allocated frequencies on this band for mobile usage. In Region 2 (Europe-Africa) changes in the allocation of new bands created the opportunity for the simultaneous use of these frequencies in various countries. The 890-902 MHz and 928-942 MHz bands were reserved primarily for the land mobile as well as the 902-928 MHz and 942-960 MHz bands for land-based mobiles on a secondary basis.[585]

The common band in Europe, although still just a possibility, raised the status of land mobile radio, previously shadowed by maritime and aeronautical mobile radio, now making it the focus of interest. Various issues related, on the general level. to land mobile radio were assigned to several CEPT and ITU task groups. Most of these groups were to accomplish their missions during the period 1982-1984.[586]

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582 See Communication Outlook 1993; OECD countries were given liberalization indexes. Of all the European countries, the highest index was given to Sweden (16), the United Kingdom got 14, and Finland got 8. The third European country was Portugal (3).

583 See Temple 1991.

584 EC did not have any formal relationship with CEPT, nor it did it have formal influence on the EFTA countries, even though they had joined the European Economic Area, before 1994.

585 Borman, Dorian, Johnson and Miller 1981; Ebel and McNaughten 1981.

586 GSM Doc 5/82; Memo from Paris meeting 8.-10.10.1980, O. Mäkitalo et al 3.11.1980; The task of SF/CEPT (SF2/10) was to survey current and envisaged mobile services (by 6/79); identify preferred services (10/81); define operational and facility requirements and user procedures for the international service (3/82); define operational and facility requirements and user procedures for the international service (10/81); and produce a Draft Recommendation (3/82). The deadline was March 1982, but work was not in line with the

Although land-based mobile radio became more attractive after WARC–79, it still held in low esteem by CEPT.[587] Before the frequencies could be implemented, the practical question of radio links was to be solved. These links used by military forces could not totally be cleared before the year 2000. They were also of rather important economic significance, since they held investments of approximately FRF 2 billion.[588]

The potential of pan-European mobile communications was observed by the French PTT, which in June of 1980 invited several PTTs of Western European countries for a meeting to be held in October in Paris. The invitations were sent to Germany, Austria, Switzerland, the Netherlands, the United Kingdom, Denmark, Finland, Sweden and also to Norway, Italy and Belgium, but the latter three declined the invitation. The main agenda of the meeting was to find out the plans of the participating countries for exploiting the allocated 900 MHz band and for lower bands allocated a long time ago. In addition to the bands to be exploited, issues such as timetabling, capacity and technology of the outlined systems were of interest. On the basis of the information obtained, a rough summary was drafted, with two major outcomes. Firstly, there was a huge gap in the level of technology to be applied. Only France had made a decision to start, in 1981, a project based on digital technology. The Nordic countries had unofficial plans to implement their digital systems in the 1990s. All the other countries, excluding the Nordic countries, France, the United Kingdom and Germany, would accept pre-cellular systems. Secondly, however, only France and the United Kingdom were in the immediate situation of having to exploit the 900 MHz band by 1985. The Netherlands would possible have to switch over to the 900 MHz band, but the Nordic countries and Germany, however, were not planning to implement system on 900 MHz until the 1990s. Other countries omitted the 900 MHz from their plans.[589]

According to the agenda to the Paris meeting, administrations would discuss the use of the 900 MHz band for public mobile telephony.[590] In actual fact, the French PTT had a much more "compact" objective. It wanted to start the harmonization of a common system. In order to carry out this task, a proposal for CEPT should be outlined in the names of one or two administrations. In addition to this, at the same time the task was to be continued unofficially, because it would take one to two years to get the issue approved and organized within the CEPT. This decision had to be made immediately. The French proposal got frigid feedback. The other countries wanted to think it over instead of rushing into it blindly. The Nordic countries and Germany, in particular, criticized the 1985 time-table on the grounds that it

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schedule. Working group R outlined a draft on the use of frequency band 862-960 MHz. ELT group initiated study on market analyses; new service concepts; frequency needs; and interface to fixed networks. Also CCIR and CCIT of ITU had initiated activities related to land mobile radio.

587 For example, SF group held priority C, while R group had priority B, see GSM Doc 5/82.

588 SA RD Memo from Paris meeting 8.-10.10.1980, K. Teräsvuo 21.10.1980.

589 SA RD Memo from Paris meeting 8.-10.10.1980, Ö. Mäkitalo et al 3.11.1980; Memo from Paris meeting 8.-10.10.1980, K. Teräsvuo 21.10.1980

590 SA RD Arrived letters 142/623, 1.7.1980.

was impossible to meet within the CEPT region. For this reason, there were also plans to carry on the work without any involvement by the CEPT organization, and to gather together a limited number of interested countries.[591]

The Paris Meeting was a failure from the point of view of outcome, because there was no general need for immediate exploitation of the 900 MHz band. On the other hand, it had a two-fold impact on the national level. Shortly afterwards, the Nordic the countries pushed ahead with their "digital outline", the second generation NMT-2 (FMK)[592] group being established in March/April of 1981. While the Nordic countries did not intentionally hesitate, the first meeting of the group was not held until December of the same year. [593] France also pushed the planned national digital project ahead, but it is likely that the over-optimistic nature of the timetable was revealed.[594] Since only France and the United Kingdom were anxious to exploit the 900 MHz band, it is no surprise that these countries, sharing the same situation, also embarked on a project of cooperation. In April of 1982, on the behalf of both administrations, BT invited several countries to participate in a meeting in June. According to the invitation, both countries were planning to go to London to implement an NMT-based system, similar in signaling but using the 900 MHz band. This system was to be operational by 1985. Actually, the attracting feature of this initiative had already died before the London meeting, because only a few days earlier, the Netherlands had issued a proposal at the Telecommissions meeting in Vienna that work be started on the 2nd generation mobile system. This responded much more to the needs of other European countries since in their opinion the demand of urgent 900 MHz solution had remained unchanged. In addition to the United Kingdom and France, only the Nordic countries and Ireland showed serious interest towards an immediate pan-European system. [595] In spite of this, the United Kingdom and France continued with preparations with the Nordic countries, and another major meeting was held in October 1982 in Paris. This, however, turned out to be a dead end as far as Franco-British cooperation was concerned.[596]

The issue of the Paris meeting had been incubating for over 18 months, when the Dutch made their initiative, an initiative that was favorably received. In principle, it was decided to establish a working party under the hierarchy of the Harmonizing Committee of CEPT. The CEPT also altered its plan of action in favor of land-based mobile radio. What made the European countries engage

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591 SA RD Memo from Paris meeting 8.-10.10.1980, K. Teräsvuo 21.10.1980.

592 The original name was NMT-2, but this was used only for a while. Unofficially an abbreviation ISMOC (Integrated Services Mobile Communications) was used initially, but it was not accepted officially, and was replaced by scandinavian term FMK (Framtidens Mobila Kommunikationer)

593 SA RD NR 9; Min. of ISMOC # 1 (1-2.12.1981).

594 French delegation visited Swedish NTA in October 1981, and Swedish gave thorough and specific information on NMT system and also on new Nordic NMT-2/ISMOC (FMK) project. It is not known what was the impact of this visit, but it is likely that it revealed the impossible nature of French schedule, see SA RD Received letters Dno 256/640 1981.

595 SA RD Memo, B. Magnusson 8.6.1982 Rml 7751.

596 GSM Doc 18/82.

in cooperation was the Franco-British initiative, because it generated an actual pressure to utilize the 900 MHz band.

The pan-European mobile radio initiative made quite rapid progress, the Nordic countries giving it practical support with them formulating the draft mandate for the established working party, together with the Netherlands. This was done in September after the summer vacation, and CCH processed it in October. After a period of less than half a year, the first meeting of the GSM Group started in December 1982.[597]

It would be tempting to argue that pan-European cooperation in mobile radio started with the failure of national projects, the success of the NMT having provided a model which to emulate.[598] This contention is, however, false because at that time national projects were based on the implementation of the 450 MHz band (the Nordic countries, Germany and Italy), and none of them failed. Only the British and French study projects of sorts were connected to idea of using the 900 MHz frequency. Paradoxically, due to unrealistic timetabling, the British and French had to unite resources and seek unorthodox solutions, although Franco-British cooperation failed before it actually got started. On the other hand, as early as 1982, the Nordic NMT system had proved to be very successful, but it was not an incentive strong enough to start up a campaign of pan-European cooperation. The carrot was tempting, but it needed a stick as well. This came in the form of a joint Franco-British immediate system proposal which would endanger the usage of the 2nd generation pan-European mobile radio service.

3.2 The GSM Development process

The chapter is divided into three parts, corresponding to the actual phases of standardization of the GSM system, these phases being partially overlapping. The feasibility phase embraced the period from 1982 to early 1985, when the GSM Committee was formed, starting to define the given task and to evaluate its feasibility. This phase ended upon attainment of adequate certainty, giving way to the standard-setting phase, covering a period from early 1985 to late 1991. The main task of the phase was to define technical specifications. After the technical specifications were finalized and approved by the supreme standardization body, the implementation of the GSM system began. Originally the set goal was July 1991, but, in practice, commercial deployment of GSM networks was postponed by one year.

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597 SA RD Memo from preparatory meeting of GSM in Copenhagen 19.9.1982, T. Hahkio; Memo from CCH meeting in Florence, 17.-18.11.1982, T. Hahkio; GSM Doc 2/83, 3/83, 5/82.

598 As claimed by Bach 2000, for example.

3.2.1 Feasibility phase

3.2.1.1 Setting the task

3.2.1.1.1 Action Plan

The Netherlands and the Nordic countries had proposed establishing a pan-European Mobile Communications Group at the Telecommission meeting in June of 1982. As a result of these activities, the countries were given the task of drafting a preliminary study plan for the first official meeting of the GSM Group.[599] Nordic influence was an obvious feature, the draft study plan bearing a close resemblance to the mandate of Nordic second generation FMK system.[600] The FMK Group had already been established a year before GSM. There were also essential differences. First of all, the time schedule for finalizing specifications was to be one year earlier for the FMK. On the other hand, the deployment of these systems was the reverse of this, since the launch of the GSM system was targeted for the early 1990s, but for the FMK system not before 1992-1994.[601]

The action plan of the Nordic FMK system was marked by experience gained from the development and launching of the NMT system. This was a striking observation, the FMK action plan containing several purely non-technical issues, such as the timetable for the development of the test system and for running it, the preliminary and final deployment decisions, as well as the synchronous construction of the networks. An FMK-like approach was strange to GSM, because Telecommission and CCH had limited the task of GSM to technical issues only. The CCH stuck very strictly to this policy, eliminating all issues concerning type approval procedures from the preliminary draft. The proposal drafted by the Nordic countries and Netherlands did not contain anything about deploying the system, and there was only a very broad reference, that the need for verification of the proposed system was must be considered.[602]

The most essential action limiting the GSM plan was the CCH decision to cut down all post-1986 time attributes (see TABLE 16). This organ outside the GSM enabled it to interfere in GSM plans. The shortening of the post-1986 timetable was understandable from point of view of the original mandate, but otherwise the decision was absurd, since all the post-1986 tasks were left untouched. According to CCH, the GSM Group was, in principle, required to finalize the work before the end of 1986. The Nordic countries had found this to be impossible, interpreting the task as meaning that only the broad outline specifications of the system should be defined before the end of 1986. The actual detailed specifications could then be worked out between 1986 and

599 GSM Doc 2-4/82.
600 Toivola 1992; compare SA RD NR-9-6 and Min. of ISMOC # 2 to GSM Doc 2/82.
601 SA RD NR 9, 13; GSM Doc 2/82.
602 See particularly SA RD Memo from CCH meeting in Florence, 17.-18.11.1982, T. Hahkio, and appendixes of it.

TABLE 16 Major assignments of GSM Committee according Action Plan of 1982 and adjusted Action Plan of 1984
Source. GSM Doc 2/82, 39/84 Rev 1

1982 ACTION PLAN	TIME LIMIT	1984 ACTION PLAN	TIME LIMIT
Specification of operational and technical requirements of the system.	ASAP	Services and facilities	late 1986
Examination of on-going studies in other groups	Interim report in Oct. 1983.		
Identification and study of relevant reports etc. available for use by GSM from research institutes such as universities, public research laboratories etc.	Interim report in Dec. 1983		
Investigation of the administrative and regulatory aspects of the use of mobile radio-communications equipment by subscribers not permanently domiciled in the country in question, including border-crossing procedures.	Dec. 1983		
Investigation of the different national conditions for type approval of radio transmission equipment.	Dec. 1983		
Assessment of the impact on system capacity, caused by inclusion of portable mobile stations	Dec. 1983	Portable stations: an assessment	Late 1985
		System structure	end of 1985
Establishment of basic system parameters (outline specification) for the various parts of the system and their interfaces.	Dec. 1986	Choice of analog vs. digital system	mid 1986
		Modulation and access	mid 1986
		Encryption (other than speech)	mid 1986
Further, the following technical specifications, including functional aspects in sufficient detail to allow for type approval and to guarantee compatibility of mobile stations, should be established: 1) System specification 2) Specification of system parameters relevant to the mobile services switching center 3) Specification of system parameters relevant to the base station 4) Specification of system parameters relevant to the mobile station, including man-machine interface	Removed		
Recommendation on harmonized administrative procedures for licensing and type approval.	Removed	Type approval	Open
Recommendation on harmonized rules for the use of mobile radio-communications equipment by subscribers not permanently domiciled in the country in question, including border crossing procedures.	Removed	Free circulation of users (mainly non-GSM task)	early 1985

1990.[603] Although the study plan was severely hampered by CCH, the GSM Group proceeded as if nothing had changed, and it considered the year 1986 as only a period of rough system description. It took until 1984 for CCH to become aware of the fact that there was a major "black hole" in the GSM study plan. CCH requested a more detailed plan, but again the GSM Group persisted. Although the GSM Group prepared a more detailed plan, it did not approve of 1986 as the final year of the project.[604]

3.2.1.1.2 Basic requirements

The basic requirements set for the GSM were part of the study plan in addition to the time table. Since they had also been drafted by the Nordic countries and Netherlands, it was no surprise, that the NMT experience was exploited. The focus of requirements was laid on services and a dependency on fixed networks. On the other hand, there were only a few technical requirements related to fixed networks. There were some exceptions from the Nordic "NMT tradition". Spectral efficiency was mentioned because of a demand by the Dutch, but it was formulated in a very broad manner. At the CCH meeting, the Germans even wanted to add a formula on how to calculate the maximum capacity of the system, but this intention was intercepted. These examples clearly showed the difference in approach between the Nordic countries and the others.[605]

Even the joint use of the system was a basic idea and the most fundamental requirement, roaming, was not mentioned, but this requirement was indirectly present in forms other requirements, and it was a working assumption. There were more issues, which were not formally requirements, but which were more or less working assumptions, e.g. handover. Digital transmission of speech was not mentioned at all, but it was basic original idea, and study work of the GSM Group focused on digital technology. The absence of these requirements may be exposed intelligible by the fact that there was not a single requirement dealing with the radio part of the system, not taking spectral efficiency into account[606] (see TABLE 17).

The requirements set for radio frequency utilization later turned out to be essential, when the decision related to the radio access method was made, despite the fact that the requirements were in contradiction with the decision-making aspect.

The original basic requirements were presented as a simple list with no logical ranking or classification. In 1985 the requirements were revised, although the main change was in their re-organization. The requirements were categorized into five classes: services, quality of service and security, radio

603 SA RD Memo from CCH meeting in Florence, 17.-18.11.1982, T. Hahkio; GSM # 1
604 GSM # 5; Doc 39/84 Rev1.
605 SA RD Memo from preparatory meeting of GSM in Copenhagen 19.9.1982, T. Hahkio , Memo of CCH meeting in Florence, 17.-18.11.1982, T. Hahkio.
606 GSM Doc 2/82.

frequency utilization, network aspects, and cost aspects. The contents remained basically the same, although some issues were shaped in a more specific way, some restructuring also taking place. The original requirements, however, laid down the basis for the work of the GSM Group.

TABLE 17 Basic requirements of GSM system
Note: Alterations shown in *italics*
Sources: GSM Documents 2/82, 73/85 Rev1

1982 Requirements		1985 Revised Requirements	
Services			
b	A future 900 MHz mobile communications system should be harmonized to such an extent that mobile stations can be used in all participating countries, preferably all CEPT countries.	1.1	The system shall be designed such that mobile stations can be used in all participating countries.
c	It is expected that in addition to normal telephone traffic, other types of service (non-speech) will be required in the system. *However, since such predictions concerning the user requirements at the time the system of the 1990s will be in operation will contain a great amount of uncertainty, a modular system structure allowing for a maximum of flexibility will be necessary. This purpose may be achieved by applying the same philosophy as applied for modern developments such as ISDN and OSI. The choice of standards for protocols, logic functions, etc. shall as far as practicable seek to obtain compatibility with such modern developments.*	1.2	In addition to telephone trafic, the system must allow maximum flexibility for other types of service, e.g. ISDN related services.
e	The services and facilities offered in the public switched telephone networks and the public data networks at the relevant period of time should be available in the mobile system. It'shall be possible to benefit by the full advantages of new techniques to to be introduced. The system may also offer additional facilities (e.g. special barring functions, rerouting of calls, and special message handling facilities).	1.3	The services and facilities offered in the PSTN/ISDN and other public networks should as far as possible be available in the mobile system. The system shall also offer additional facilities, taking into account the special nature of mobile communications.
g	It should be possible for mobile stations taking part in the system to be used on board ships as an extension of the land-based mobile service.	1.4	It should be possible for mobile stations belonging to a system to be used on board ships, as an extension to land-based mobile service. *Aeronautical use of GSM mobile stations should be prohibited.*
j	The system shall be capable of providing for portable (hand-held) mobile stations, *but the consequential impact on the system shall be assessed.*	1.5	In addition to vechile-mounted stations, the system shall be capable o providing for handheld stations and other categories of mobile stations.

Table 17 continues

	Quality of service and security		
		2.1	*From the subscriber's point of view, the quality for voice telephony in the GSM system shall be at least as good as that achieved by the first generation 900 MHz analogue systems over the range of practical operating conditions.*
k	*The demand for voice security (encryption) may increase considerably and must be taken into account.* Any encryption facilities should not have a significant influence on the costs of those parts of the system used by mobile subscribers, who do not require such facilities.	2.2	The system shal lbe capable of offering encryption of user information, but any such facility should not have a significant influence on the costs of those parts of the system used by mobile subscribers, who do not require such facility.
	Radio frequency utilisation		
d	The system concept to be chosen shall permit a high level of spectrum efficiency and state-of-the-art subscriber facilities at a reasonable cost. *Information on the order of ultimate system traffic capacity is needed at an early stage.*	3.1	The system concept to be chosen shall permit a high level of spectrum efficiency and state-of-the-art subscriber facilities at a reasonable cost, *taking into account both urban and rural areas and also development od new services.*
f	The system shall be designed to allow for operation in the entire frequency bands 890-915 MHz and 935-960 MHz.	3.2	The system shall be allow operation in the entire frequency bands 890-915 MHz and 935-960 MHz.
a	The existence of earlier mobile telephone systems working in the 900 MHz band must be taken into account. In order to ensure full compatibility from the frequency sharing point of view, the work concerning these systems should be thoroughly followed.	3.3	The 900 MHz CEPT mobile communications system must co-exist with earlier systems in the same frequency band.
i	The system should be designed with a high degree of flexibility in order to ensure that mobile stations of earlier public 900 MHz systems in Europe will be able to operate in the same frequency band without mutual interference. - It shall be possible for each individual country to choose the point of time for transition from earlier system to the new system and have both systems operating simultaneously		
	Network aspects		
h	To ensure unambiguous identification of the mobile stations, a high capacity integral identification plan for mobile units is required, which will have to be compatible with the numbering plans and routing possibilities used in the public switched telephone	4.1	*The identification plan shall be placed on the relevant CCITT Recommendation.*
		4.2.	*The numbering plan shall be based on the relevant CCITT Recommendation.*
n	The system design shall permit the participating countries to maintain their existing charging systems, thus enabling different tariff principles and rates to be used.	4.3	The system design must permit different charging structures and rates to be used in different networks.

Table 17 continues

o	For the interconnection of the mobile switching centres, an internationally standardized signalling system shall be applied. This interconnection must not require a dedicated signalling system exclusively for the purpose of the mobile communications syst	4.4	For the interconnection of the mobile switching centres and *location registers*, an internationally standardized signalling system shall be used.
l	The design of the system shall be such that no significant modification of the fixed national telephone networks will be necessary.	4.5	No significant modification of the fixed public networks must be required.
		4.6	*The GSM system shall enable implementation of common coverage PLMNs.*
		4.7	*Protection of signalling information and network control information must be provided for in the system.*
Cost aspects			
m	Since the cost of the mobile stations will constitute the main portion of the total system cost, the system parameters shall be harmonized with the view to limit the cost of the mobile unit.	5.1	The system parametres shall be chosen *with a view to limit the cost of the complete system*, in particular the mobile units.

3.2.1.1.3 Organizing the work

Between 1982 and 1985, the work of the GSM Group was characterized by the limitations and definitions set by CCH of CEPT. The GSM Group was defined as being a coordinator, which implied that it was the intention for the burden of the work load to be carried by organs other than the GSM Group. Another restriction related to this issue was a rule according to which the GSM Group was allowed to maintain direct contact with the other working parties of CEPT. Contacts with non-CEPT groups had to go through CCH.[607]

The most urgent task of the GSM Group was to chart the work and studies carried out or planned by all possible organizations in order to launch studies in missing areas. The group of potential colleagues turned out to be quite numerous, but after the second GSM meeting the group was limited to SF, CD, CS, ELT and R working parties of CEPT and the COST study project.

In early 1984, CEPT TR3 actively expressed its wish to formalize the relationship with GSM on the subject of low bit rate speech encoding, since TR3 was studying new speech coding techniques. The GSM Group also contacted the ITU CCITT SG XI and XVI groups due to the problem associated with the long delays occurring in connection with sophisticated digital speech encoding algorithms to be used on the radio link.[608] The GSM Group had planned

[607] GSM # 1.
[608] GSM # 4; GSM Doc 22/84.

cooperation with several ITU organs, belonging both to CCITT and CCIR, but in general the progress of work within ITU was too slow for the timetable of GSM. ITU turned out to be a useless partner for GSM, although GSM exploited CCITT work already available, e.g. numbering plan and Signaling system # 7.[609]

TABLE 18 Status of relevant studies from GSM point of view in summer 1983
Source: GSM Doc 31/83

ORGANIZATION	TOPIC AND STATUS OF STUDY
CEPT SF	Contribution of definitions and user requirements to various kinds of services and facilities relevant to mobile communications
CEPT CD	GSM Group has proposed a new question regarding the technical requirements for non-voice communications between mobile stations and public data networks, telex and other relevant networks
CEPT CS	GSM Group invited working parties CS, CD and SF to contribute on the subject of encryption.
CEPT ELT	Working group ELT is collecting and will present information on market research concerning the future demand for mobile services.
CEPT R	A letter has been sent to the chairman of WG R drawing attention to the problems of frequency sharing between the GSM system and the systems that will be introduced earlier in the same frequency band in some countries. A possible solution, taking into account the fact that the bandwidth of the GSM system channels has not yet been defined, is being proposed for the consideration of WG R.
COST 207	A study program has been elaborated taking into consideration the viewpoints of the GSM Group. The main study items are propagation tests, modulation technique and base-band processing

The synchronizing of time with outside groups turned out to be a difficult problem. In addition to this, the working methods and procedures of the GSM Group became a bottleneck. The GSM Group assembled less than frequently: at first only once a year, since 1983 twice a year, and after that three times a year (up to 1987). These general meetings took from three to four days and, from late 1984 onwards, sessions of five days became the rule.[610] The scattered frequency of the meetings became a hindrance, since the GSM Group was not able to provide data and information to outside working parties early enough. In order to solve this problem, the GSM Group established three temporary sub-groups in early 1984.[611] These sub-groups assembled only during plenary meetings of the GSM Group, which meant that the assemblies of the GSM Group were split into three parts. Formally, the GSM Group had to establish sub-groups for every meeting, but in practice the task areas of sub-groups became stable quite soon. These were:

- WP 1 Services and facilities
- WP 2 Radio transmission issues
- WP 3 Network aspects

609 Interview of Thomas Haug.
610 GSM # 1 to 30.
611 GSM # 4.

As early as at the stage when the temporary sub-groups were being established, the GSM Group also foresaw the need for making them permanent, but the CCH strictly opposed this proposal.[612]

Division of labor between the GSM Group and other organs was easily realized, since the tasks the GSM Group gave to outside parties were quite well defined and restricted. The only exception was the COST 207 project, which was elaborated at the same time as the GSM. At first, this caused the GSM Group some headaches, for fear of its work being duplicated, if there were two groups working simultaneously. This menace was very soon removed, when the operational scenes were defined. COST was focusing on study and the GSM Group on technical specifications. In general, the relationship between these two organs was good and the GSM Group set priority to study the items proposed by COST. Based on the GSM Group's opinion, COST 207 established three sub-groups, focusing on radio wave propagation, digital modulation techniques, and speech processing respectively.[613]

3.2.1.2 Securing prerequisites

3.2.1.2.1 Frequency issue

A generally accepted frequency band was the most important and self-evident prerequisite for an international mobile communications system. The frequency issue was not solved, despite that in 1982 the CEPT released its *Recommendation T/R75-02*, allocating the 862-960 MHz band for international maritime radio and land-based mobile telephone. Maritime radio caused trouble, since it was outlined to implement at least the part of the reserved 895-907/940-952 MHz band, overlapping the land-based mobile band of 890-915/935-960 MHz.[614]

Maritime radio was an extra nuisance for the GSM Group, because the original mandate released by Telecommission defined the task of the GSM Group being to harmonize technical and operational characteristics of public mobile communications system in 900 MHz without any specific qualifiers. The Nordic countries and the Netherlands clearly set focus on land mobile communications and the CCH set aside the issue of maritime radio by deciding that use of the system at sea would be allowed. The GSM system was identified primarily as a land-based communication system from the beginning, but the frequency problem was not solved.[615]

The issue of interim analog systems turned out to be the most complex and far-reaching problem, particularly since the CCH eliminated the standardization of interim systems from the GSM study proposal. In practice, this decision left the issue of interim systems – and especially that of

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612 GSM #4, 5; Doc 38/84.
613 SA RD Memo from CCH meeting in Florence, 17.-18.11.1982, T. Hahkio; GSM # 4-6; GSM Doc 82/84.
614 GSM Doc 27/83.
615 SA RD Memo from CCH meeting in Florence, 17.-18.11.1982, T. Hahkio; GSM # 1

standardization - to the participating NTAs. On the other hand, the GSM Group had to be aware of the situation, and it could not totally neglect the issue. During the first two meetings of the GSM Group the interim systems generated a lot of discussion. There was no consensus. Germany in particular was against placing interim systems on the 900 MHz band, because the future of the GSM might be endangered if interim systems were to show explosive growth and administrations would go on their own. Other delegates admitted that the anxiety of Germany was real, but at the same time it was emphasized that there was no alternative. Some countries simply had to deploy interim systems and exploit the 900 MHz band.[616]

The second meeting of the GSM Group in March 1983 was a culmination point for the interim systems. Franco-British cooperation had now failed. France and Germany were negotiating on cooperation related to a common interim system on the 900 MHz band, and Germany went so far as to declare its willingness to cancel totally its C-450 system (450 MHz), a project still under development. In addition to this, the Nordic countries had already officially made the decision to start development of the NMT-900. It was, however, the United Kingdom, where plans had accelerated most rapidly, proceeding on a wide front, including policy aspects. At a stage as early as late 1982, the United Kingdom had plans to allocate 15 MHz for an interim system, in such a way that at first 7.5 MHz would be allocated and in 1988 another 7.5 MHz. This would leave 10 MHz for the launch of the GSM system.[617]

In March 1983, the United Kingdom introduced its national frequency proposal to the GSM Group, which accepted it, conveying the proposal to the CEPT–R group as the GSM Group's recommendation. Furthermore, the GSM Group also recommended that the band for maritime radio was no longer current. According to the proposal, 890-905/935-950 MHz should be reserved for interim systems and 905-915/950-960 MHz for the GSM. The United Kingdom had identified the weak points of its proposal. First of all, the 10 MHz band of the GSM system needed to be continuous for a wide-band approach to be chosen. Secondly, the interim systems might not be able to use the same continuous band everywhere, and for this reason, the interim systems should be able to exploit the whole 25 MHz band.[618]

The GSM Group adopted the British proposal quite readily, because interim systems were no longer avoidable, and the leading participants in the GSM system were heavily committed to deploying interim systems. It was an inevitable reality. An equal sense of reality was reflected in the GSM Group's decision not to try to remove the reservation of 914-915 MHz for cordless telephones, since several countries had already allocated this block for this purpose.[619]

The frequency allocation to interim systems and to GSM was accepted by sub-working party R21, and the main R group accepted the proposal a couple

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[616] GSM # 1 and 2, particularly the former.
[617] GSM # 2; Doc 11/83.
[618] GSM # 2; Doc 11/83.
[619] GSM # 2; Doc 28/83.

of weeks later in March.[620] Formally, CEPT recommendations were not binding to member countries, because CEPT lacked sanctioning power. In practice, at least the leading countries, which were developing their interim systems, adopted the recommendation and, as a rule, obeyed it. Their activity was no longer a menace to the GSM system from the frequency point of view.

3.2.1.2.2 Defining services

The overall objective for GSM systems was, that they should offer the same services and supplementary services and facilities available on fixed networks. GSM should also be able to offer communication between mobile terminals, and between mobile and fixed terminals, and this communications should be as good as between fixed terminals.[621]

In cooperation with CEPT SF, GSM WP 1 prepared a preliminary report on services and facilities. This report included a list of services, although not all of them had been officially accepted by the GSM Group. The most important of these were :[622]

- Types of usage (carried by a person, mounted in land-based vehicles, ships and used on inland and coastal waters or on trains)
- Roaming (international, national and inter-system between two or more PLMNs)
- Handover (three types of handover, but required only within the same MSC; possible also between different MSCs of the same PLMN)
- Basic services (telephony; telex, teletex, facsimile; Circuit Switched Data; Packet Switched Data; ISDN)
- Supplementary Services (implementation under consideration)
- Charging requirements (how services are provided).

One single issue generated prolonged discussions, that of whether to allow hand-held terminals or not. It was an important decision from the system definition point of view, but from the future commercial point of view, it was one of the two most important decisions made by the GSM Group. The approach to hand-held terminals also revealed the attitude of different operators towards the importance of service orientation. From the beginning, the most eager advocate of hand-held terminals was the United Kingdom delegation. At first, the British members were not even really aware of the impact on the system, they just wanted to have hand-held phones, since they would be allowed in the TACS system. The Nordic countries, Denmark in particular, were also in support of hand-held terminals. In the other pool, the most noisy opponent was Germany, who, even before the GSM Group had been established, emphatically announced that it would forbid hand-held phones, and continued declaring this message. Germany's attitude put France in an

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620 GSM Doc 32/84.
621 GSM Doc 2/82.
622 GSM Doc 25/84, 28/84; see also GSM # 8; GSM Doc 65/85.

inconvenient position, since originally France was cautiously in favor of the idea, but since the beginning of Franco-German cooperation, France was obliged to be loyal to her new ally. France even proposed the idea of constructing two different networks.[623]

The idea of forbidding hand-held terminals was based on concern for securing sufficiency of capacity. This was always the view upheld by Germany. In many countries of continental Europe, operators limited the call times to two minutes, and this recipe bounced up during pre-GSM talks in the fall of 1980. The Nordic countries eschewed this kind of approach, since they were already advertising "mobile telephones for everybody".[624]

The support for hand-held terminals was so strong that the idea could not easily be rejected. The GSM Group started its evaluation of hand-held phones based on system requirements. By 1985 the movement to approve hand-held terminals had won a victory within the GSM Group.

3.2.1.2.3 Market studies

It was quite logical for the GSM Group to be interested in marketing issues, since the development of a new generation system required exploiting new technology and considerable investments of capital and resources. As early as in the fall of 1981,a consulting company by the name of Pactel had prepared a study named "Future Mobile Communication Services in Europe", which estimated the European market potential for the year 2000. According to Pactel estimates, every sixth automobile would be equipped with a mobile telephone, making the total number mobile stations 20 million. The use of hand-held terminals would increase the numbers of users. According to the most optimistic scenario, a 50 per cent penetration of the population could be reached, totaling over 150 million handsets. But the most conservative scenario arrived at only 3.3 million subscribers or 1%of the population. The supposition for this conservative scenario was based on the high price of the terminal (USD 1 000) and the high prices of phone calls. The most optimistic scenario was based on low-cost terminals, which would correspond to only one tenth of the conservative scenario, and the call prices would correspond to the level of fixed network prices.[625]

It would be tempting to praise the farsightedness of Pactel, because the most optimistic scenario was at least on the same level as the materialized situation, but the vision was based on assumptions unrealistic before the mid 1990s. It was the conservative scenario which was the closest to the estimates prepared by operators before the mid-1980s. According to them, there would be 200 000 mobile telephone subscribers in year 2000 in the United Kingdom. The Nordic countries would exceed one million subscribers between 1995 and 2000,

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623 GSM # 2, 5; GSM Doc 33/84, 69/84, 35/85.
624 See SA RD Memo from Paris meeting 8.-10.10.1980, K. Teräsvuo 21.10.1980.
625 GSM Doc 5/85.

and France would have 204 000 subscribers by 1994. The Germans were even more cautious than the others, estimating the capacity of the C-450 system to be around 60 000 and 70 000, which they hoped would be sufficient up to 1990! [626] This was only about 10% of the peak actually attained by the system.

The operators were not thrilled over the maximum market potential, because they were used to coping with the problem of shortage of capacity. It had been a rule for demand to exceed supply. The operators were consequently interested in issues such as capacity of a system and the variety of services a system could provide. Estimates of subscribers was a difficult task to carry out, because only the Nordic countries had the experience of cellular systems combined with large markets before the mid-1980s. Even the estimates announced by operators were very modest compared to the reality, operators understanding that the GSM system would provide unparalleled capacity. It was the prevailing historical facts and experience that prevented the operators from seeing GSM as everyman's commodity.

The GSM system did not utilize many resources for its marketing estimate issues. The need was identified, and the task was given to CEPT ELT group, which in summer 1983 released charting of ongoing and planned market studies. Subsequently, the GSM Group passed the task of preparing estimates and subscriber categories to participating PTOs, information, however, being received only from France and Nordic countries. Also ELT was given the task of studying and identifying the factors, which could change the trends in the use of mobile communications on the market during the next twenty years. The ELT delivered preliminary reports in early 1985.[627]

The 1985 ELT reports were important,[628] in applying, as they did, the Pan-European mobile communication system to wide-ranging societal, social and economic issues. The first of these draft reports gave a qualitative evaluation of long-term effects on the demand for mobile services, including general economic development, technology development trends, social changes and market development trends. The second report gave a quantitative evaluation of the effect on the demand for mobile services of a wide range of factors covering medium-term environmental and market variables. Although these reports were considered to be preliminary by nature, the ELT drew from them some important conclusions on probable trends: in the near future every country will offer a full product line; telecommunications products will become cheaper; competition on the market for mobile telecommunications will increase; there will be overall growth in data processing, regardless of the degree of economic growth, growth favorable to most kinds of telecommunication.[629]

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626 SA RD Memo from Paris meeting 8.-10.10.1980, K. Teräsvuo 21.10.1980.

627 GSM Doc 5/83, 54/83, 18/84, 34/84, 40/84, 62/84.

628 Yet it is quite typical that these reports are not acknowledged. For example Garrard 1998 only refers to the market study (ETCO report) ordered by EC and published half a year later than CEPT reports.

629 GSM Doc 5/85.

The report dealing with long-term effects on demand was of special interest, since it estimated the potential the GSM system could have in changing the social environment. The ELT employed OECD forecasts on general economic development. Although it was admitted that it was not possible to commit oneself to any of the five scenarios on economic development, it was considered that economic growth was most likely option after a recession. The most fascinating scenario was related to "Big Growth", where an open Europe was under the leadership of international commerce. According to the variables of central importance, the EEC had to undergo a process of strong evolution, and a new, decentralized technology, consisting both of narrow and wide band networks, would have a large impact.[630]

Technology development trends were closely related to hand-held terminals. Pactel had already estimated that the size of terminals would decrease by 50 percent to 300 cubic centimeters and their weight to 500 grams. In addition, a Nordic FMK market study claimed that the development of hand-portable terminals with the aforementioned features would be suited for the utilization of the small-cell system in contrast to traditional systems. Therefore, the availability of hand-held terminals must be expected to have great influence on the realization of the potential market for land mobile communication. The Nordic study also revealed that enterprises wanted to have combined data and speech transmission features. There was no interest ion mere data transmission. Another interesting issue was related to the implementation of the satellites considered unnecessary by Europe. The most extensive point of interest was related to ongoing institutional change within telecommunications, its effect on technical development and the market. It was estimated, that the regulatory situation would be adjusted throughout Europe at varying speeds and in different ways. The PTTs would be forced into a form of self-deregulation to provide necessary and competitive products and services. In a fast-expanding market guided by customer needs, there will be a demand for a high innovation rate and product diversification. This, accompanied by liberalization initiatives, would put pressure on the service providers to act in a strongly market-oriented manner in an environment of increased competition. As an overall result of these tendencies, technical development would be reinforced as a consequence of pacing the innovation rate. Even in the case of the current international deregulation trend vanishing with changes in the political and economic arenas, the need to be market-oriented and competitive was considered to be an irreversible term of existence.[631]

The predicted social changes were notable. The studies reviewed by the ELT originated in the United States, claiming that information was a strategic resource in all sectors and at all levels of society, and that the information society was no longer an abstraction but an economic reality, possibly more important than oil. It was stated that IT would facilitate, and generally support, a decentralization of society. According to the experience of the United States,

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630 GSM Doc 5/85.
631 GSM Doc 5/85.

this was clearly the case especially in some parts of society. Parallel development was expected in Europe also, leading to the assumption of an increased level of traffic at least within the business sector and consequently a growing demand for mobile communication. The ELT foresaw changes in the relationship between society and technology. The situation was now characterized by a move towards a market guided by customer needs and, consequently, by high product diversification. As a result, the question of human acceptance of new technology had become a factor of increased importance. In this connection, it was pointed out that the response to high-technology had been the evolution of a highly personal value system to compensate for the impersonal nature of technology. This was described as the emergence of a "high-tech/high-touch" combination. Implying that if new technology was not customer-friendly, it would be rejected. Introducers of new technology should therefore take into account the human response and see to it that there was a built-in "high-touch" component.[632]

The market development trends were regarded as tempting. With regard to all telecommunication products, the consultant firm of Macintosh forecast the market potential in Western Europe to rise from USD 18.72 billion in 1984 to USD 42.00 billion in 1991. In 1991, telecommunications would be the third-largest sector in electronics and its growth during this ten-year period would be 180%, leaving consumer electronics far behind. Also, mobile communications was seen as promising. As has already been mentioned, Pactel had forecast an unequaled market for mobile telephones, particularly if hand-held terminals were to be used. A Nordic market study arrived at a similar conclusion, predicting that lower prices and portability would have great impact on the total market for mobile communications. Economic factors would thus have a major effect on demand and, in particular, the major incentives to further use of IT within the business transport sector would be for reasons of rationalization and efficiency. In the Nordic countries, the services sector was expected to become a great potential market for mobile communications, while currently the greatest market for mobile public phones to date had been found within the construction and transport sectors. The Nordic experience gave a clear indication that, there was a need for adapting to the transformation of a seller's market into a buyer's market. The precondition for triggering off demand was the establishment of an adequate technical system as the infrastructural basis for mobile communication. The ELT claimed that the full exploitation of the market potential for mobile communication on a Europe-wide basis called for technically advanced and compatible networks. The mobile communication area seemed to offer an extremely favorable combination of both existing and dormant market-pull and the possibility of technology-push and further expansion carried by expected technical break-through and product innovations.[633]

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632 GSM Doc 5/85.

633 GSM Doc 5/85.

The results of market studies presented to the GSM Group by the ELT in early 1985 clearly demonstrated the social and economic value of a joint mobile communication network. At the same time, it became obvious that the PTTs had to be prepared to review their strategies. It is very difficult to estimate the impact of these reports on the GSM Group, but at least the main economic issue of allowing hand-held terminals became a very difficult thing to deny.

3.2.1.2.4 True 2nd generation system: Digital speech transmission

Digital speech transmission on the GSM system was not a matter of course, although the proposals of both the Netherlands and the Nordic countries to the Telecommission in the summer of 1982 were based on the idea of a digital system. During the first meeting of the GSM Group, one member of the German delegation even questioned the meaningfulness of a study of the digital system, since manufacturers had not yet reached any promising results![634] The digital system was an inconvenient object of study from the practical point of view.

Digital speech encoding, channel coding, modulation and propagation were particularly difficult to deal with from the resource-planning point of view. They were strongly interrelated, this making it difficult to split up the work. Far more important was the supposed fact that digital speech encoding did not promise any improvements to spectrum efficiency. The performance in this respect was the same as for analogue speech. Other factors could nevertheless point towards a digital modulation scheme, e.g. improved encryption capability, a simplified system integration, and potentially more compact mobile stations. Also the time schedule of the early 1990s was in favor of digital technology.[635]

The most severe threat to the implementation of digital technology came from interim analogue systems, because most of them were to be deployed in 1986, concurrently with the planned finalization of the pruned GSM time schedule. The menace against digital solution was dualistic. Most of the pressure coming from outside the GSM Group was not a direct stand in favor of the analog system, but rather one related to the time schedule, speaking indirectly for the analog systems. Within the GSM Committee the threat was mainly a mere possibility. France and Germany had in July 1983 signed a declaration of cooperation in order to introduce their joint S-900 system. Since the time schedule for developing the S-900 was very tight, the French and German delegates of GSM interpreted the only possible alternative for the S-900 to be based on the analog technology.[636] In November 1984, France and Germany declared that they were withdrawing altogether from the S-900 project to start a joint digital study project where they would deploy this system. The joint declaration was a catalyst of sorts for the digital approach, but

634 SA RD Memo from GSM # 1, M. Makkonen 22.12.1982.
635 GSM # 1.
636 SA RD Memo from GSM # 6, T. Hahkio 26.11.1984

certainly it was not the primus motor, several countries already having started their digital studies at an earlier stage.

Within the GSM Group, there was no severe menace to digital technology.[637] Studies were focusing on digital technology, since it was not the familiar field that analogue technology was. New technology became more easily acceptable when Sweden reported in March 1984 that a digital system could be even more spectral efficient than an analogue system according to the results of simulation tests.[638] The GSM Group decided in June 1984 to aim for a digital system although the analog alternative was not eliminated. The same meeting accepted four scenarios for radio access. These were FDMA (single channel per carrier), a simple evolution from the analog systems; narrow band TDMA ; wide band TDMA ; and CDMA with slow frequency-hopping.[639] The prevailing opinion was clearly in favor of digital technology. The Digital Mobile Radio Seminar, initiated by the Nordic FMK Group, and held in Finland in February 1985, reflected the opinions of the manufacturing industries. The Nordic countries interpreted that the manufacturers were aiming at the digital system, this not being a distant goal, as far as the technology currently available was concerned.[640]

3.2.2 Standard production phase

Adequate proof was obtained of the economic, technical and overall feasibility point of view during the feasibility phase. The transition to the second phase was not sudden, but it can be pinpointed to early 1985. The standard production phase (1985-1991) required the completing of tasks of selecting basic technical alternatives, defining specifications, and insuring the implementation of the system. In order to be able solve this challenging mission, a strategy had to be defined responding to the limited available time and institutional structures. Also, the standardization body had to be adjusted to respond to the requirements.

3.2.2.1 Flexibility of the GSM organization

During the feasibility phase, the GSM Committee acted as a coordinator and because of this there was at first no excessive pressure to establish an operational organization. When the external bodies started to require more instant flow of information, a committee type of working was found to be

637 Although it seems that there were individuals who were not in favor of analog alternative, see GSM 5, 7. In the spring the German delegate proposed to remove comparisons between analog and digital system from the evaluation criteria, because the GSM committee had decided to aim for a digital solution. The UK opposed, because the committee did not make a decision between the digital and analog system, it had merely expressed its intention.

638 GSM # 4; Doc 15/84

639 GSM # 5; Doc 51/84.

640 SA RD NR-21-11; GSM # 7.

inadequate. In spite of the apparent demand, the CCH (acting as the supervisory body of the GSM Group), rejected plans to restructure the working methods of the GSM Group.

Since the GSM project had passed the critical point of changing from feasibility study to executive project in 1985, the GSM Committee had to restructure both its organization and working procedures. The GSM organization was transformed into an active central player instead of a semi-active coordinator.

Defining the basic parameters of a system, and especially working out of the specifications, require constant and increasingly rapid actions. The GSM Committee prepared itself in advance and established permanent sub-groups in the fall of 1985, allowing them to assemble in between the meetings of the GSM Committee. The tasks of these sub-groups remained basically unchanged. Working Party (WP) 1 was in charge of Services and Facilities, Modulation was the task of WP2, and WP3 dealt with Network Aspects.[641] Specific issues required cross-organizational expertise. In May 1985, a joint meeting of CEPT-TR3 and COST207 was held in Norway, and a Joint Expert Group on Speech Coding (JEG, from 1987 onwards SCEG) was established; it activities began in November 1985.[642] In May 1985, experts on security aspects representing GSM and CEPT TE (later TD) met in Sweden and decided to establish a Joint Experts Group on Security (SEG), which also started operating in November 1985.[643]
With the selection of basic technical choices done in early 1987, the way was open for escalating work on the specifications. The schedule did not leave any spare time, because the Recommendations essential for procurement had to be finished before the spring of the following year. Each of the WPs were in charge of specified Recommendations, but they needed assistance from a body, which would be constantly active. The GSM organization also needed a body for cooperating with the manufacturers, whose specific competence became valuable during the shaping of the Recommendations. To carry on all these tasks, a Permanent Nucleus (PN) was established in the fall of 1985, although it did not became operational until mid-June 1986. The terms of reference of the PN consisted of: 1) Preparation and management of GSM documentation (Preparation of Specifications and Management of GSM documentation); 2) Technical and secretariat assistance to the GSM Working Parties; 3) Acting as a permanent contact point for equipment manufacturers; 4) Analysis of technical options or items; and 5) Reporting to the GSM Committee.[644] Originally the PN consisted of a coordinator and six experts in addition to a couple of secretaries.

The GSM Committee was reluctant to increase the number of Working Parties, but internally the Working Parties had more freedom. At least WP1 and WP2 had established unofficial sub-groups on functional basis already in the fall of 1986. The GSM Committee recognized the "predominant situation" in early 1987, at first temporarily, and then in the spring it gave official status

641 GSM # 9.
642 GSM Doc 52/85, 5/86.
643 GSM # 7, Doc 54/85; 18/86.
644 GSM Doc 94/85.

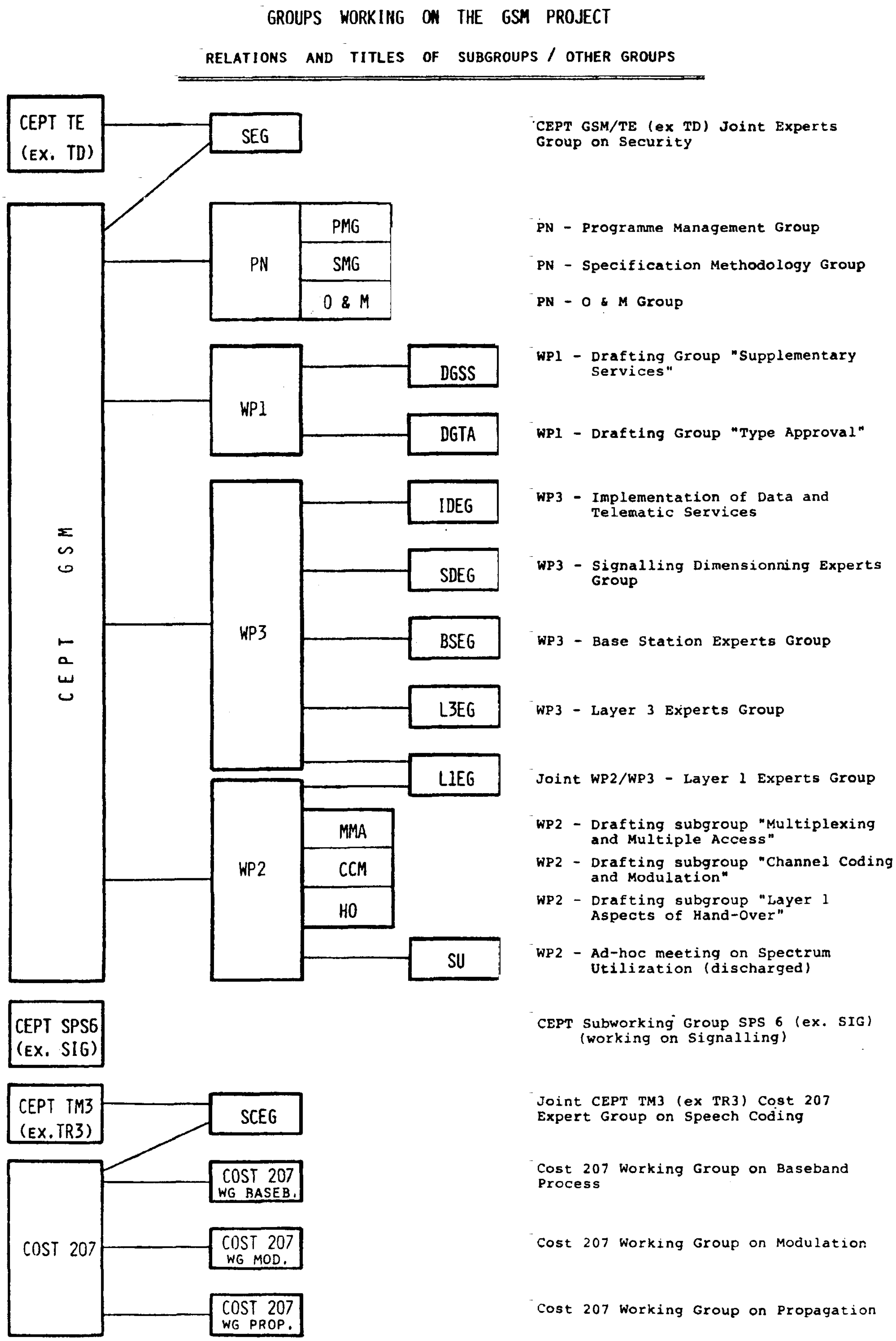

FIGURE 10 Organizational structure of the GSM project in 1987

to sub-groups. The policy of establishing formal sub-groups within the Working Parties was made very liberal, and the GSM Committee considered that an announcement to CCH was adequate as an action. The division into sub-groups was put into practice on the basis of needs. Within WP2, a new partition was performed before the end of 1987.[645]

New sub-groups were established at the end of 1987. The sub-group Discontinuous Transmission (DTX) was established within SCEG in October, and SIMEG (SIMM card) within WP1 in December. In December, the BEG group was established also to define a new interface between BSC and TRS (Transceiver). In actual practice, the BEG was an autonomous Working Party reported directly to the GSM Committee. [646]

Formally, it was very difficult to organize the new Working Parties, which had broad operational areas. Only two Working Parties were formally established before the end of Phase 1 (early 1991) and both, WP4 and WP5 were born on an evolutionary basis. The origins of WP4 were within IDEG (Implementing of Data and Telematic Services), which was formally established as a sub-group of WP3 in February 1987, although it used separate resources and it reported also directly to the GSM Committee in addition to its formal mother Working Party. This tangled arrangement was short lived; already in November 1987 IDEG was renamed WP4.[647] The genesis of WP5 was a prolonged process, because there was no unanimity on the policy of the group, in addition to there being general resistance to establishing new Working Parties. Although the Panel of Experts on Patents was established already in December 1986, and it tried to formulate a more effective tool, it was not until June 1988 that the Patent Panel was transformed into Working Party 5. WP5 was not long lived, however, because it was promoted to become the independent Technical Committee in the spring of 1989, when the GSM organization was transferred from CEPT-CCH to ETSI.[648]

The GSM Committee re-considered the organizational structure when there was a shift to Phase 2 and when the DCS1800 task was handed over to the GSM Committee, but it chose to retain its current structure.[649] When the work load of the GSM Committee showed signs of diminishing, 3rd generation issues were transferred to the GSM Committee in late 1991 as WP5, and then the GSM Committee was renamed SMG (Special Mobile Group). WP6 was established in early 1992; it was the former sub group of PN (Operation and Maintenance).[650]

Originally it was not considered that the main organizational structure would last for ever, and in the latter half of 1987 the GSM Committee even considered when would be a good time to disband WP3. Quite soon it was

645 GSM Doc 142/87; MMA, CCM and HO sub-groups of WP2 were replaced by TR (Transmission) and OR (Organization) sub-groups.
646 GSM # 15, 16.
647 GSM # 15.
648 GSM # 19, 23, Doc 150/88.
649 GSM # 26.
650 Mouly-Pautet 1992.

discovered that the Working Parties in charge of making Recommendations would be necessary in validating them.

The task of the GSM Committee was restricted to technical issues. Although the GSM organization adopted broader interpretations of the contents of "technical issue" (e.g. patent policy) after 1985, the commercial aspects had not become infiltrated. With the Memorandum of Understanding (MoU) signed in September 1987, the MoU created an organization, which was in charge of introducing the GSM system into service. The GSM Committee and the MoU shared issues vital for both organizations, e.g. change procedure regarding Recommendations and IPR issues, and this required close liaison.

3.2.2.2 Preparing specifications

3.2.2.2.1 Pruning timetable

The GSM Committee's aim was to define only the basic parameters of the system by the end of 1986, and then to define the specifications, which would take two more years. From this point of view, it was quite a surprise that European Community (EC) started to put pressure on the GSM Committee in early 1985 to bring the timetable forward by two years. This would have meant that the final specifications would have to be finished by the end of 1986.[651] When analyzing the motives behind the goal of the European Community, there are two alternatives. Whether the relevant experts of the EC were short on expertise related to modern cellular and digital technology, plus multinational standardization procedures, or then the EC wanted to industrialize the whole project.

The GSM Committee was able to withstand the pressure. It prepared a new timetable, but it did not accept the scheme proposed by the EC. On the contrary, the GSM analyzed whether it was possible to prune specified working phases. GSM Committee concluded, that it was not possible to shorten the phases of defining basic parameters and that neither did industry have enough time to develop the equipment. The only possible alternative was to shorten the time allocated to making the Recommendations. Detailed specifications were planned to be finalized by the end of 1988. The GSM Committee decided to cut the timetable by six months and to get the specifications ready before mid1988. The introduction date of 1991 was kept retained.[652]

Comparing the requirements of the EC to what the GSM Committee had actually pledged, the GSM Committee managed to run the gauntlet by stealth, mostly just showing good will. It was a passage of time during which the EC evolved from being a potential threat to becoming a political supporter.[653]

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651 GSM # 7.
652 GSM # 7.
653 This issue is discussed in more detail in Chapter 3.2.4.1.1.

3.2.2.2.2 Preparing the Recommendations

3.2.2.2.2.1 Strategy of defining the Recommendations

It has been claimed that the GSM Committee initially planned to divide the work into three phases, clearly separated from each others. These were: 1) Specifications formulation, 2) Validation, and 3) Field tests with operational equipment.[654] But the original plan did not actually comprise of these phases, nor did the modified Study Plan of 1984 mentioned in this part. The 1985 Action Plan defined the three-phase division, but on a different basis.[655]

The idea of separating specification formulation from the validation phase gradually faded during the standardization process. It became more obvious that it would not be enough to write all the specifications first in a very short period of time. It was around 1988 that the idea matured, and it was agreed that the launch in 1991 would not be with the full palette of services. At the launch of the GSM system's Phase 1 only the most common services would be included, while Phase 2 would introduce supplementary services.[656]

The idea of having two separate evolutionary phases of standard made it easier to validate the Recommendations and to develop equipment, not to mention that the system had to be introduced to the market in due time, too. Having the Recommendations in two phases did not arise suddenly from nowhere, since the Recommendations already had a one kind of order of preference due to procurement activities, and the services were also classified. At the beginning of 1986, Working Party 1 presented Recommendation 1.06 "Services implementation phases and possible further evolution in the GSM PLMN", which had a three-type classification. E class services would be "essential" in the sense that they would be made available by all GSM PLMNs. A class services would be "additional", available only in accordance with decisions of certain GSM operators. FS class services would be for further study. Also, the implementation of the services was divided into three categories:

- Phase 1: Operation with telephone service and a few supplementary services (E1, A attributes)
- Phase 2: Operation with telephone service and a limited set of non-voice services as well as a limited set of supplementary services (E1 + E2, A attributes)
- Phase 3: Operation with telephone service and an extended set of non-voice services and an extended set of supplementary services (E1 + E2 + E3, A attributes).[657]

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654 Mouly and Pautet 1992.

655 GSM Doc 2/82, 39/84, 35/85; 1985 Action Plan had three phases, and they were 1) system concept definition at the end of 1986, 2) detailed specification in December 1988, and 3) industry lead time ending early 1991. There was no mention at all of validation, but system demonstration was included, although it was not defined to be anyone's responsibility.

656 Mouly and Pautet 1992.

657 GSM Doc 19/86; #10.

Although the services and the implementation of services were divided into phases, it did not reflect on the Action Plan before June 1990.[658]

The GSM Committee introduced a division into three phases in the autumn of 1988, but it was related to the work phases of the GSM Committee, and specifically how to proceed in developing the standard. These phases were:

1) Development of the Recommendations
2) Validation and consolidation of the technical aspects
3) Maintenance of the standard based on pre-operational experience.[659]

Originally, the phase 'Development of the Recommendations' was classified to belong to Work Phase 1, 'Validation and maintenance' to Work Phase 2, while Phase 3 was left undefined,[660] but in the autumn of 1990 there was formally a small, albeit quite an important, change in practice. 'Validation and consolidation' was transferred to Phase 1, where it belonged functionally. This meant that the work phases corresponded to the service phases of how the GSM system was going to be introduced to market.[661]

When the GSM Committee treated the elaboration of Phase 2 standard, it chose the "major step approach" instead of the "piece-by-piece approach". Furthermore, it was agreed that Phase 2 equipment must be backwards compatible, but all the facilities need not necessarily be covered. This meant that the new infrastructure software should be able to work together with both Phase 1 and Phase 2 mobiles. It was also decided that it was not possible to recall terminals approved for Phase 1 for modification and that changes to terminals not MS-upward-compatible cannot be accepted.[662]

3.2.2.2.2.2 Defining Recommendations

The first new type of Action Plan was prepared in February 1986. Instead of work tasks, it included a list of required Recommendations, although the list was, naturally, not a complete one. The Recommendations were divided into twelve sets. Each Recommendation nominated a Working Party in charge of the work, in addition to possible supporting Working Parties. The status of the Recommendations was divided into four categories: Preliminary Draft, First Draft, Final Draft, and GSM Approval. The first definition was not important from the GSM procedure's point of view, but the latter three steps were scheduled in Action Plan of the GSM Committee, although at first the dates for GSM Approval were left open.[663]

A few Recommendations of Series 1 and 2 reached the status of 1st Draft already during 1985, but the actual work started in 1986. In the fall of 1986 there

658 GSM # 27.
659 GSM #20, Doc 217/88, 225/88.
660 GSM Doc 299/88.
661 GSM Doc 82/90.
662 GSM # 26; Doc 252/90.
663 GSM #10, Doc 23/86.

were already twenty-eight First Drafts ready, all but one belonging to one of the series between 1 to 4. Work progressed rapidly during 1986 and 1987. From the

TABLE 19 Number of completed First Drafts of Recommendations
Source: GSM Doc 23/86, 23/86 rev2, 55/87, 146/87, 75/88

	February 1986	October 1986	May 1987	December 1987	March 1988
Completed First drafts	14	28	42	66	70
Total number of Recommendations	72	82	116	133	146

spring of 1987 onwards, manufacturers were allowed to participate directly in the work of the GSM Committee. By the fall of 1988, most of the First Drafts were completed. The number of Recommendations varied with time, because it was quite typical for several Recommendations to be totally deleted.

In parallel with the First Drafts, work had started on the Final Drafts as well. In actual fact, work on the Final Drafts did not drag far behind the First Drafts. At the end of 1987, twenty-four Final Drafts were already finished and fourteen of them had gained the GSM Approval. In June 1988, the corresponding figures were seventy and fifty-eight (see TABLE 20). Due to tender invitations, sixty-one Recommendations were classified as "necessary" to be available before the spring of 1988. During the first week of March 1988, only thirty-four "necessary" Recommendation were finalized, sixteen were lagging behind schedule in addition to another eleven Recommendation, which had been postponed.[664] At the end of March 1988, an extraordinary assembly of the GSM Committee was organized in order to finalize the required Recommendations. After the meeting, seventy-three Recommendations, altogether over 3 000 pages each set, were sent to ninety-two companies.[665]

TABLE 20 Breakdown by time of GSM Recommendations passing through Final Draft and Approval phases
Note: Months indicated by Roman numerals. Sources: GSM Doc 156/88

	PERIOD			
	End of 1987	I-III/1988	IV-VI/ 1988	TOTAL
Final Draf	24	32	14	70
GSM Approval	14	31	13	58

In the fall of 1988, the GSM Committee launched the Change Request procedure for modifying Recommendations. At the beginning of 1989, Change Requests were classified into four categories and only A class changes had to be agreed as soon as possible and incorporated into Recommendations.[666] At the end of 1989, the GSM Committee decided that the GSM 25 bis meeting early in 1990

664 GSM Doc 77/88.
665 GSM #17 E, 18; Doc 89/88.
666 GSM # 21, Doc 5/89.

would be the last possibility to incorporate Charge Requests to Phase 1 standard, unless they would be absolutely vital to system.[667]

The GSM # 25bis meeting in January 1990 decided which Recommendations belonged to Phase 1 and "froze" them. After the meeting, Phase 1 Recommendations (including all approved Recommendations) were released for circulation. Altogether, there were five different kinds of packages of Recommendations.[668]

In the spring of 1990, the GSM Committee sent thirty-two Recommendations to the Preliminary Enquiry of ETSI to become I-ETS standards, including 3 NETS. Later on, the number of I-ETS decreased to twenty-six. It should have been quite clear, already in spring 1990, that the commercial launching of the GSM system in June/July 1991 would be like winning the first prize in a lottery even in the most optimal situation, since the Recommendations were to return from the Public Enquiry in December 1990. This would finally put an end to Phase 1 in January 1991. After that the Recommendations would be sent to the National Standardization Organization or to be voted on in the Technical Assembly of ETSI in April 1991.[669]

Phase 2 Recommendations were prioritized in the autumn of 1990. First priority was given to completion of Phase 1 issues, at the latest before January 1991. Second priority was given to completion of the supplementary services; micro-cell, extension bands 900, 1800; optimatization of Phase 1 standard, half rate speech codec specs; studies regarding personal numbering, SIM functionalities, local routing, and roaming between GSM 900 and GSM 1800. The Phase had to be finalized before December 1991. The lowest priority was given to issues including national payphone and validation of the Phase 2 standard. These, too, had to be done before December 1991. In addition, there were issues, which would most likely be dealt with before December 1991.[670]

3.2.2.2.3 The Evolutionary Path of Standard

Three settlements, which were decisive presuppositions on the possibilities of the GSM system to become a widely successful standard, were achieved during the elaboration of the GSM standard (1982-1991). Firstly, the GSM Committee set its sights on standardizing on the European level. Secondly, the concept of Personal Communication was assimilated with the GSM system. Thirdly, the 3rd generation system was implanted into the GSM environment.

The GSM Committee set itself the goal of a European standard, which was a rational decision, since it was the only realistic alternative. Even on the European level, interest was founded on a narrow basis, and only half of the CEPT countries participated in the work of the GSM Committee. Getting global through the organization of the ITU would be extremely difficult. Regions 2 and

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[667] GSM # 25.
[668] GSM # 25 bis.
[669] GSM Doc 88/90.
[670] GSM Doc 252/90.

3 already implemented the 900 MHz band for analog systems and WARC-79 allocated frequencies on regional basis.

"Globalization" of the GSM system got some external incentive. Bell Communications Research (Bellcore), which was a affiliate of seven newly independent regional telephone companies, and previously comprising the "Bell System", announced in the autumn of 1984 that it was interested in setting up technical liaison with the GSM Committee. Bellcore hoped that the proposed liaison would lead to a closer compatibility between future North American and European systems. This was a tempting goal, since portable telephones have the potential of being used for local calling in any area to which its owner travels, including the potential for intercontinental roaming.[671]

Even though the initiative of Bellcore seemed to have been quite alluring, there were at least three major issues to be considered. Firstly, the institutional structure did not make cooperation easy, because all external relations to CEPT had to be carried out via CCH, and technical committees like the GSM Committee were not allowed to operate on their own.[672] Secondly, the motive of Bellcore could not be interpreted merely as being a charitable one, since during the Interim Meeting of the CCIR Study Group 8 (Mobile Services), the United States tried to get the AMPS specifications accepted as s CCIR Recommendation and Bellcore played an important role in this attempt. The goal of the American attempt was to promote "commercially-proven standards" in order to make choosing easier for operators. Europeans did not find this approach useful, because they were aiming to have a single, common standard. Lastly, the timetable was too tight for a cross-continental attempt and the whole idea was questioned in any case.[673]

The GSM Committee had to defer the Bellcore initiative to the CCH in order to comply with the correct procedure. The CCH returned the issue already to the next meeting of the GSM Committee, which was held early 1985, and asked for an opinion as to the technical implications of cooperation. Later on, the CCH would assess political aspects of cooperation. The GSM Committee estimated the possible results of cooperation assuming that the goal was to reach a common CCIR standard. Most conclusions were negative, to the exten that the predominant view was that one standard in Europe and another in American would make it impossible to reach a common CCIR standard. There were convincing institutional facts speaking against cooperation. The GSM Committee considered that organized cooperation with the Americans would probably lead to an increasing work load, which would not be proportionate to the benefits to be expected. Also, considerable difficulties would arise when identifying the organizations with which collaboration could be established. This was due to structural differences between the American and European societies as regards the roles of operating companies and manufacturers. The

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671 GSM Doc 72/84.

672 Actually Bellcore had already violated formal protocol, because contact was made directly with the GSM Committee, by-passing the CCH!

673 GSM # 6, Doc 72/84. Particularly the German delegates had doubts as to whether the Americans had general speaking gained competence in digital radio technology.

last nail in the coffin was the scope of the initiative: the interest of the Americans in the CEPT work was not limited to mobile communications, but included the entire CEPT area. Actually, only the experience related to the harmonization of the duplex distance in the 900 MHz band in Regions 1 and 2 showed that early collaborative contacts enabled important improvements without excessive effort. The GSM Committee recommended that it was in favor of having exchanges of views with suitable American organizations, but not under too strictly organized forms and not necessarily restricted to mobile communications. The purpose of such a dialogue would not be to establish a world-wide standard.[674]

The GSM Committee rejected the path of organized cooperation, and the United States and Canada had indeed made it clear that they would not accept the GSM as a standard unless they were allowed to participate the work of the GSM Committee.[675] In October 1985, an ad-hoc Working Party of the GSM Committee responsible for policy issues met representatives of Bellcore and there were exchanges of information.[676] The time of favorable momentum had actually already passed, since the European Community had started to put heavy pressure on the GSM Committee to bring its timetable forward. On the other hand, new possibilities were arising within the CCIR.

In the Final Meeting of CCIR's Study Group 8 (Mobile Services) in October 1985, the Study Program 39A/8 was approved to be carried out during 1986-1990. Interim Working Party 8/13 was established to deal with future public land-based mobile telecommunication systems. The main tasks of IWP 8/13 were to determine the overall objectives, the suitable frequency band or bands, and the degree of compatibility or commonality, which would be desirable or achievable, and the essential characteristics of the systems necessary for this purpose.[677]

Before the work of IWP 8/13 commenced, the GSM Committee considered whether it should make use of the favorable situation and try get the GSM formally accepted as a world-wide standard. But this possibility was unanimously rejected, because it would have impacted on the timetable and that could not be accepted. However, it was found to be essential to make the GSM system known outside Europe, and particular in regard to the frequency band the system would run on. The IWP meeting was considered to offer a good opportunity for this purpose.[678] Considerations proved to be successful, because the First Meeting of IWP 8/13 came to the conclusion that the GSM frequency band should be made available outside Europe for GSM types of systems. Also, much of the work on the services and facilities was based on the outcome of the GSM. The Second Meeting in 1987 adopted a lot of GSM services

[674] GSM # 7.
[675] GSM Doc 72/84.
[676] GSM # 9, Doc 126/85.
[677] GSM Doc 14/86.
[678] GSM # 10.

and facilities, perhaps even too many, since the United States declared that the GSM system would not be adopted in Region 2 (Americas).[679]

The GSM system had gained a lead, which was difficult to overtake. In the United States, it took until September 1987 for a proposal to be made to establish an EIA Technical Committee TR45.3 to focus on future digital cellular standards. The goal of introducing commercial service already in 1991, was more than ambitious.[680] The United States was again active, and the CTIA (corresponding to ETSI) contacted Permanent Nucleus early 1998 and in the autumn GSM representatives met EIA TR 45.3. Liaison with the United States correspondents was under consideration, but apparently it remained on the level of mere information exchange.[681]

The strategy applied by the GSM Committee soon proved to be the right one, because in the United States there were difficulties in approving standard. The policy of the GSM Committee started to bear fruit. From March 1990 onwards representatives of Hong Kong Post Offices and Telecom started to participate in meetings held by the GSM Committee.[682] The Australian Telecommunications Authority (AUSTEL) recommended already in May 1990 that operators should commence service applying the GSM technology. In November 1990, the Australian Government accepted AUSTEL's Recommendation "prima facie", since continuing technological development was taking place. The new Australian policy required early availability of quality technology.[683] Australia became the first country outside Europe to sign the GSM Memorandum of Understanding (MoU).[684]

The second path chosen in early 1990 had a two-fold impact, as it intercepted the idea of an independent Personal Communications (PCN) system assimilating the PC concept to the GSM system and gave more capacity for the GSM. The PC initiative came from the United Kingdom, where the Department of Trade and Industry (DTI) had granted a number of licenses for operating Telepoint services in January 1989. The DTI was also considering the possibility of granting licenses for operating systems in the 1.7 GHz band, because it found it impossible to have three GSM operators. At first no precise decision concerning the type of system had been taken. It was only thought that the envisaged system would be more of the Telepoint-type than a full mobile telephone system.[685] The DTI requested responses to the PCN initiative. By April 1989, the DTI got fifty responses, of which some around twenty were studied seriously. Virtually all the responses expressed the view that the system should be based on the GSM or DECT, but of the responses representing studies, solutions related to DECT and Telepoint were in a slight majority. Since the service should commence already in 1992, the GSM technology got the most

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679 GSM # 10, 12, 14.
680 See also Chapter 3.3.3.1.3.
681 GSM # 19, 23; Doc 117/89, 250/89; GSM # 24 should have decided on liaison, but finally the issue was never addressed there.
682 GSM # 26.
683 Horton 1991.
684 GSM Association. History of GSM.
685 GSM # 21.

suitable position as it was the alternative to be most swiftly implemented. In December 1989, the names of three license holders were announced.[686] These three had based their proposals on the GSM technology, which meant that the GSM technology was the de facto choice for the United Kingdom's PCN. The DTI delegated responsibility for technology to ETSI and operators, because the chosen operator consortiums had to agree together with ETSI on a common technology.[687]

The PCN issue was taken to ETSI instead of having a national solution. The Strategic Review Committee (SRC), which compiled the "Report on Mobile Communications" for the 6th Technical Assembly (TA) of ETSI in March 1990, also gave a Recommendation on PCN. The British operators had already in November and February presented their vision, which was based on an idea of implementing the GSM as the core of the PCN and adding such low-cost, high-capacity and high-quality features as can be provided cordlessly. The other requirements included a band around 1800 MHz, stability of Recommendations by the end of 1990, enhancements to service aspects, infrastructure sharing, and re-examination of the mandatory/optional status of Recommendations of the GSM Committee in order to benefit from simplification. The Recommendation of the SRC to TA6 was based on the British views.[688]

ETSI TA6 approved Recommendation of SRC on PCN, but called it DCS1800 (Digital Cellular System)[689], on the condition that the GSM was given first priority. The task of creating a common European standard was given to the GSM Committee, which then had free hands to define the task and choose the organizational structure. Due to the tight timetable, it was no surprise that the GSM Committee decided basically just to switch the system over to a new band and do the required changes. The decision on organizational structure was not that easy, since various kinds of more or less semi-autonomous structures were suggested, but the GSM Committee decided to keep the current structure. This meant also that the DCS1800 was buried within the GSM standard and becoming part of it. The changes planned for the DCS1800 would also be implemented to the GSM, since they were part of the same standard. The most visible feature of the PCN vision, cheap and light hand-portables, became the goal of the GSM Committee.[690]

When the GSM Committee received the task of DCS1800 standard in March 1990, the first step was to start solving the frequency issue. There were a lot of instability factors, because the 1,8 GHz band was not allocated for the GSM system and there was no reliable information on the bandwidth or even on duplex separation. The GSM Committee then decided to do something unusual. It asked the Frequency Management (FM) Group of CEPT to allocate a

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686 These were: Mercury Personal Communications (Cable& Wireless, Motorola, Telefonica); British Aerospace with Matra, Millicom, Pacific Telesis; Unitel Ltd comprising STC, Thorn EMI, US West with the Deutsche Bundes Post having an option.
687 MEG 1990; see also Garrard 1998.
688 GSM Doc 121/90, 124/90, 126/90.
689 In 1997 DCS1800 was renamed as GSM1800.
690 GSM # 26, Doc 140/90.

band between 1,7 and 1,9 GHz already in the April meeting. If detailed agreement on frequency allocation were not possible, at least guidance on a working assumption was requested. [691] This request was not easily fulfilled; not because of the minimal time available, but due to misunderstandings. The FM Group interpreted that the European standard for DCS1800 would comprise both the GSM extension and the UK PCN system, and that the outcome would be interim national systems before 3G would be introduced. In order to ensure the development of the standard and of pan-European roaming, the FM Group settled on the usage of the 1710-1785/1805-1880 MHz band and left administrations to choose from within the proposed limits. There was one condition. The allocation might turn out to be interim, because European harmonization of the use of the frequency band l-3 GHz was not yet finalized as it was dependant upon the decisions taken by the ITU conference WARC 92. It might, therefore, be necessary to change the bands for the DCS1800, which required sufficient flexibility on design of the DCS1800.[692]

The GSM Committee tried to remedy the misunderstanding related to status of the DCS1800 standard, but when the FM Group held its next meeting in September, it practically refused to admit the committed incorrect estimate. Again it emphasized that the allocated band could be implemented for national systems. Thus administrations would be free to choose the required frequencies on a national basis within given limits, but the system had to be able to exploit the entire allocated band in order to ensure pan-European roaming.[693] In practice, the GSM Committee got the green light to proceed and the capacity of the GSM standard was hugely enlarged. This was to become an important improvement, since eleven Western European countries[694] had implemented an analog cellular system on 900 MHz before the end of 1990 and thus having only part of the 900 MHz band available for the GSM. The GSM Committee's Working Party 2 had already in October 1989 agreed on the urgency of the need to have an extension to the frequency bands for the GSM system defined in order to have, as soon as possible, equipment available to provide service in this extension band. CEPT RR1 sub working group recommended the 870-890/915-935 MHz band, even though several countries had planned to use part of it (888-890/9333-935 MHz) for Digital Short Range Radio. The Frequency Management Group of CEPT accepted this proposal in June 1990.[695]

Work on 3rd-generation land-based mobile communication systems had been carried out on three forums, these being IWP 8/13 of CCIR, the RACE1043 project of the European Community, and the COST 231 research project. In March 1990, the Strategic Review Committee (SRC), which had prepared the "Report on Mobile Communications" proposed to the 6th Technical Assembly

691 GSM # 26, Doc 144/90.
692 GSM Doc 197/200.
693 GSM # 27, Doc 225/90, 307/90.
694 According European Mobile Communications 94 July/August 1995, TACS was adopted by six countries (Austria, Ireland, Italy, Malta, Spain and the United Kingdom) while NMT-900 was adopted by seven countries (Cyprus, Denmark, Finland, the Netherlands, Norway, Sweden and Switzerland).
695 GSM Doc 300/89, 197/90.

(TA6) of ETSI that a new independent Technical Committee to be put in charge of the Universal Mobile Telecommunications System (UMTS) should be created in 1990 for the 3rd generation of mobile telecommunication systems. The objective was to be to coordinate the activities of the ETSI members and, at appropriate time, to provide a European standard building on the work done in CCIR IWP 8/13 and 8/14, RACE 1043 and COST 231.[696] ETSI accepted the proposal, but instead of an independent Technical Committee, the issue was handed over to a Sub-Technical Committee under RES (Radio Equipment and Systems).[697]

The Decision of ETSI TA6 was meant be an interim arrangement preceding WARC 1992, but it did not endure up to that point in time. Already in March 1991, TA9 discussed whether the GSM system would be a more appropriate TC as a focus for the network-radio convergence. No decision was made yet, because the RES ad hoc group on UMTS was about to present its report to RES in June 1991 with Recommendations on the standardization of 3rd-generation systems. Immediately after the TA9, the British DCS1800 operator Unitel asked the GSM Committee to give advice to RES. The major points of initiative were to emphasize that the GSM Committee had experience, not only in standardizing the air interface, but the complete network system. In addition to this, UMTS standardization should not neglect exploiting the existing standards where appropriate in order to capitalize on the great effort and specialist expertise that had been required to develop earlier standards. Particular mention was made of investments in standards development, in infrastructure, and in terminal equipment. The GSM Committee found Unitel's proposal useful and contacted RES.[698]

UMTS standardization was transferred from RES to the GSM Committee in 1991 and from there to the established Working Party 5. The standardization of the GSM system had already proved to have been a valuable lesson in the required time span, which the Nordic countries had realized in the late 1960s. But the transfer of standardization to the GSM Committee ensured, that the expertise acquired was not wasted, that the technical base was utilized, and finally, as the 21st century began, that the leading position gained by the GSM standard gave feedback in the form of re-strengthening the position of the GSM system.

3.2.2.3 Choice of major technologies

In the mid-1980s, the cellular radio was the only modern telecom network using analog transmission. There was a formidable incentive to digitize cellular radio for at least three reasons. Firstly, it would provide compatibility with Integrated Services Digital Networks (ISDN). Secondly, the use of digital circuit

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[696] GSM Doc 126/90.
[697] GSM Doc 135/90.
[698] GSM # 30, Doc 182/91.

technologies in the radio should lead to great economies as had happened with calculators and personal computers. And thirdly, the use of digital special processing technologies might allow substantially greater network capacity, which would in turn fully realize the potential of cheaper terminals. As counterweights, there were two fundamental issues, which had to be resolved: namely, speech coding and spectral efficiency.[699]

Pulse-Code Modulation (PCM), as used in conventional fixed network, was a proven technology. PCM was used for coding voice signals into digital form implementing the bit rate of 64 kbit/s, but it was not suitable for mobile-radio usage. Thus, new algorithms for digital coding speech at much lower bit rates, and able to cope with the expected error rate, were required. A reasonable target was 16 kbit/s. The task was technically difficult, because there were a couple of factors causing instability. The new technologies would introduce unusual factors into system specification, e.g. coding delay. The new coding technologies themselves were usually very complex and needed custom integrated circuits for their implementation. It was estimated in 1986 that even at the current state of VLSI technology these circuits would constitute a significant cost element.[700]

Spectral efficiency was a vital and challenging task, because the dominating effects of multipath fading had less effect on analog as compared to digital transmission. This required various methods to be employed in digital systems to combat the effects of multipath fading. And even then, it was generally thought that it was unlikely for the digital systems to offer dramatically increased capacities compared to analog technology in the light of the state of knowledge of the mid-1980s. It was estimated that only a two-fold increase might be possible, but then the resultant system would be significantly more complex than the current analog systems.[701]

During the Second National Cellular Conference in February 1986, serious doubts were expressed at to whether digital technology was possible and reasonable to be implemented in a mobile-radio system. The quality improvements familiar from normal digital systems were difficult to obtain due to multipath fading. And above all, due to the likely complexity of a digital system, it was not clear whether the digital would be cheaper than the analog system. In particular, since the digital system would not offer dramatic capacity improvements, it was not clear whether the large market size primarily needed to obtain low product costs could be achieved.[702] But doubts were fading away and in the spring of 1986 manufacturers were in a position to announce that a digital cellular system was possible to be implemented based on the currently available technology, but that the development of the equipment would take at least three years.[703]

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[699] Haine and Maile 1986.
[700] Haine and Maile 1986.
[701] Haine and Maile 1986.
[702] Haine and Maile 1986.
[703] GSM Doc 63/86; GSM # 11; Early in 1985 manufacturers stated that the goal of digital technology was not far from the currently available technology. See GSM # 7.

3.2.2.3.1 Risk assessment

In the fall of 1986, before the GSM Committee started to pinpoint the basic parameters of the system, United Kingdom took up the issue of risk assessment. Three particular risk areas were identified to be as follows: 1) VLSI Technology, 2) Software Definition, and 3) System Definition.[704]

According to the prevailing view based on the investments made in sub micron technology world-wide, and the current state of development of near lμ processes, the required processing capability would be available by 1990, but perhaps not at the required costs and returns on investment until late into the 1990s. This would put VLSI-enabling technology on the critical path for the GSM system, particular since the GSM had been assuming its cost benchmark as being two years into production. This had an impact on the selection of speech coder. It was estimated that the least complex of the candidates could be realized in a single chip by 1990. Another equally important VLSI risk was related to implementation of the equalizer for the "mid-bandwidth systems" (narrow-band). All but one of the candidate systems would require an equalizer, and the experiments indicated that an equalizer was necessary if the effects of multipath were to be reduced. The opinions of experts indicated that realization of an equalizer for the mid-band type of systems was practical given lμ CMOS technology meeting the performance predictions in terms of speed and power consumption. This placed the GSM system again dependent on VLSI technology for it to meet its predicted performance, cost and yield figures.[705]

Software was considered to be an equally critical risk although less fundamental. Switch software was so complex that it required several man-years of labour within a limited timeframe. This was required for a reasonably firm specification by the end of 1987 to allow companies to begin the task with confidence. Also, sufficiently experienced software designers had to be available in sufficient numbers to solve the problems and produce tested software by 1990. Furthermore, the market had to be sufficiently attractive for a number of companies/consortia to want to enter it, creating the competition necessary to achieve realistic pricing and delivery of the finished product within the required timeframe. To create action, operators had to purchase the systems in 1990 in order to encourage companies to invest in R&D with reasonable expectations on returns for investment. Software development had to ensured by not changing the specifications.[706]

System Definition was defined to be a major risk possibility if excessively complex specifications were viewed too optimistically or if they could not be rationally implemented. The more complex the system the GSM Committee wished to specify, the higher was the risk of this information transfer function going wrong. The GSM Committee had to ensure a highly professional

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[704] GSM Doc 80/96.
[705] GSM Doc 80/96.
[706] GSM Doc 80/96.

approach to checking the details for consistency and monitoring that the totality of what is being built-up is technically and economically sound.

The proposed document also drafted a four-step approach to analyzing the risks in a systematic way. These steps were as follows: 1) The number of technology uncertainties remaining to be solved, 2) The outcome of unsolved uncertainties, 3) Managing complexity versus time, and 4) Managing complexity versus resources. The last approach was particularly interesting, because it connected competition with decreasing risks. As competition was seen to be the most powerful stimulus for accelerating the timeframes and reducing costs, increasing competition would increase independent resources in parallel to overcoming of problems. As the complexity of the system increases, there would be less enterprises which would have the technology or resources to tackle the industrial stage. This was leading to a balancing of the competitive forces against the risks being taken.[707]

The GSM Committee agreed on four actions related to risk control:

1. Working Party 2 should introduce a risk factor in their comparison of radio subsystems, and for this factor to be placed within the spectrum utilization and the cost of the system (in the first set of comparison criteria) and to agree on the precise method of assessing the risk factor.
2. After the choice of multiple access method had been made in February, to select in all areas of the standard the lowest complexity solution meeting the GSM objectives.
3. To encourage the independence of the semi-conductor, mobile, base stations and switch markets via the publication of open standards and to select a solution ensuring competitive supply in each of the markets mentioned.
4. To ask the PN to take all necessary measures to ensure rigorous technical control of the documentation so that the published standard is complete, accurate, understandable, unambiguous, and above all implementable in the VLSI and software by 1990-1991. This should include a Recommendation review procedure involving industry VLSI, software and system experts.[708]

The GSM Committee introduced risk assessment at the last possible moment before the evaluation of the radio-access candidates and speech codecs. Risk evaluation and avoiding increasing complex solutions was of importance when choosing the solutions. In addition to these specific issues, the risk assessment problem also outlined significant policy steering functions in developing the technical standard.

3.2.2.3.2 Radio sub-system

Although the GSM Committee had already in June 1984 decided to aim for a digital system, the aim was acceptable only on reasonable conditions. It was not yet discussed as to the criteria to be used, but three factors related to speech

[707] GSM Doc 80/96.
[708] GSM Doc 92/86, # 12.

codecs were found to be important. Firstly, the cost of the codec must not be excessive. Secondly, the frequency economy must be at least as good, as in the current analog systems. And lastly, speech quality, including the transmission delay, must be acceptable.[709]

The level of requirements rose in pace with digital technology becoming more and more promising. The requirements were presented already in the autumn of 1985. The performance in respect of the relevant criteria had to be at least equal to that of analog systems and significantly better in at least one criterion. The accepted six criteria were: 1. Speech quality, 2. Spectral efficiency, 3. Infrastructure cost, 4. Subscriber equipment cost, 5. Hand-portable viability and 6. Flexibility to support new services.[710] The evaluation criteria were modified during 1986. An additional two requirements were spectrum management and risks assessment.[711]

In June 1984, the GSM Committee had accepted three basic radio-access methods for further study, these being FDMA, TDMA (wide and narrow-bands) and CDMA with slow frequency hopping.[712] At the end of the year, France and Germany rejected the introduction of an early system operating on 900 MHz and launched a joint digital study. Three consortia were formed submitting bids in both countries, these being the companies AEG/SEL/ATR/SAT, ANT/Bosch/Matra, and TeKaDe/TRT. These consortia consisted of companies from both countries. In addition to them, Laboratoires Central des Télécommunications (LCT), which was a subsidiary of CGCT and TRT, submitted an offer only in France. Later on, when the management of projects had been divided between the administrations of France and Germany, Matra and TRT left their consortia thus leaving ATR/SAT/AEG/SEL as the only true multi-national venture (TABLE 21).

The aim of this Franco-German cooperation was to introduce a joint system for the two countries, and to offer it to other countries also. Although industry was given free hands in choosing their radio-access technology, the wide-band TDMA project had gained an edge over the others, as SEL was the only company relying on digital technology during the "pre-digital" phase of the Franco-German cooperation (before the end of 1984). The SEL-driven proposal had in fact been presented to the GSM Committee already in the autumn of 1985. The wide-band TDMA approach was strengthened after Italy joined the Franco-German cooperation in June 1985.[713] This practically prevented Italian R&D contribution in turning to concrete prototypes. The

709 GSM # 5, Doc 39/84.
710 GSM # 9;Doc 115/85.
711 GSM Doc 79/86; GSM # 9, 12.
712 GSM # 5.
713 GSM # 9; GSM Doc 92/85.

TABLE 21 Franco-German digital cellular proposals
Remarks: * = used sectoral antennas; ** = a hybrid system
Sources: GSM Doc 65/85, 85/85, 86/85, 87/85, 88/85

Project	Companies by country of origin		Manager of project	Deserted companies	Radio access		Radio channel	Channels per carrier	Cell cluster
	French	German			Scenario	Technique			
CD 900	ATR, SAT	AEG, SEL	France	None	wide band TDMA	FDMA/CDMA/TDMA	6 MHz	60	3*
S 900 D	Matra	ANT, Bosch	Germany	Matra	narrow band TDMA	FDMA/TDMA	250 kHz	10	7
MATS-D	TRT	TeKaDe	Germany	TRT	wide/narrow band TDMA	FDMA/CDMA/TDMA-FDMA/TDMA	2.5 MHz /25kHz **	64/1 **	3/7
SFH 900	LCT (CGCT, TRT)	none	France	None	narrow-band slow frequency hopping	FDMA/CDMA (SFH)/TDMA	200 kHz	3	3*

Italian interest had been focusing on narrow-band implementation, but after joining the Franco-German cooperation, Italtel joined also the CD-900 wide-band consortia, though only as an associate member.[714]

The United Kingdom had also launched R&D projects, but without the aim of industrializing them. Even if there were a hidden industrial aim, it would have been difficult to fulfill, since British R&D, e.g. on CDMA or slow frequency hopping technologies, ended in a deadlock.[715]

It seems that according the prevailing view all the advantages were connected to the broad-band solution. Initially, SEL probably choose the wide-band approach in aiming at maximum capacity, but later on wide-band networks in general became the common focus. This was particularly the case since the European Commission launched its RACE project on pilot level in late 1985.[716]

TABLE 22 Nordic Radio Access proposals for GSM
Source: Lindmark 1995

System	Country	Company	Access type	Carrier Spacing (kHz)	Channels per carrier	Modulation type
ADPM	Norway	ELAB	nb-wb TDMA	200-4000	10-160	DPM
DMS-90	Sweden	Ericsson	nb TDMA	340	10	GMSK
MAX II	Sweden	Televerket	nb TDMA	300	10	GMSK
Mobira	Finland	Mobira	nb TDMA	252	9	GMSK

The only counterweight for the Franco-German cooperation came from the Nordic countries, which had launched their joint digital project already at the end of 1981. The original goal of the Nordic FMK Group was to introduce a joint digital system. Although the FMK Group conducted development work, each participating country carried on studies o ftheir own.[717] The Swedes had studied digital radio already in the late 1970s.[718] The Nordic countries did not actually have any advantage in technological research, since both Televerket and Ercisson concentrated on FDMA technology at first. It took until 1985 for the Televerket to focus its interest in a narrow-band TDMA project and Ericsson followed.[719] The Finnish company Mobira also launched a narrow-band TDMA project (late 1985 or early 1986). The only divergent approach was chosen by Norway, where ELAB of Trondheim Technical University focused on an adaptive wide/narrow-band scheme.[720]

In early 1986, all the candidates eventually participating in evaluation tests had registered with the GSM Committee.[721] There was marked anxiety within the Nordic group. The Finnish administration interpreted the possibilities of narrow-band to be poor on grounds of the poor quality of the German narrow-

714 GSM Doc 87/85, 97/85.
715 GSM Doc 78/84,116/85, 16/86; GSM # 16.
716 Outside GSM there were views expressing the importance of RACE for GSM. See GSM # 10.
717 Minutes of FMK committee.
718 McKelvey et al 1997.
719 GSM Doc 98/85, 9/86, 73/86.
720 GSM # 10; GSM Doc 9/86.
721 GSM WP2 Doc 8/86.

band version, and believed tha the wide-band candidate would probably win, and nobody took Televerket's proposal seriously. The Norwegian candidate was at that moment only at the laboratory stage.[722] Later on, Televerket had to do major modifications only a couple of months before the final tests started.[723] This was reflected in the autumn of 1986 also in the work of the Swedish delegation, which tried to convince the GSM Committee to reject the wide-band TDMA, because it was not suitable for all countries.[724]

The GSM Committee had already decided in June 1986 that the task of WP2 was to choose the access method and to optimize it.[725] This meant that the GSM Committee did not aim to choose a prototype of a certain consortia, but instead a radio-access method ("broad avenue") between FDMA, narrow-band TDMA (with or without frequency hopping or wide-band TDMA (with or without CDMA)[726]. The candidates had to be tested at CNET facilities in Paris between mid-October 1986 and early January 1987. Some parts had to be repeated, but all in all they ended in time.[727]

The evaluation of tests were two-fold. First, the minimum requirements were evaluated. All the digital approaches fulfilled to speech quality, peak traffic density, handheld station and maximum band-width requirements, but FDMA did not pass the cost requirement. Since a digital system was found capable of exceeding the current analog systems, the evaluation proceeded. According to the GSM Committee requirements, the performance in respect of the six criteria had to be at least equal of that of analog systems and significally better than it in at least one respect. In addition to this, the proposed systems had to be analyzed with respect to spectrum management and risk criteria.

Evaluation of the test results revealed that TDMA was clearly better than FDMA. The most obvious shortcomings of FDMA were its high cost (it did not even match the cost of analog systems) and lack of flexibility in accommodating new services.

Comparisons between wide-band and narrow-band TDMA gave amazingly clear results in favor of narrow-band, because with respect to only two criteria these approaches were comparable, but in respect to six criteria the narrow-band was superior. Particularly in regard to spectrum management and co-existence, the results favored the narrow-band approach taking into consideration matters such as the entire band not being available in all countries, and the subdivision between competing operators being required in some countries, and the gradual replacement of existing systems being easier when applying the narrow-band approach. In general, the wide-band system

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722 This could be an exaggeration, because the Finnish administration tried to justify why it wanted to provide capital for Mobira's proposal, but anxiety was clearly to be observed.

723 Lindmark 1997, MacKelvey 1996.

724 GSM Doc 72/86. Formally the Swedes were critical of the prevailed test conditions, because all candidates did not get a change to use CNET's fading simulator and they wanted to split the tests between several laboratories.

725 GSM # 11.

726 GSM # 12. – E.g. Bekkers 2001 incorrectly claims that the GSM Group chose between technology of Ericsson and SEL.

727 GSM Doc 77/86, 7/87.

would generate a lot of problems, since it did not take into account the parallel existence of analog systems. This was understandable, because wide-band research originated in Germany, which was the most eager country to resist the adopting of an "interim system" operating on 900 MHz. But ever since the very early requirements for the GSM system, the existence of analog systems was one essential requirement! In order to alleviate the drawbacks of the wide-band system, it would have had to be scaled down to a 40-channel system to fit into a single 5 MHz band, but this would have severely exhausted the major gain of the wide-band approach.

The criteria (see TABLE 23) used to evaluate access methods were not questioned, except for the interpretation of risk criterion. Nevertheless, no unanimous decision could be achieved. All the delegations agreed on the adequacy of the narrow-band concept, but only the delegations of France and Germany regarded the wide-band concept to satisfy their requirements. This attitude was a special case, because formally WP2 was in charge of the tests, not the participating administrations and their national needs. WP2 evaded a stalemate situation by recommending both narrow- and wide-band TDMA for the optimizing phase with alterations.[728]

TABLE 23 Evaluation of GSM Radio-Access alternatives ("Broad Avenues")
Remarks: n-b = narrow-band; w-b = wide-band
Source: GSM Doc 22/87

Criterion	Analogue vs. Digital		FDMA vs. TDMA		TDMA N-B vs. W-B	
1) Speech Quality	Comparable		Comparable		Comparable	
2) Spectrum Efficiency	Comparable		Comparable		NB	
3) Infrastructure & 4) Mobile Cost		Digital		TDMA	NB	
5) Hand Portable Viability		Digital		TDMA	N-B	
6) Flexibility for New Services		Digital		TDMA	Comparable	
7) Risk	Analogue		FDMA		N-B	
8) Spectrum Management	Comparable		FDMA		N-B	

WP2 finished the evaluation report at the end of January 1987, and this left two weeks for lobbying before the GSM Committee met in Madeira. The plenary accepted that the GSM system should be based on digital technology and on TDMA technology instead of FDMA.[729] The decision between narrow-band and wide-band was difficult, and time went on. According to the prevailing impression, the tide started to turn after the delegation from the United Kingdom gave its approval for the narrow-band concept.[730] The GSM Committee found itself in an annoying situation as 13 of the 15 administrations[731] were in favor of narrow-band, and only France and Germany expressed preference for the wide-band concept, though they did not challenge

728 GSM Doc 22/87.
729 GSM # 13.
730 Thomas Haug's and Matti Pasanen's interviews.
731 Physically there were 14 administrations present, but the UK had a mandate to also represent Ireland.

the technical evaluation of WP2 and the statement that narrow-band concept would satisfy also the requirements of France and Germany.[732]

The official minutes of the GSM Committee immortalized a flamboyant spectacle by dispelling further actions. Since the decision, the procedure of the CEPT assumed unanimous agreements, France and German delegations were asked to "reconsider their position for the sake of European unity and the future of the GSM project".[733] The GSM Committee was well aware that the representatives of Germany and France were not able to reject supporting wide-band concept due to political reasons, since both countries had invested a lot on it and the concept had political support.[734]

Formally, the GSM Committee resulted in a decision where no final decision could be reached during the meeting. But since Germany and France did not resist the narrow-band concept on the technical level, the GSM Committee had established an ad-hoc working party to formulate the goals for a narrow-band TDMA. This group defined the Working Assumptions, which were accepted, but the content was listed in a separate document.[735]

The Madeira Meeting was undoubtedly a very important event, but not because of extraordinary drama. The main importance was laid on the decision of the GSM Committee to continue the work based on working assumptions, which made the work of WPs possible without any major delay. The second important implication was that the decisions made enabled work on more detailed specifications. This in turn required the participation of manufacturing industries, which was also enabled. The first companies took part in the meetings of the Working Parties already in the spring of 1987.

Those attending the Madeira Meeting are sure to have felt the hectic atmosphere, which left a very deep impression. But a totally different question is that of whether the destiny of the GSM project was really in scale or not.[736] It is more than likely that on political level another "French poker", or more likely intra-French[737], was played, since already in late 1986 it was decided to set time limit to Easter of 1987 for the GSM Committee to reach a decision.[738] Preparations proceeded to a point where a draft of Memorandum of Understanding for Implementing GSM was presented to the Madeira Meeting. The preparations of the European Commission were also put forward in March, and this resulted in the Recommendation on implementation of the GSM system and of a directive on the reservation of frequencies. When ministers of the "QP" block (Germany, France, Italy, and the United Kingdom) met in May 1987, final "last-minute milking" took place, which paved the way for

732 GSM # 13.
733 GSM # 13 Article 6d.
734 Interview of Thomas Haug.
735 GSM # 13, see Doc 41/87.
736 It is, of course, possible that Alcatel would had been willing to accept a "French solution", because it was trying to enter the US markets.
737 Between the minister responsible for telecommunications and others supporting European integration.
738 Avery 1986.

"approving" the results of the Madeira Meeting and manifested itself in the imminent establishing of the MoU in September.

3.2.2.3.3 Speech Codec

The Joint CEPT TR3/COST 207 Experts Group on Speech Coding started its work in November 1985 with representatives from nine administrations (i.e. Denmark, Finland, France, Germany, Italy, the Netherlands, Norway, Sweden, and the United Kingdom). Originally, there were twenty-six candidates for codecs, and even though several of them bore close resemblances to one another, it was impossible and inappropriate to evaluate them all. It was decided to eliminate the superfluous candidates and allow one codec per country. Each administration was responsible for electing the national alternative. The potential nine candidates were reduced to the six most suitable ones for evaluation.[739]

Originally, the plan was just to choose the most suitable candidate, but in March 1986 the work plan was divided into two phases. Phase 1 would be extended to the end of January 1987 at the request of the GSM Committee. Phase 2 would have two codecs being retained for optimization rather than one as was originally envisaged.[740] This change reflected the concern about relying too early on just one alternative, in case of narrowness of the evaluation test.

The selection process became a little bit easier, since the Netherlands and Denmark actually did not submit a national candidate. In the fall of 1986 six candidates were selected for evaluation. Since the HUT proposal of Finland proved to be unsatisfactory, it was eliminated. The other candidates were examined by the Italian CSELT laboratory in November-December. Italian and Norwegian candidates did not fulfil requirements, and they were dropped. Two main types of codecs were left: the French and German candidates were based on the exited linear predicting coding (LPT) method while the British and Swedish proposals were sub-band codecs (SBC).

As was expected beforehand, no single codec was superior compared to all others regarding all criteria. In a situation where proper weighting of mean speech quality versus delay versus complexity could not be achieved, making a hard choice was considered to be risky. In addition, some uncertainties caused by implementation problems overlay the evaluated data. Since several claims of possible improvements were considered to be credible, but could not be quantified, it was decided to merge the four candidates to two proposals for compromise candidates.

The RPE-LPC codec of Germany had the best average speech quality. It was ranked into the best group considering complexity and in the second group considering delay. The MPE-LTP codec of France had a good mean quality, too, but it was ranked last in respect of complexity. In order to improve the error

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[739] GSM Doc 5/86.

[740] GSM Doc 39/86, 29/87.

robustness while keeping the same level of quality in error free environment it was proposed to study a modification of the RPE-LPC by adding a feature of the MPE-LTP, namely long-term prediction (LPT).[741] This hd the feature of reducing the net bit rate from 14.77 to 13.0 kbit/s.[742]

TABLE 24 Ranking of speech codec candidates by evaluation criteria
Source: GSM Doc 29/87

CRITERIA	RANKING ORDER			
	1st	2nd	3rd	4th
Voice quality	FRG	F	S	UK
Delay	UK	F, FRG, S		
Complexity	FRG, S, UK	F		

The SBC codecs complemented the shortcomings of the proposed candidates. The 8-band SBC codec of the United Kingdom showed an outstandingly short delay, but it was ranked 4th in respect of mean speech quality, while the 16-band SBC codec of Sweden showed a better mean speech quality, but it was ranked into the second group of delay. By looking at the different results and regarding the different strengths of the SBC codecs, the experts of the United Kingdom and Sweden saw an opportunity for developing a better 8-band compromise with SBC having delay and better speech quality than the Swedish 16-band SBC. It was expected that this codec would have the capability of transmitting non-voice signals without any significant increase in complexity. The United Kingdom and Sweden decided to propose an improved SBC coded for Phase 2 tests.[743]

According the working plan, Phase 2 was required to include optimizing of two candidates. The JEG Group had decided to introduce two joint compromise candidates, but in less than one month the GSM Committee decided to choose the RPE-LPC codec as the working default codec. This decision was taken at the Madeira Meeting in February 1987. It was certainly in line with the plans, and the change seemed quite sudden, since before the discussion on radio access the GSM Committee considered that the task of JEG included evaluating possible challenging candidate codecs, but later it was decided to proceed on a wide front of working assumptions instead of optimizing parallel alternatives.[744]

3.2.2.3.4 Non-proprietary technology

The European practice within CEPT was based on standardizing non-proprietary technology. The aim of the GSM project was to define an open standard, although the issue was not discussed. The question was considered self-evident or less important. The IPR question did not pop up until late 1984,

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741 GSM Doc 29/87
742 Vary 1988.
743 GSM Doc 29/87.
744 GSM # 30.

when France and Germany declared their cooperation in the joint digital project. France and Germany issued a request for proposals to manufacturing industry on digital study and testing. They were not intending to restrict exploiting the findings of the projects by IPRs or trade barriers of any kind, because the intention was to launch the diffusion of the Franco-German future system to other countries. The goal was a selfish one, particularly as only companies located in France or Germany were allowed the possibility to participate.[745]

The companies involved in the Franco-German project had to sign a statement, wherein they committed to grant a non-exclusive free-of-charge operating license to any competent third party of the European countries represented in CEPT, including manufacturers, sellers and operators. This pattern was offered to the GSM Committee, which adopted it as the foundation of the IPR procedure.[746]

The GSM Committee did not formulate a holistic patent policy, one that would be widely considered beforehand. Instead it adopted at first a procedure, which had to be supplemented due to circumstantial reasons. Soon it became evident that simply up scaling the Franco-German procedure would not solve the problems. Early in 1986 the Speech Coding Group (JEG) made it known that a large number of big companies would be involved, and it might be difficult to get the IP statements from all them. The most vital question was: Would the GSM Committee accept only those companies, which had given an IPR statement as its speech codec candidates?[747] The GSM Committee drew realistic conclusions on the prevailed situation:

- The problem is very specialized and the legal aspects of it need to be analyzed by experts.
- The problem had to be sorted out now before the candidate systems are put forward and the decision has to be made.
- Regarding non-European patents, it is very uncertain if anything can be done at all to protect the Administrations and industries from having to pay royalties.

The decision of the GSM Committee was very firm. Since the essential technologies used in the system need to be available on a royalty-free basis, the issue will not be presented as a negotiable one in the contacts to be made with the industry. And only companies, which had signed the required IPR statement would be considered as GSM candidate systems. To fulfill this aim, the experts had to formulate a written legal document.[748]

In June 1986, the CCH requested that the patent question be taken into consideration by the Telecommission. But at the same time the GSM Committee had to proceed, because the speech codec issue required a solid and logical policy. Finding a common stand was difficult, because there was no unanimity

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745 GSM # 6, Doc 76/84.
746 GSM Doc 11/86.
747 GSM Doc 5/86.
748 GSM # 11.

as to whom free licenses should be granted.[749] In order to manage the problem in time, the GSM Committee agreed to operate on an interim basis requiring IPR statements from the speech codec candidates. This became a standard procedure for the GSM Committee. The owners of essential patents for speech codecs were required to grant licenses to the users within the CEPT countries on a non-exclusive basis and on royalty-free terms, and to users from countries outside CEPT on a non-exclusive basis and on commercial terms.[750]

The IPR aim of the GSM Committee regarding speech codecs turned out be successful: by fall, the GSM Committee had received statements for all but three corresponding requirements. Later on, PKI and IBM consented to the required formula, but British Telecom (BT) dawdled and the GSM Committee banned BT from participating in the work of JEG.[751]

The equivalent IPR statement procedure was implemented with the radio-access candidates in the autumn of 1986 with good results. But in general, it was noted that the statement procedure was not sufficient and the administrations were obliged to perform patent searches in regard to both speech codecs and radio-access methods. Acute measures were no more coercive than as earlier and in addition to this, they required complementing procedures. The GSM Committee also wanted to patch up the shortcomings of the IPR procedure in general. The main concern was to ensure the openness of the standard, which included the requirement of granting licenses on essential patents and the possibility to procure equipment from several sources. In order to consider the different patent search methods and the validity of the statements, a joint meeting of technical and patent experts was arranged in London.[752]

The joint expert meeting in London (December 1986) was a turning point. Instead of circumstantial related procedure, the IPR question was considered as a holistic policy. For the very first time, there was open questioning of the issue of it perhaps being not a good policy to have a GSM standard not protected by any patents. It was though that perhaps a certain degree of protection against non-European manufacturers would be required to induce European companies to decide to invest in the development of the equipment, since such protection could not be ensured by the type approval procedures because of international trade agreements. But it proved impossible to reach an agreement on the basic elements of a common IP policy. More success was achieved in improving practical activities related to patent search. It was also agreed to establish a panel of experts on IP, which would have advisory role in regard to the GSM Committee and the WPs. In addition to this, the meeting refined the methods of requiring statements on unindentified patents. The aim was to create a European "patent club", which would create a network of operators and

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749 Within the JEG, only Finland and Norway were willing to grant free licenses to all countries. France wanted to limit free licenses to the CEPT countries and Sweden was willing to limit this to GSM-participating countries only. Germany was ready to accept both of the last two alternatives.

750 GSM # 11, Doc 61/86.

751 Actually, JEG did not apply the strict rule of the GSM Committee and BT was allowed to take part in the work of JEG. BT also signed a satisfactory statement in 1987.

752 GSM # 12, Doc 91/86.

manufacturers within which there would be access to IP rights on reciprocal conditions.[753]

When the GSM Committee discussed the proposals of the London meeting in early 1987, it started to debate on the premises of patent policy. This led to the approval of the idea of a Patent Club, although there were various views on how to implement it. The basic differences were related to the role of the payer, whether it would be the operators or the manufactures, who would carry the burden. In order to evade the shortcomings of these plans, a different plan was introduced by the British. According to it, "foreground"and "background"[754] patents would be available on unrestricted basis and without cost to the owners of IPRs and on fair and reasonable terms to the members of the club. Both types of patents would be available to non-members on commercial terms. Membership would be open to all signatories of the MoU and to all manufacturers on the approved bidders list of a MoU signatory. In order to encourage manufacturers to join the club, only members were accepted to participate in supplying equipment. This plan consisted of a clear defensive element against non-European manufacturers and claims by third parties for infringement of their IPRs. In such a case, all the members were expected to act in concert against such claims.[755]

Basically, the GSM Committee approved the British scheme of patent panel in the autumn of 1987, but it made it clear that it would not start buying patents. Although the scheme was basically logical, it did not do away with the problem caused by third parties. The patent panel suggested establishing a legal body, which would negotiate with the third parties. In 1988 it was proposed that the ETSI would play the role of a legal entity, but this problem was not solved.[756] When the GSM Committee was transferred to the ETSI in the spring of 1989, WP5 (former patent panel) was promoted to the status of Independent Technical Committee of ETSI, cutting the direct connection between IPR issues and the GSM Committee.

The fundamental shortcoming of the Patent Club scheme was in the imbalance between operators and manufacturers. The aim of the club was to negotiate the most competitive supply arrangements for the equipment.[757] The idea was a thrilling one, because it would make procurement easy. However, this could not be implemented, probably because Motorola started to resist the plan,[758] and this caused a shock among European manufacturers, whose policy

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753 GSM Doc 1/87.

754 "Foreground" patents were direct outcomes of GSM work, whereas "background" patents were outcomes of the pre-GSM era or indirect outcome. The GSM Committee replaced these concepts by those of essential and non-essential patent.

755 GSM Doc 122/87.

756 GSM # 16, 18, Doc 46/88, 88/88, 150/88, 180/89.

757 GSM 122/87.

758 Usually it is claimed, that Motorola resisted the patent policy of GSM in 1988. However, there is no sign of this in the GSM documents, but they are fragmental. It seems that the resistance of Motorola was related to concerted procurement and open IPR statements. Procurement was an issue of the MoU organization and it did not have directly anything to do with the GSM Committee. According to Doc 88/88, "Procurement terms which transfer all of the risks associated with IPR infringement from system operators to manufacturers

was not based on IPRs. The manufacturers were left to solve the problem among themselves, and this led to agreements on cross-licensing.[759]

Although the Patent Club and plans for procurement procedures did not succeed, the IPR procedures related with standardization continued and were composed of both IPR statements and patent searches. Actually, at that stage, the GSM Committee did not have any other alternatives, as it did not have earlier, because patent procedures were related to the practices and preferences of the participating NTAs.[760]

3.2.2.3.5 Flexible technology

The requirements of the GSM Committee were not focused on one aspect. On the contrary, there were contradictory requirements. Capacity was an essential requirement, but it was not superior to others, since on the counterweight there were requirements of cost factors and providing service equally to remote and densely populated areas. In addition to this, at the time that the basic choices were made, it was a common knowledge that digital systems could offer double the capacity of analog systems.

The question of ensuring sufficient capacity was knowledged, although it was not considered to be an urgent issue. The Working Assumpition in early 1987 included a half-rate speech coder, which would give double the capacity. But it was not until early 1990 that this work was initiated.[761]

Another method providing enlarged capacity was Discontinuous Transmission (DTX). The idea was that if nothing was transmitted on the air when there was no useful information to transmit, this would reduce interference on the air and hence help to increase the spectral efficiency by reducing cluster size. According to early calculations, the gain in spectral efficiency could theoretically be around 50% in optimum conditions, but in practice much lower.[762] In the fall of 1987, SCEG (former JEG) established a new sub-group to study the DTX function.[763] Within the DTX sub-group there was already uncertainty as to whether the claimed improvements in spectral efficiency by using DTX really can be achieved. This uncertainty was found to

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are not acceptable to manufacturers". See Bekkers 2001.

759 Cattaneo 1994; Bekkers and Liotard 1999.

760 The IPR policy of the GSM Committee has been criticized by Cattaneo 1994, Bekkers and Liotard 1999 for lack of policy, which is justified, but the "IPR policy" (should read: procedures) was related to the circumstances of the European NTAs. Particularly Bekkers and Liotard estimated the GSM from the elaboration of the ETSI IPR policy point of view. From the standard-setting point of view, the procedures of the GSM Committee related to IPRs leave less room for criticism, because a strict policy was a prerequisite for avoiding aspirations of of industrial policy. Thus it was also affecting the cohesion of the GSM Committee.

761 Motorola informed the GSM Committee that Japan and the United States were going to introduce half-rate codec with a very rapid procedure. The intention of Motorola was to totally remove the optimizing phase, because in Japan and United States one candidate was chosen and set to a part of standard.

762 Hansen 1988.

763 GSM # 15.

be one possible reason for laboratories and companies being reluctant to commit themselves to study the issue. The GSM Committee was not unanimous on whether DTX could fulfill the promised spectral efficiency, but the possibility of power saving was tempting.[764] Later on, the power saving effect on hand-portables was seen as the most important benefit to be had from using DTX.[765]

The GSM network is intelligent and allow flexibility. Particularly this concerns the implementation of handover. The detailed algorithms employed in handover processing and decision-making were not defined by the GSM Committee, but were instead left open to be defined by operators and manufacturers. This is essential since the algorithms to be used depend on many other factors in the system design, e.g. size of system, cell size, cell topology, frequency reuse strategy, traffic distributions. In addition, the interfaces defined between the infrastructure entities (MSC, BSC and BTS) allow handover processing and decision-making to be distributed throughout the network. This permits optimum allocation of processing resources depending on the type system deployed. In remote areas, MSC is responsible for handover. In small cell urban systems, a large BSC could control an area such as a city center employing a microcell network, and handle all handover processing and decisions without reference to the MSC. MSC would only be employed for handover decisions across BSC areas.[766]

In order to ensure that network operators would be able to seek a competitive supply of digital cellular infrastructure equipment, the GSM totally started to define the "A" interface between the base station and the switching center.[767] But the BSC unit practically became nearly as complex as MSC[768], which meant that switching companies supplied BSCs also.[769]

Due to the complexity of the Radio Sub-System interface between BSC and MSC, the GSM Committee started to define the "B" interface (later "A bis") between BSC and BTS/TRX, an interface at the transceiver level in order to ensure possibility of a simple base station, which could be used in remote areas, and to increase the number of companies manufacturing base stations.[770]

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764 GSM # 16, Doc 191/87.
765 Hansen 1988.
766 Target and&Rast 1988.
767 Knight 1988.
768 According to an estimate by Orbitel, it required 200 man-years to develop the MSC software, 180 man-years in the case of BSC, while the figures for BTS and MS were respectively 50 and 35. See Pinches 1991.
769 Interviews of Matti Pasanen, HansThieger and Kari Laihonen.
770 Rosenlund 1988; GSM # 17, Doc 33/88.

3.2.2.4 Ensuring implementing of GSM

3.2.2.4.1 Political framework

The Madeira Meeting in February 1987 was important, since it reflected that the NTAs accepted the technical concept and considered it to respond to their needs. The next logical step was to activate measures ensuring the implementation of the GSM system. This was deliberately excluded from the tasks of the GSM Committee.

Actually, the already partial motive of the Franco-German cooperation was to ensure the implementation of the GSM system, and this aim was strengthened when Italy joint the block in 1985[771], although it still clearly remained by nature an industrial political pool. The three countries involved were by no coincidence the engines of European integration and they represented a significant general industrial force. With the United Kingdom joining in 1986, it attained more credibility, since the United Kingdom had just one year ago introduced an "interim" analog system, and it was currently the only member of this Quadriparty to implement the analog system on the 900 MHz band. The Quadriparty was politically strong enough to promote the objective.[772] In December 1986, the EC's heads of state and the European Council asked the Commission and Council of Ministers to make a special effort to secure an agreement on standards and the commitment of operators to enable Europe to compete in the development and marketing of digital cellular radio in the 1990s.[773]

The Quadriparty took a decisive step when the ministers responsible for telecommunication met in Bonn on May 19, 1987, and signed a declaration ensuring the opening of commercial service in the four countries in 1991. The GSM Committee was informed already at the Madeira Meeting in February and now all authorized operators of CEPT countries were invited to sign a Memorandum of Understanding (MoU) in September.[774]

The MoU was signed in Copenhagen on September 7, 1987 on general director level. Generally speaking, the MoU is considered essential for the GSM system, because it assured manufacturers to invest in developing equipment.[775] In the short term, the MoU did not have similar impact on operators, because of sixteen countries participating in the work of the GSM Committee, only Austria, Greece and Switzerland did not initially sign the MoU.[776] The initial

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771 The agreement was signed in Nice on 20th June 1985. The signatories agreed actively to support the work of the CEPT related to the definition of a common European standard (GSM). See GSM Doc 92/85.

772 Formally the Franco-German-Italian cooperation was open to all CEPT countries, but only the UK joined it.

773 Compare to Richter 1991, who presents the process from the European Community point of view.

774 GSM Doc 68/87, # 13; according to the History of GSM Association, the MoU was drafted by Stephen Temple from DTI of the UK.

775 This a predominat statement in literature; see also interviews (Thomas Haug, Matti Pasanen, Hans Thiger, Kari Laihonen).

776 Originally, the MoU was signed by representatives of 14 operators from 13 countries (two

interest shown by operators was a surprise, because it was considered that at least a small number of operators had to commit themselves to implementing the GSM system in concert.[777] This shows that "active operators"[778] had already realized the value of early and synchronous implementation of the GSM system without "legal sanctions". On the other hand, in practice, the signing of the MoU did not require much. Formally, the agenda of the GSM MoU contained many ambitious issues, which were either not realistic,[779] e.g. industrial policy aim, or did not require true commitment, such as giving support on promoting the GSM as a world-wide standard recognized by the ITU and diffusion outside the CEPT countries. In practice, the signatories were committing themselves only in opening commercial service in 1991 and providing international roaming, implementing the GSM in accordance with defined interfaces, constructing of a network in accordance with very broad objectives, establishing of the MoU organization, and supporting standardization work on the GSM.[780] Later on, the importance of the MoU was increased due to other reasons, because it created a natural base to promote the GSM system outside Europe also.[781]

The meetings of the GSM MoU carried out the burden related to practical actions on preparing procurement, roaming, and other issues with implementation. Although there was quite a natural line separating the tasks of the GSM Committee and the MoU organization, they had issues with common interest needing coordination. In spite of that, there were no serious confrontations between the organizations of the GSM and MoU, partly because mainly same persons were involved in both organizations.[782]

The European Community had the general aim of establishing the Single Market in 1992. In the telecom sector one of the focal areas of the EC was mobile communications. On June 25, 1987 two acts related to the GSM system were ratified. Council Recommendation 87/371 emphasized stimulating the process for the creation of technical standards for the infrastructure and terminals, obtained fully coordinated approval for the implementation of the GSM system and promoted the usage of hand-held terminals. Council Recommendation

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UK operators), plus a representative of DTI from the UK. The original signatory countries were Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, and the United Kingdom.

777 History of GSM Association ; officially GSM MoU required 30 votes (as per the definition by MoU on European Telecommunication Standards) to become valid. The votes of France, Germany, Italy and UK amountef to 40. The other EEC countries represented 36 votes, while the five EFTA countries had only 19 votes.

778 The GSM MoU was originally signed by 81% of the countries participating the work of GSM, but only 50% of all CEPT countries.

779 According Article 8 of MoU, "The procurement policies of the network operators shall be to **encourage a strong competitive European industrial manufacturing base** for 900 MHz digital cellular mobile telecommunications technology **within the constraints of commitments to GATT** and the **obligations of the individual network operators to secure the most cost effective solution** for their respective organizations. Competition shall be encouraged in each of the markets for mobile stations, base stations and mobile switching equipment." These contradictory aims (in bold, by the author) could not easily be included within a single shared aim.

780 GSM Doc 121/87.

781 History of GSM Association.

782 Interview of Matti Pasanen.

87/372 reserved frequencies for the GSM systems. The member states had to ensure that at least the 915-914/950-959 MHz band would be reserved exclusively for GSM by January 1, 1991 and that the necessary plans be prepared to explore the entire band 890-915/935-960 MHz as regards commercial demand as quickly as possible.[783]

The European Community started actions supporting the implementation of the GSM system. In 1988, a market study was carried out by a consulting company revealing that the predicted market would be ECU 20 000 million up to the year 2000. The forecast of terminals was worth of almost ECU 1 500 million per annum by the year 2000.[784] The number of subscribers was estimated to exceed 10 million in 1998 and 15 million in the year 2000. The popularity of GSM was expected to exceed analog systems in the mid-1990s.[785] The EC also monitored the observance of Recommendation 87/371 and Directive 87/372 in the member states and compiled a report by the end of 1990. The report also revealed a number of critical areas, where coordinated action was required. These included establishment of an interim approval scheme for GSM terminals, implementation of mutual recognition for the GSM system in the countries of Central and Eastern Europe.[786]

3.2.2.4.2 MoU activities

The MoU coordinated all the activities of cooperation directed to assure an actual European roaming service from July 1991 onwards. The chairmperson of the MoU was rotated every 6 months and the plenaries assembled from the fall of 1987 onwards. In addition to plenary meetings, there were seven expert groups focusing on:[787]

- Billing and accounting
- Marketing
- European roaming
- Technical coordination
- Technical compatibility
- Administrative procedures of acceptance

The original MoU document included an Action Plan of activities, although specific dates were left to be defined afterwards. The Action Plan was divided into four major phases, but not all were obligatory.[788] The operators were given free hands to adopt experimental and pre-operational phases, the main common objective being the opening of commercial service in July 1991.[789]

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783 Weltevreden 1991; There was no strict deadline for exploiting the entire CEPT band (including the band of analog systems), but just an estimate that it would be realistic to envisage to use it within ten years. See Council Directive 87/372 EEC

784 Weltevreden 1991.

785 Böhm 1989.

786 Weltevreden 1991.

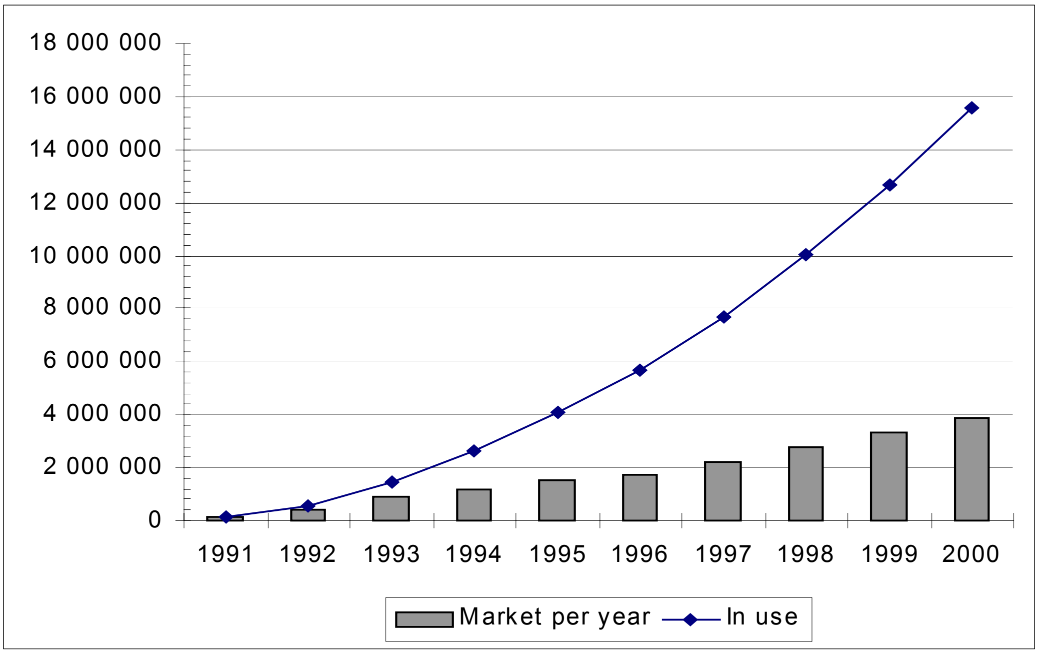
787 Failli 1988.

788 GSM Doc 121/87.

789 Failli 1991.

TABLE 25 Estimations of 1988 of exhaustion of analog systems and demand for GSM
Sources: MEG 1990; ITU YSTS 1988-1997 (fulfilled situation); EMC Report March 2001 (subscribers in year 2000)

Country	ANALOG SYSTEMS Estimated:		GSM			
	Capacity (1000s)	System full	Estimated number of subscribers in year 2000	Estimation fulfilled Year	Subscribers in Dec. 2000 (1000s)	Estimation as percentage of materialized situation in Dec
Austria	350	1997	232	1996	6 000	3,9
Belgium	50	1991	432	1996	5 577	7,7
Denmark	350	1995	292	1995	3 428	8,5
Finland	700	1995	231	1995	3 735	6,2
FRG	500	1992	3 400	1996	48 295	7,0
France	350	1991	1 600	1996	29 052	5,5
Greece	350	2000	16	1993	5 932	0,3
Italy	1 000	1997	1 100	1996	39 607	2,8
Netherlands	350	1995	666	1996	10 720	6,2
Norway	550	1997	120	1994	3 008	4,0
Portugal	100	..	8	1992	6 665	0,1
Spain	500	1997	375	1996	24 052	1,6
Sweden	800	1995	780	1995	6 338	12,3
Switzerland	300	1992	1 288	1998	4 717	27,3
United Kingdom	1 600	1992	4 880	1997	39 891	12,2
Total	7 850		15 420		237 017	6,5



Sources: MEG 1990
FIGURE 11 Estimations of 1988 regarding the terminal market of GSM in Europe

TABLE 26 Three Phases for implementation of the GSM system (Planned schedule)
Source: Failli 1991

PHASE	TASK	TIMING
Experimental phase	Validating the system	1989
Pre-operational phase	Verifying the characteristics of the various equipment	March 1990 – March 1991
Operational phase	A) Starting with the delivery of network equipment B) Opening commercial service	A) March 1991 B) July 1991

3.2.3 Implementation

3.2.3.1 Market: shift to digital

The market study carried out in 1988 as an EC assignment did not promise a carefree future for the GSM network, although this was not emphasized in public. The first years of implementing the GSM would customarily involve unsureness shadowed by reaction of the markets, but there was one specific factor causing disturbance. Of the countries which had an analog system operating on the 900 MHz band, or who were planning to implement one, only the United Kingdom and Switzerland considered themselves as having a shortage of capacity as early as in 1992, both relying on idea of a swift GSM implementation.[790] Other countries foresaw the capacity lasting at least up to 1995, five of them anticipating the need to postpone GSM to 1997 or to even a later date. Germany and France were in a position of their own, not having an analog system operating on 900 the MHz band, and they were tackling capacity problems.[791]

The market situation for the GSM became even more inconvenient, because the United Kingdom -implemented ETACS (extended frequency band for the TACS system) and Italy, Spain and Austria opened their TACS networks in 1990.[792] It would not be realistic to assume that these three countries would open the GSM networks just one year later without amortizing major investments. At the national level, decisions were made making the commercial implementation of GSM even more difficult. When Italy opened its TACS network, the price level of calls was halved and hand-held terminals were allowed.[793] This provided a threshold for the GSM.

According to a Nokia estimate released in February 1991, it was most likely that the first GSM networks to be launched would be in Germany, then in the United Kingdom, France, the Benelux countries (Belgium, Netherlands and Luxemburg), and the Nordic countries. Germany and the United Kingdom would hold the key positions. In the event of a successful launch, the other countries would benefit. High hopes were set particularly on Germany, where

790 The United Kingdom and Switzerland had set exceptionally high estimates of subscribers in the GSM system.
791 See TABLE 25 (p. 200).
792 EMC Reports (e.g. # 49)
793 See Failli 1991.

there was severe lack of capacity and a relatively high price level for mobile phones. In the United Kingdom and the Nordic countries, the odds were against GSM, these countries having "properly working" analog systems and low terminal prices.[794]

The successful diffusion of GSM was seen as depending on handsets related to price and size. According to Nokia, the terminal manufacturer would not make a profit before 1993, when there would no longer be any need to calculate R&D costs in terminal prices. The price level was double that of analog in 1991, and it was not expected to come down to the same level before 1993 or 1994, due to economies of scale and poor component technology.[795]

Both the GSM MoU and the EC had aimed at a coordinated introduction of GSM. In practice this implied the procurement of infrastructure. The coordinated opening of networks was a more complicated issue. Even though the GSM MoU and the EC had stipulated that the GSM networks should be opened on July 1, 1991, there was no definition at all of the level of service.

3.2.3.1.1 Opening of networks

The commercial launching of GSM networks was postponed by one year from July 1, 1991. The lack of terminals turned out to be the bottleneck. The terminal manufacturers were not willing to produce GSM terminal equipment in any great volume until they were guaranteed wider access to the market. Under the provision of the current approvals scheme, equipment approved in one country would not necessarily be approved in another country. There was also delay due to another issue; test equipment was not available in mid-1991. One manufacturer (Rohde and Swartz) had been chosen to be the only European accredited GSM test equipment supplier, but it could not meet its schedule, because the GSM standard (Phase 1) passed the ETSI approval procedure in May 1991.[796]

In order to accelerate the introduction of the GSM services, the MoU group decided, in May 1992, to allow GSM terminal manufacturers to self-certify their products, rather than wait for certification from independent testing bodies. This self-certification covered only some of the tests required for interim type approval. The remaining tests would still need to be independently conducted. The new procedure allowed manufacturers to by-pass the delay caused by the non-availability of test equipment.[797]

Two privately-owned operators, Radiolinja in Finland and Vodafone in the United Kingdom, had opened their GSM networks in December 1991, but it was not until June 1992 that terminals passing the interim type approval became available. This was the actual commercial launch of the first GSM networks. During the last six months of 1992, networks were opened in eight

794 Wilska 1991.
795 Wilska 1991.
796 Cranston 1993.
797 Cranston 1993.

TABLE 27 Commercial opening of the first GSM networks

Legend: In bold = private operator; in italics = DCS (GSM) 1800 operator; ~ = limited operation only; x = commercial operation;~/x = approximate time; Dk =Denmark; FIN = Finland; F = France; D = Germany; G = Greece; Ir = Ireland; It = Italy; L = Luxemburg; N = Norway; P = Portugal; S = Sweden; C = Switzerland; UK = United Kingdom ; A = Australia; HK = Hong Kong; NZ = New Zealand

Sources: compiled from various sources (particularly the European Mobile Communications Report 78: Dec 1993/Jan 1994)

Country	Operator	1992							1993												
		Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dk	Tele-Denmark Mobile	X	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	X
Dk	**Dansk Mobil Telefon (Sonofon)**	X	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	X
FIN	Telecom Finland		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
FIN	**Radiolinja**	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	X
F	France Telecom		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	X
F	**SFR**							~	~	~	x	x	x	x	x	x	x	x	x	X
D	DeTeMobil		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	X
D	**Mannesman**		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	X
G	**Panafon**														x	x	x	x	x	X
G	Stet Hellas														x	x	x	x	x	X
Ir	Telecom Eireann														x	x	x	x	x	X
It	Telecom Italy Mobile	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~
L	P&T Luxenbourg													x	X	x	x	x	x	X
N	Tele-Mobil										x	x	x	x	X	x	x	x	x	X
N	**Netcom**																x	x	x	X

TABLE 27 continues

P	TMN					x	x	x	x	x	x	x	x	x	X	x	x	x	x	X
P	**Telecel**					x	x	x	x	x	x	x	x	x	x	x	x	x	x	X
S	**Nordictel**				x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	X
S	Telia Mobitel					x	x	x	x	x	x	x	x	x	x	x	x	x	x	X
S	**Comviq GSM**				x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	X
Ch	Swiss Telecomm PTT										x	x	x	x	x	x	x	x	x	X
UK	Vodafone	~	~	~	~	~	~	~	~	~	~	~	~	~/ x	~/ x	~/ x	x	x	x	X
UK	*Mercury One-2-One*																x	x	x	X
NON-EUROPEAN																				
A	**Telecom MobileNet**											x	x	x	x	x	x	x	x	X
A	**Optus Mobile**												x	x	x	x	x	x	x	X
A	**Vodafone**																	x	x	X
HK	**HKTCSL**														x	x	x	x	x	X
HK	**Smartone**								x	x	x	x	x	x	x	x	x	x	x	X
NZ	**Bell South**														x	x	x	x	x	X

countries: Finland, the United Kingdom, Denmark, Germany, France, Sweden, Portugal and Italy (TABLE 27).[798] In practice, however, the "coordinated introduction" of the GSM was a failure even within European Community, since only six out of twelve countries opened GSM networks during 1992. The situation was actually even worse, because Vodafone refrained from true commercial service before the summer of 1993. Service in Italy was even more insignificant and government forbade the opening of genuine commercial activity before the spring of 1995.[799]

The commercial launch of the service was saved from failure by the demands on the German GSM market, introducing competition to the operator business. Particularly during the first two years, the German market was

798 Most sources do not note the difference between quasi-commercial and truly commercial opening of networks, e.g. Paetsch 1993.

799 Profile 1995.

responsible the lion's share of the total GSM market; it was as high as 90% in 1992 and still around 70% the next year (TABLE 28).

In the short- and long-term, competition became vital for the GSM. Even though only six countries launched GSM networks commercially[800] during 1992, the total number of operational networks was twelve. Sweden introduced three, Denmark, Finland, Germany and Portugal each two, while France had one operator initially, but at the end of 1992 and the beginning of 1993 the second operator also opened a network. Private operators had an indispensable role, because they were willing to take the risk and start early. It was only in France that a private operator started several months after the PT operator. The eagerness of private operators was logical, because they wanted to start amortizing investments and they did not have the benefit of having earned on an analog system.[801]

TABLE 28 The German GSM market share of European and world-wide GSM subscribers
Source: Calculations based on ITU statistics (ITU YSTS 1988-1997); * according to European Mobile Communications data

	1992	1993	1993*	1994
Share of European GSM market (%)	90	73	70*	42
Share of world-wide GSM market (%)	90	71	69*	37

The role of private operators was emphasized by the fact that of those granted a license in 1991 at the latest, it was only Netcom in Norway that did not start in 1992. Those countries, which had introduced by early 1991 their possible plans to give a second license to a private operator, but did not put this intention into practice during 1991, could not proceed before 1994.[802]

The commercial start of the GSM was not the only issue at stake on the national level. It was also a "pan-European" dimension on a narrow base, because operators in only seven countries had signed roaming agreements before the end of October 1992.[803]

The second wave of the GSM started in 1993, when GSM networks were launched in five countries. Norway, Greece and the United Kingdom had two operators each, while in Ireland, Switzerland and Luxembourg only the PTs were active. This phase included the diffusion of the GSM to the Asia-Pacific

800 Here commercial opening does not mean a real mass market, but continued operation without artificial regulatory limitations.

801 Only the French SFR had a commercially significant analog network. The Swedish Comvik had around 20 000 subcribers in its network. Others were new entrants to this business area. Vodafone, like Cellnet, had invested heavily in the TACS networks. As Cellnet was postponing the launch of the GSM network, the situation changed in 1993 when Mercury (DCS1800) opened its network.

802 The countries (Italy, the Netherlands and Spain) retiring their plans actually became among the last to introduce competition.

803 These operators were: (number of roaming agreements in parentheses) in Denmark, Tele Danmark (2), Dansk Mobiltelefon (2); in Finland, Telecom Finland (3), Radiolinja 4; in Germany, Deutsche Telekom (5), Mannesman Mobilfunk (1); in Norway, Norwegian Telcom (2); in Sweden, Swedish Telecom (2), NordicTel (3); in Switzerland, Swiss PTT (5); and in the United Kingdom, Vodafone (3). See Cranston 1993.

area, networks being opened in Hong Kong (2), in Australia (3) and in New Zealand (1).

The countries, which did not open GSM networks before the end of 1993 had also difficulties in their licensing policy. The group of ultimate tailgaters consisted of Belgium, the Netherlands, Austria, Italy and Spain. In addition to these laggards, Ireland, Luxembourg and Switzerland hesitated to introduce competition to the GSM (see Table 29).

TABLE 29 The last West-European laggards in launching the GSM service
Sources: Compiled from PNE 1998, 1999; Profile 1995

COUNTRY	OPERATOR	OPENING OF GSM NETWORKS						
		As 1st operator in country			As 2nd operator in country			
Overall laggards								
Austria	PTV (Mobilkom)		10/94					
Austria	MaxMobil					10/96		
Belgium	Belgacom Mobile		1/94					
Belgium	Mobistar					8/96		
Italy	Telecom Italy Mobile			4/95				
Italy	Omnitel Pronto Italia				12/95			
Netherlands	PTT Telecom (KPN)		7/94					
Netherlands	Libertel				9/95			
Spain	Telefonica			7/95				
Spain	Airtel				10/95			
Competition laggards								
Ireland	Esat Digifone						3/97	
Luxenbourg	Millicom Luxenbourg							5/98
Switzerland	Diax							12/98
UK	Telecom Securicor*				7/94			

TABLE 30 Regional breakdown of new GSM networks in Europe
Note: W-E outsiders include countries, which did not belong to EEC or EFTA
Sources: Profile 1993, 1995; PNE 1998, 1999

	1992	1993	1994	1995	1996	1997	1998
Western Europe	12	10	6	5	3	1	11
W-E "outsiders"	0	0	2	1	0	1	2
East Europe	0	0	3	10	11	10	3
Total	12	10	11	16	14	12	16

The 'overall laggards group' in Western Europe cannot actually take the credit of having made the GSM a success because in early 1994 the GSM had already been implemented in many countries outside the EU-EFTA region (TABLE 30. Even Eastern Europe saw the introduction of the GSM. Hungary was the first country to do so, opening two networks. Later on, a network started in Russia, but the process started in earnest in 1995 after the 900 MHz band was cleared from military use in several Eastern European countries. Western Europe faced one further wave in 1998, with the bulk of GSM-1800 operators opening their networks.

3.2.3.1.2 Subscriber growth

In retrospect, the original estimation of subscribers seems ridiculous, as estimations of cellular subscriptions usually are. But the estimation compiled in 1988 was based on knowledge gained during the years after the mid-1980s. There were "only" 390 000 new subscribers in 1987 in Europe. Compared to this, the estimated figure of 425 000 subscribers for the first year of the GSM was ambitious.

As a matter fact, the GSM estimation did not correspond to the materialized market situation before 1994, the commercial launch having been postponed by one year. After that, the growth took a new path with the GSM having more subscribers in the summer of 1996 than did the analog systems in Europe (TABLE 31 and FIGURE 12).

TABLE 31 Numbers of GSM subscribers compared to 1988 estimate
Note: includes only countries of Western Europe
Sources: European Mobile Communications; FT Mobile Communications; MEG 1990

Subscribers (x1000)	1991	1992	1993	1994	1995	1996	1997
Estimation of 1988	141	566	1434	2622	4082	5672	7672
Materialized situation	0	221	1341	4243	10229	22625	44999
Difference	-141	-345	-93	1622	6148	16954	37328

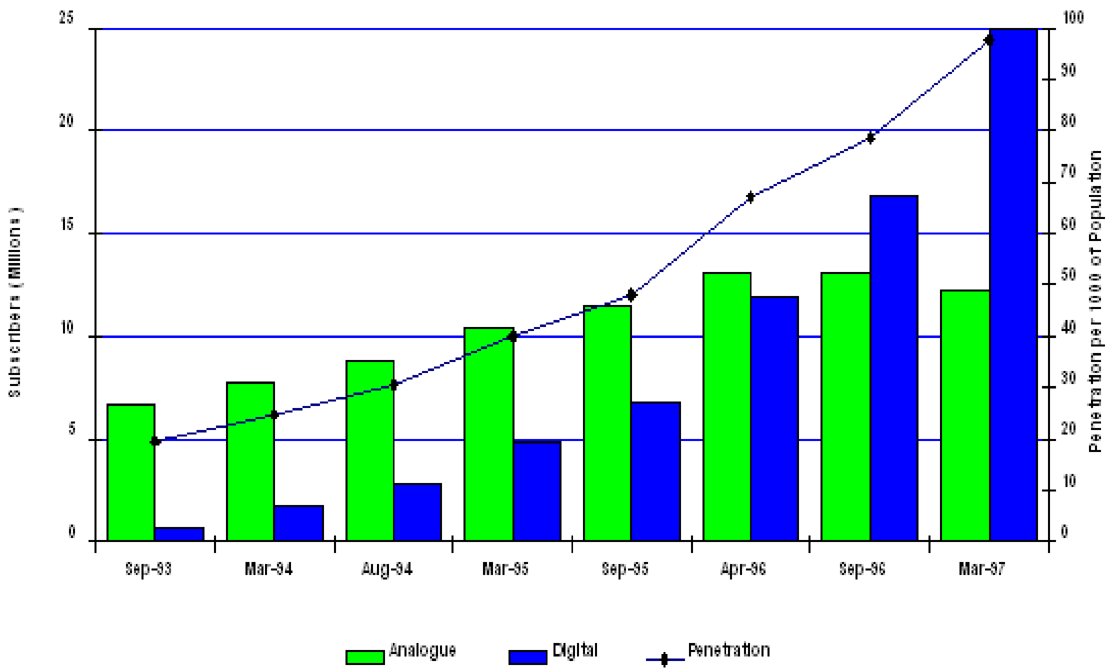


FIGURE 12 Subscribers to GSM and analog systems in Europe

People have mostly forgotten the trouble-filled beginnings of the GSM, because it certainly was not a bright, promising example of a "success story". The main obstacle was the shift to digital, or more precisely the timing of this shift, because the popularity of the analog system, particularly the TACS system, persisted due to investments recently made in several countries, combined with decisions to postpone the commercial launch of GSM. The first challenge faced by the GSM was to beat the TACS as the leading cellular standard in Europe. This took over three years (see Table 32).

The turning-point in the process of increasing the probability of success was 1997 . It took five years, until the summer of 1997, to get 50 million subscribers, but then followed a period of annual doubling. Just one year later, the GSM networks had over 100 million subscribers, one more year and the 200 million point was passed, and a further year saw the 400 million limit broken (see Table 33).

TABLE 32 Cellular subscribers (millions) in Europe by standard
NOTE: * 1989 figures related to October; ** 1995 figures relates to August; others to December
Sources: European Mobile Communications 1989-1995

	*1989	1990	1993	1994	**1995
TACS	0,8	1,3	3,6	5,9	7,3
NMT-900	0,3	0,6	1,8	2,1	2,3
NMT-450	0,7	0,8	1,1	1,3	1,4
Others	0,4	0,8	1,1	1,1	1,0
Analog systems together	2,2	3,5	7,6	10,4	12,0
GSM	0	0	1,4	4,3	6,5
Total (analog and digital)	2,2	3,5	9,0	14,7	18,5

TABLE 33 GSM subscribers (millions)
Note: World-wide GSM figures are rough estimates based mainly on ITU statistics
Sources: European Mobile Communications 1989-1995; GSM Association Statistics; ITU YSTS 1988-1997

	1992	1993	1994	1995	1996	1997
GSM West-Europe (EU&EFTA)	0,2	1,3	4,2	10,2	22,6	45,0
GSM Europe total	0,2	1,3	4,4	10,8	24,1	49,2
GSM World-wide	0,2	1,3	5,0	..	..	66,0
Total cellular, world-wide	23	34	55	87	138	204

3.2.3.2 Manufacturers

The emergence of the GSM system set formidable requirements for the manufacturers, who had to develop equipment in under three years. According to an estimate, at least ten manufacturers had invested ECU 300 million and 5 000 man-years in order to participate in bids for the GSM service. Offsetting this there was an incentive of ECU 1 billion on a yearly basis. This demanding task in due time compelled manufacturers to cooperate, this having forms varying from agreements or consortiums to mergers.

Although ultimately the GSM turned out to be an astonishing success, it had required tremendous investments and effort. By the end of 1987, when manufacturers had to make commitments regarding the development of equipment, sixteen operators had signed GSM MoU. In addition to this, only the United Kingdom, Germany, Sweden and Finland had granted a second operator a license by the end of 1990. Ultimately, competition on the operator market had an epoch-making impact, because it at least doubled the equipment market in a relatively short period and put an end to the traditional relationship between operator and supplier. The GSM market became a springboard for even network suppliers, fixed networks having been the main source of income in the early 1990s, digitizing of public networks continuing throughout the whole decade. Also the collapse of the Iron Curtain gave new possibilities for exports to Eastern Europe.

3.2.3.2.1 Market strategies

From European market point of view, the GSM turned out to be of notable importance as a wedge into the monopoly status of the PTTs. Furthermore, the EC was planning to create the Single European Market (SEA). It is interesting to give examples of the external interest in the opening up of the European telecommunication market, because it was intended to have the launching of the GSM precede the elaboration of the Single European Market. Particularly in the United States, the SEA project 1992 was labeled "Fortress Europe". Actually one can not claim that there was a big rush to the European telecommunications market, excluding services. AT&T had, as early as in 1982, before even announcing of the Single European Market, established APT (later AT&T Network Systems International NV), a joint venture with Philips. APT (AT&T NSI) had subsidiaries in several European countries.[804] Its market success was limited, and AT&T strengthened its presence on European market by buying a 20 per cent share of Italtel in 1989. It did not, however, make any particular structural assessments related to GSM (see Appendix 9).

Northern Telecom (Canada) was another North American manufacturer with direct ties to an operator. It entered the European market in 1987, when it bought 27 per cent of STC (UK) and practically the rest in early 1991. STC, however, did not provide a springboard to the Continental Europe.

Both AT&T and Northern Telecom missed the first GSM wave. AT&T did not react until 1994, when it allied again with Philips, this time to market GSM infrastructure. Northern Telecom reacted earlier. In 1990, STC agreed with Orbitel to develop base stations for the DCS1800 network and in May 1991 Northern Telecom signed a contract for a switch to the PCN (DCS1800) network with Microtel (later Orange), a firm with Matra among its original shareholders.

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[804] Noam 1992.

Since Orbitel had cooperated with Matra in developing GSM equipment, this provided a natural direction for more intensive cooperation. In 1992, Northern Telecom acquired a 20% holding in Matra Communication, a joint venture Matra Cellular being established in July 1992 to develop, sell and install GSM technology world-wide.

Motorola, the leading cellular phone manufacturer, already had a strong bridgehead with regard to terminals in Europe, where it had also supplied infrastructure to the TACS networks of Cellnet (UK) and to both NMT and TACS networks in Austria. Motorola did not ally with European companies in equipment development. In 1988, it won contracts to supply four validation systems, but next year it got only one order for a pre-operational GSM system in Spain. In 1991, Motorola started a cross-licensing policy with Alcatel and Siemens, and subsequently with Ericsson and Nokia. Motorola also made an agreement with Northern Telecom on inter-operability between the equipment of both companies. Similar agreements were made also with leading European switching companies Siemens, Alcatel and Ericsson.

Invasion by the Japanese manufacturers was still to come, though it had come to be repeated almost like a mantra ever since the early 1970s. In 1978, Mitsubisbi had established Mitsubishi Electric UK Ltd (MEUK), a firm that was to become the major international subsidiary of Mitsubishi Electric Corporation. MEUK became the base for the export of telecommunications equipment to Nordic countries.[805] It had supplied the base stations for the pre-cellular MTD networks and the NMT networks of Denmark, Norway and Sweden, but in the latter part of 1980s it stopped manufacturing NMT base stations.[806] Mitsubishi continued its production of mobile terminals. It seems that Japanese manufacturers were focusing on the growing TACS system, particularly in volume, but also in the number of networks at the turn of decade. Mitsubishi opened a new production plant in France early 1991. The production volume initially planned was between 3 000 to 5 000 units per week, a volume not insignificant in those days. Also, Matsushita Communications UK (Panasonic), established in 1988, manufactured TACS phones for the British, Irish, Austrian, Italian and Spanish markets. NEC, who had been exporting mobile phones since the early 1980s, established a new subsidiary, NEC Europe, in 1993, to take command of the firm's affiliates in seven European countries. All three manufacturers were planning to introduce GSM phones. Matsushita even displayed a transportable at CeBIT in spring 1991, and NEC was heading for the Telecom 91 event in October. Mitsubishi's targets were the year 1992 for its auto-based phone and 1993 for the hand-held version.

Actually, the EC's aim of creating a single market did not directly reflect the structure of the European manufacturers. There was a major re-structuring of European telecommunication manufacturing industry, this change, however, getting its impetus from digital switching. The first one to move was Philips,

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[805] Yearbook of European Telecommunications 1991, 1992, 1995, 1996; The European Telecommunications Fact File 1992 I-II, 1995, 1996.

[806] See Mölleryd 1996.

which was developing its own digital switch, but in 1982 it allied with AT&T, and the R&D project was cancelled. Philips's old ally Alcatel was planning to replace its pioneering E-10 digital technology, and it was also looking for a new market. The break down of AT&T in 1984 provided a fascinating opportunity for entering the United States market. At the same time, the French PT was looking for a second supplier for digital switching. There was heavy political pressure within the European Community towards Alcatel's plan to enter the American market and, reciprocally, to open the French market to a second supplier, particularly since Philips and Siemens were eager to enter the French market. Even in France there was severe opposition on the political level, excluding the minister responsible for telecommunications, and this resulted in the wrecking of Alcatel's plans. As compensation, Alcatel bought the multinational ITT in December 1986, bringing with it ITT's strong organizational position in Europe and modern digital switching technology. It was decided to privatize Alacatel in early 1987. The issue of the second switch supplier was solved by choosing Ericsson as the least harmless alternative. As a result, Ericsson and Matra established MET in 1987 to manufacture the AXE digital switch.[807]

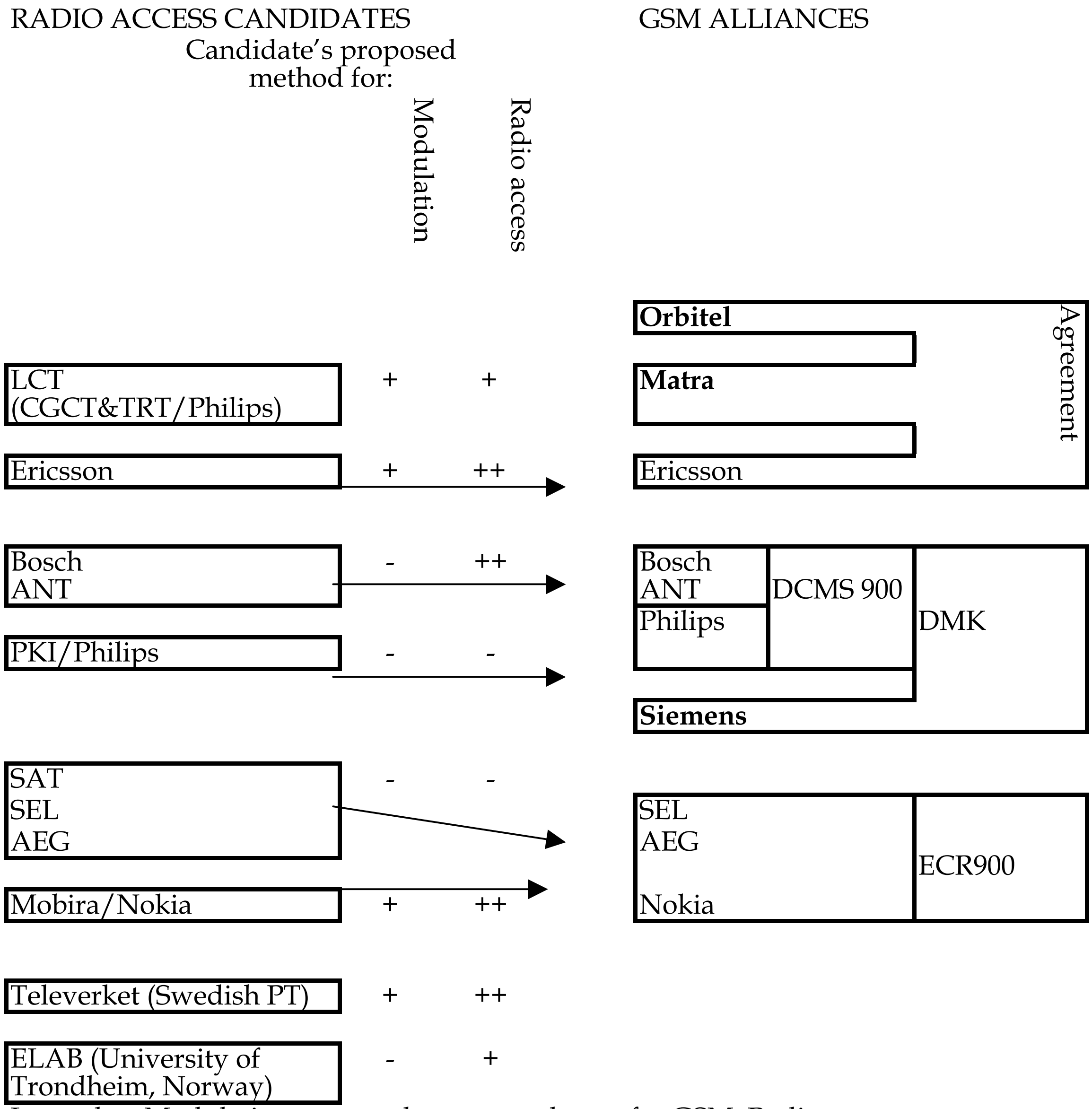
The strategic importance of switching was emphasized by the fact that there was no multinational European cooperation. The same approach of avoiding European cooperation in switching was adopted also in Italy and the United Kingdom. Italtel choose AT&T in 1989 to bolster its national digital switching project and British Telcom brought national companies to develop the System X digital switch. In the spring of 1988, GPT was established by merging the telecommunication activities of GEC and Plessey to develop and market System X. It was the "second wave", which brought a "cross -European" dimension to digital switching. In 1989, Plessey was taken over by Siemens, leaving GPT as a60/40 joint venture between GEC and Siemens. Siemens improved its market position also in Italy, where it made an agreement with Italtel to form a 50/50 joint venture. This agreement was reached by March 1993, but it took until February 1995 for the European Community to approve it. The activities of Siemens can not be labeled as Pan-European cooperation. Siemens was just securing market position against Alcatel, which had merged its Italian subsidiary with Telettra (I), and attained a 25 per cent share of Telettra.[808]

3.2.3.2.2 Infrastructure supply

Cellular radio was not in a situation corresponding to that in switching, Franco-German cooperation originally aiming to open the market reciprocally.[809] During the initial phase of the Franco-German digital project, three out of four

[807] Noam 1992.
[808] Yearbook of European Telecommunications 1991, 1992, 1995, 1996; The European Telecommunications Fact File 1992 I-II, 1995, 1996.
[809] See Roberts 1984 (75).

consortia were at least quasi-supranational, although when the consortia were allocated to the management of French and German PTs, only the SAT-SEL-AEG consortia remained truly supranational.[810]



Legend: Modulation: - = not chosen; + = chosen for GSM; Radio access: - = not chosen; + = partly equivalent; ++ = equivalent. **Bold** = did not participate before 1987; /name = parent company. Note: in 1987 Ericsson and Matra bought CGCT, which was a parent company of LCT

FIGURE 13 The Transformation of Radio Access Candidates to GSM alliances

After the basic technical solutions related to radio technology of the GSM system had been made, manufacturers started to prepare alliances. Since generally wide and narrow band radio access candidates are incorrectly allocated along the axis Nordic versus Franco-German,[811] it has been tempting to explain that the only motive to ally was to gain competence. Although this

810 See Chapter 3.2.2.3.2.
811 Cattaneo 1994; Bekkers&Liotard 1999, Bach 2000.

aim is quite obvious within former Franco-German developing consortia, it is also obvious that the Nordic manufacturers Ericsson and Nokia were trying to get a foothold in the markets, and in the case of Nokia it seems that the company's activities with consumer electronics brought it together with SEL.[812]

Also, the general re-structuring of telecommunications manufacturing had its impact on the alliances formed. Ericsson had started cooperation with Siemens, but this ceased after Ericsson was chosen as the second supplier for fixed network switching for the French PT.[813] Cooperation between Ericsson and Matra was logical, because they had already formed a joint venture MET to manufacture AXE switch for fixed networks in France. Since Matra had an agreement with the newly-established (1987) British manufacturer Orbitel, a troika was formed. After Ericsson broke with Siemens, however, Siemens was left alone, because the Alcatel-SEL-driven ECR900 consortium, which also included AEG and Nokia, was out of the question due to competition between Siemens and Alcatel. The only possibility left was the DCMS900 consortium already in existence, which consisted of joining forces for two projects, PKI (Philips Germany) and the Bosch-ANT venture. The joint DCMS900 and Siemens venture formed the DMK consortium. In France it is striking that Alcatel and Matra were not allocated to the same consortium, even though both companies were state-owned. The most logical reason for this was the competition in PSTN switching, Alcatel being the main and Matra the second supplier for the French PT.

The GSM consortia were able to supply a wide and overlapping range of equipment. The Ericsson-Matra-Orbitel alliance had two different Base Station Controllers, three different Base Transceiver Stations, but only one Mobile Switching Centre. The ECR900 consortium was able to offer three switches made by two manufacturers,[814] while the DCMS900 consortium and Motorola did not have a switch of their own to offer.

The initial phase (1988-1990) aimed at constructing and launching GSM networks shared three phenomena (see TABLE 34). Infrastructure contracts were won practically by the members of four consortiums and Motorola. Only in a few cases were local companies involved as suppliers of partial contracts. Secondly, usually operators maintained a relationship with their former analog network supplier. Thirdly, operators were not willing to count on just one supplier, but wished instead to ensure competition by sharing contracts with at least two suppliers. The Nordic PTTs were the main exceptions, since they jointly concentrated orders with Ericsson, but even they acquired another supplier subsequently in order to foster competition. The starting phase contained also two special features. The German base station manufacturers (PKI, Bosch, AEG) were focusing on the German market, which, during the first

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812 Nokia bought television production of SEL, and the company was aiming to focus on consumer electonics (see Ruottu 1998). – On the other hand Nokia had long relationship with Alcatel, and it had bought license of E-10 switch, which it initially manufactured as DX-100 before totally own digital switch DX-200 was developed (see Koivusalo 1995.

813 Meurling&Jeans 1994.

814 Pinches 1989; Böhm 1989.

TABLE 34 The suppliers of GSM infrastructure at the end of 1990
Source: European Mobile Communications Report 26, 35, 38, 49

Operator	Date	Pre-operational suppliers	Network infrastructure supplier (1989-1990)	Remarks
United Kingdom : Cellnet	July 1988	Validation system awarded to Motorola	Motorola, Nokia	TACS system from Motorola
United Kingdom : Vodafone	August 1988	Validation system project awarded to Orbitel/Ericsson	June 1989: Orbitel/Ericsson, later Nokia	TACS system from Ericsson
Nordic PTTs	September 1988	Combined validation project of four PTT's awarded to Motorola-Storno	Did not proceed further; contracts with Ericsson	
Spain Telefonica	Autumn 1988	Validation project awarded to Motorola	Barcelona/Sevilla pre-operational system: Ericsson/Motorola	
French PTT	September 1988	Pilot system projects to two consortia: Alcatel (ECR900) and Matra/Ericsson	ECR900, Matra/Ericsson	
German PT (D1)	September 1988	Two projects (validation systems) to : Siemens-DMCS900 and ECR900	Siemens, DMCS900, ECR900	
German PT (D1)	December 1988	Additional validation system to Motorola	Did not proceed further	
Germany: Mannesman (D2)	February 1990		Contract with Ericsson and DMK	
Netherlands PTT	January 1989	GSM project to ECR900	ECR900	
Switzerland PT	February 1989	Ericsson: GSM system for operation for Telecom 91 in Geneva	Ascom-Ericsson/Matra	
Italy SIP	Summer 1989	Small contracts to a number of groups including Matra/Teletra/Orbitel; OTE/Marconi; and Italtel	Alcatel-Italtel; Eriscsson-Fatme; Matra-Telettra; Siemens	Ericsson (/Italtel) primary supplier of TACS network
Austria PT	July 1989	Pilot system for small area: Alcatel Austria, Kapsch, Schrak and Siemens Austria	ECR900, Siemens	Motorola primary supplier of TACS network
Belgium PT			Contract with Philips/Siemens	
Finland: RL	December 1989		contract with 2 suppliers: Nokia and Siemens/Philips	
Portugal			Contract with Siemens	Siemens primary supplier of Netz C system network
Sweden: Comvic			Contract with Motorola and Siemens	

years, comprised the bulk of the total GSM market. Although Motorola was the most successful company in acquiring contracts for its validation system, the share of actual contracts was modest. The main initial customers were only Cellnet in the United Kingdom and Comvic, the second operator of Sweden.

The pre-operational launch of the GSM networks in 1991 brought about the de-structuring of the alliances. This process started a chain reaction in January 1991, when Ericsson bought 50 per cent of the shares of Orbitel. Matra, which was the third partner in the alliance, reacted in June and bought the Mobile Division of AEG and its Spanish subsidiary. Dissolving the ECR900 consortium was also inevitable, because there would be three companies representing four different switches, a situation irrational from the marketing point of view. The new structural composition would not provide any essential value added, since the development of equipment representing the first generation was already a matter of the past. Even though the alliances were useful in order to gain competence, the most important factor was ensuring entry to markets. Without doubt the greatest beneficiary was Nokia, which though having competence in supplying cellular networks since 1986, had only a limited number of references as a supplier of entire infrastructure before establishing the ECR900 consortium.[815] As a member of the ECR900 consortium, Nokia was the major party in the contracts with Radiolinja of Finland, Austrian PT and Cellnet (UK), which meant that Nokia assembled equipment manufactured by all the members of the consortium.[816]

TABLE 35 Market share of leading infrastructure suppliers for cellular systems
Note: includes all cellular systems
Sources: Hulten and Mölleryd 1994 (1991 data); McKelvey 1997 (1996 data)

MARKET SHARE %		
Manufacturer	1991	1996
Ericsson	40	40
Motorola	25	15
AT&T (Lucent)	7	16
NEC	7	12
Northern Telecom (Nortel)	7	7
Nokia	2	5
Siemens	..	5

Initially only Ericsson, Nokia and Alcatel were able to offer the entire network infrastructure. Ericsson was the leading cellular infrastructure supplier already in early 1980s and it succeeded in maintaining its leading world-wide position of around 40%. Ericsson's gain was based on the capacity of the AXE digital switch, widely adapted by analog NMT, AMPS and TACS systems.[817] Since 1993, the revenue of Radio Communication exceeded that of the Public

815 SFR got an operator license in France and chose the NMT-450 (modified) system. Nokia was chosen to supply the equipment together with ATR (Alcatel). Aftewards, Nokia got contracts from the former French colonies. Before that, Nokia had supplied infrasturure in 1986 to Turkey, and to the Finnish PTT, and two networks for oil fields in China.

816 Koivusalo 1995.

817 Mölleryd 1996; McKelvey 1997.

Telecommunication division.[818] Nokia was the 6th largest cellular infrastructure supplier in 1991, although its world-wide share was only 2%, but by 1996 Nokia had succeeded in raising its share in all cellular systems to 5% (TABLE 35). Nokia prospered much better in the GSM systems, where it was the second largest supplier of infrastructure at the end of 1993. Nokia's success was based on two factors: it gained the leading position in DCS1800 networks and the following year it gained a similar position in the area of base stations.[819]

Alcatel was the world's second largest switching supplier, but unlike its Nordic colleges, it was not cellular-oriented even on the organizational level. Alcatel's weakness was in its general dependency on a few large customers and a market focus excessively biased in favor of Europe. Before the mid-1990s over 70% of Alcatel's telecommunications revenues came from Europe only.[820]

Siemens was the second largest European switching supplier, and, like Alcatel, its organization was not shaped to respond to the challenges of the cellular market, but unlike Alcatel, Siemens managed to supply thirty-four GSM networks to Europe, Africa, Asia and America by 1995.

The strength of Ericsson lay in its strong hold and its comprehensive regional distribution. It was the only company, which belonged to the group of the three largest switch suppliers for cellular networks in any market. Ericsson was particularly strong in Europe and the Asia-Pacific region, where it was the largest supplier, and it was the second largest in Latin America and in the regions of the Middle East and Africa. Other European manufacturers were less successful on a wide front. Alcatel was focusing on Europe, while Siemens had a strong position in Africa, and Nokia had a minor share in North America and the Asia-Pacific region. Non-European companies did not achieve any significant hold on the European mobile switching market, their share in all was only 5 per cent in 1997 (see Table 36). There was a greater spread between several manufacturers as regards the supply of base stations. Again Ericsson, and to a lesser extent Motorola also, had a wide and strong position on several markets, while others were more focused on one major market and one or two exports markets. Of the European manufacturers, Nokia gained a leading position in Western and Eastern Europe, whereas Siemens was the largest in Africa.

3.2.3.2.3 Terminal manufacturers

There was concern in the GSM Committee regarding the ability of small and medium-sized enterprises (SMEs) to enter the market due to patents.[821] It has been claimed that the IPRS efficiently prevented SMEs from so doing, leaving

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818 Yearbook of European Telecommunications 1995, 1996. – Revenue of radio communications was 63 per cent in 1992; 90 in 1992; 142 in 1993; and 179 in 1994.
819 Koivusalo 1995.
820 Yearbook of European Telecommunications 1996; The Single Market Review 1997.
821 GSM Doc 251/90.

TABLE 36 Regional breakdown of market share(%) of cellular infrastructure suppliers in 1997

Remarks: North America switching also includes base stations.

(thick box)	1st largest
(grey)	2nd largest
15	3rd largest

Sources: IDATE-EGIS 1998

SWITCHING	WESTERN EUROPE	EASTERN EUROPE	NORTH AMERICA	THE ASIA-PACIFIC REGION	LATIN AMERICA	MIDDLE EAST, AFRICA
NEC				58		
Ericsson	50	46	23	**14**	21	32
Siemens	14	**10**		3		62
Alcatel	**13**	7		1		2
Nokia	10	37	5	6		
Italtel	6					
Lucent	2		37		3	
GPT	2					
Nortel	2		**21**	18	69	
Motorola	1		13		**7**	2
Hughes			1			
Others						2
TOTAL	100	100	100	100	100	100
BASE STATIONS						
NEC				25		
Nokia	19	55		4		
Motorola	18	3		**19**	**15**	40
Ericsson	**16**	36		26	16	**24**
Italtel	11					
Alcatel	10			0		
Nortel	10			14	66	
Siemens	9	**5**		1		29
Lucent	7			1		
Mitsubishi		1				
Kyocera				6		
Samsung				4		
Others					3	7
TOTAL	100	100	0	100	100	100

the market to the big players.[822] This is too partial an explanation, because there were several factors, which had a trend-like effect on small companies. There were some successful national manufacturers concentrating on an analog standard in a field in which they had gained a market hold by specializing, but the leap to new digital was fraught with difficulty. First of all, the product cycle was becoming shorter in analog systems; already in the early 1990s

822 Cattaneo 1994; Bekkers and Liotard 1999.

manufacturers were trying to introduce a new product every second year. In addition to that, digital technology required new qualifications, the difficulties in the amortization of expenses in an ever -decreasing period of time being even greater. Circumstantial issues also acted against the shift to digital, because the analog systems market grew well into the early 1990s, making it easy to decide to catch the early train.

The launching of the GSM networks did not cause an invasion by Japanese manufacturers, which is usually explained by the supposition that Motorola and European manufacturers were not willing to license IPRs to the Japanese.[823] Even though this explanation is most tempting, the ceremonial liturgy of the European Community embodying the idea of strengthening the European telecommunication industry, it is not a valid one. In the early years of the 1990s, leading Japanese manufacturers, such as NEC and Matsushita (Panasonic), were constantly losing their share of the market worldwide before the GSM took off or became a spectacular phenomenon. The most logical explanation is two-fold. Firstly, in Japan two networks based on the TACS standard were opened in 1989 and 1991 in response to the rapid demand of the last years of the 1980s and in Europe Japanese manufacturers invested in the manufacture of TACS terminals. Secondly, the shift to digital was delayed in Japan from 1991 to 1993. As several Japanese manufacturers were at the same time involved in similar digital projects in the United States, it seems that Japanese manufacturers were caught in the trap of withdrawing technology and delaying "domestic" technology.

Motorola was the leading cellular manufacturer world-wide keeping #1 position up to end of 1997 (Table 37). From 1988 to the mid-1990s its market share grew constantly. Since there is no data available of manufacturers' GSM market shares in the early 1990s, the relationship between Motorola and GSM had to be derived indirectly. The United States market was the world's largest and it had the largest impact on gained market share. In the United States, Motorola was opposing TDMA technology choice as premature due to circumstantial reasons and it was lobbying narrow-band AMPS as a rapid solution to increased demand.[824] Motorola's strategy was to focus on analog technology, where it has gained leading position and also kept it. Relying on withdrawing technology, left Motorola to third ranking position on the United States digital market after the mid-1990s. It would be too oversimplified to draw an analogy to Europe, since Motorola's attitude towards the European TDMA (GSM) was different, because in Europe dual-mode technology was not required. Although analog standards and particularly TACS grew remarkably in Europe up to the mid-1990s, this annual growth being surpassed by the GSM in 1994, Motorola did not neglect GSM. On the contrary, Motorola was the first company to introduce the GSM terminal and it also got a strong hold on the

[823] Bekkers and Liotard 1999; Bekkers 2001; compare to Garrard 1998. It is quite a common belief that IPR issues prevented Japanese manufacturers entering the European market, even leading Japanese firms admit that. Actually they considered that the European market was quite transparent.

[824] See e.g. Schimel 1991.

largest initial GSM market in Germany.[825] But it seems that Motorola did not particularly focus on the GSM. In 1997, Motorola's world-wide market share was nearly 25 per cent, but in Europe 21 and in GSM only 14 per cent (Table 38).

TABLE 37 World-wide market shares held by leading cellular terminal suppliers
Sources: Gartner/Dataquest

	MARKET SHARES %					
	1994	1996	1997	1998	1999	2000
Motorola (USA)	33	20	24	20	17	15
Nokia (FIN)	21	24	19	23	27	31
Ericsson (S)	11	25	15	15	11	10
Panasonic (J)	5	..	8	8	6	5
Alcatel (F)	..	6	2	4	..	..
Siemens (D)	..	9	..	..	6	7
NEC (J)	9	..	..	..	..	..
Others	21	16	32	30	33	32
TOTAL	100	100	100	100	100	100

TABLE 38 Market shares of leading cellular terminal manufacturers at selected points in 1997
Sources: Gartner-Dtaquest

MANUFACTURER	World wide	Europe	GSM
Motorola (USA)	24,5	21,3	14,1
Nokia (FIN)	19,9	23,1	24,3
Ericsson (S)	15,5	21,4	25,0
Matsushita (Panasonic) (J)	7,3	5,0	3,7
NEC (J)	5,0	2,3	..
Siemens (D)	3,6	8,0	8,1
Samsung (K)	3,0	0,0	..
Mitsubishi (J)	3,0	1,7	..
Sony (J)	2,6	0,8	..
Alcatel (F)	2,5	5,5	6,1
Philips-Lucent (NL-US)	2,0	4,5	4,4
Northern Telecom (CAN)	0,6	1,6	..
Others	10,5	4,8	14,3
Total	100,0	100,0	100,0

Nokia, or Mobira, as it was known in the 1980s, lost its market share between 1988 to 1990, but it managed to maintain the position of second largest cellular manufacturer up to the mid-1990s, regaining it in 1997, and becoming world-leader the next year. The parent Nokia Corporation became heavily involved in consumer electronics in late 1987, this diminishing its good results and even producing a loss in 1991, but after that Nokia concentrated on mobile communications. Nokia's strategy was to enter new markets early and to adopt

[825] See European Mobile Communications; FT Mobile Communications.

new standards at an early stage.[826] Nokia was an early supporter of CDMA technology. This was so striking that in 1991 Nokia was giving assurances that it was not planning to introduce CDMA to Europe.[827] Nokia's attitude was in sharp contrast to Ericsson, which tried to oppose CDMA as long as it could.[828] Earlier, Nokia was not known as a leading early developer, more like a follower instead. Nokia did not, for example, participate in development of United States or Japanese TDMA in the late 1980s, but in Japan it was the first European manufacturer to organize sales channels. Nokia, however, was not tied with CDMA technology. In general, it was focusing on all the major digital standards. Although the GSM was important to Nokia, it was the one of three leading manufacturers with the best balance between world-wide and GSM market shares.

Ericsson had been manufacturing NMT terminals since the early 1980s, but the terminal sector had been obscured by the overwhelming importance of cellular infrastructure. Along with GSM standardization, Ericsson made a commitment to TDMA technology, and it was the only European manufacturer to participate in standardization of TDMA technology in the United States and Japan causing stubborn resistance to CDMA technology. Although Ericsson's world-wide market share was fairly modest, below 10 per cent, it started to grow steadily after the GSM take-off in 1993, to become the market leader in the United States digital technology handsets in the mid-1990s. In the mid-990s, Ericsson rose rapidly, becoming the second-largest supplier world-wide, although Nokia regained its position in 1997. Ericsson's advancement led to the separation of mobile terminals to the position of a division distinct from the infrastructure in 1996.

The other major Europe-based terminal suppliers were Philips, Siemens and Alcatel. Philips was the leading European pre-cellular enterprise, because Netz B, which was developed by its German subsidiary TeKaDe, was adopted in Germany, the Netherlands, Luxembourg, and Austria. It was to be the Philips/TeKaDe/PKI destiny for Net B was too early to hit the boom, but the subsequent Mats-E came too late. Philips was focusing on consumer electronics and in the 1990s its interest in cellular telephony decreased. Philips, like Siemens, had a strong foothold in cordless telephones in Europe. Siemens was the second largest European company in electronics after Philips, and it had gained competence in its project developing the analog Netz C system, a system facing strong growth in the late 1980s, but one that was only used in Portugal and in South Africa, in addition to Germany. Alcatel faced severe problems with its handset manufacturing before the mid-1990s.

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[826] Pulkkinen 1997.
[827] Wilska 1991.
[828] See Bekkers-Smits 1998.

3.2.4 Key players

Key players have been regarded as a driving force behind GSM development. According to Cattaneo, the key players consisted of the following: National Telephone Operators (NTO), the GSM Group, National Governments (mainly Ministers of PTT and Industry), international cooperation bodies (European community, CEPT and ETSI), manufacturing industries, and users.[829]

Each player had a specific area of responsibility. The European Community was responsible for economic and political integration. The Conference of European Posts and Telecommunications (CEPT) was in charge of harmonizing regulations, allocating frequencies, and standardization. The European Telecommunications Standards Institute (ETSI) replaced the standardization task of CEPT as of 1988. National Governments were responsible for domestic telecommunications policy. Most participating countries were members of the European Economic Community (EEC), while the rest were members of the European Free Trade Association (EFTA).[830] National Telephone Operators (NTO) had actually the dual role of operator and regulatory administration (NTO/NTA). Manufacturers were responsible for equipment development and production. The task of the GSM Committee's task was to define a technical standard.

This chapter deals with the motivations and roles of the leading players. Motivation is seen as a concept, which includes both set goals and incentives. The method for identifying motivation is important. If motivation is defined on the basis of the outcome of a process, one has to suppose that the goals of all the players are convergent, and the whole process is monolithic without significant changes. This is hardly acceptable without some solid justification. A more reliable way is to identify the motivations in the historical context, thus seeing motivation as a state of mind, which can change during the standardization process.[831]

The roles of the leading players are studied horizontally and vertically in relation to the standardization process. The former includes the forming of a role. How a player attempted to have an impact on the standardization process, and was it positive or negative from the viewpoint of the standardization process, and was the role of the player indispensable. Since the actual standardization process was not a monolithic event, the evaluation of the roles is further divided into three phases corresponding to the actual phases of standardization, which were as follows: Feasibility[832] (1982-1985), Standard production (1985-1991), and Implementation (from 1991 onwards).

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829 Cattaneo 1994; although she named these actors, the role of users was not addressed at all.

830 Seventeen countries participated in work of the GSM Committee between 1982 and 1991, and only Hong Kong came from outside Europe.

831 Cattaneo 1994 did not split the standardization process into phases. This biases her analyze. Nor did she estimate both positive and negative impact of essential players.

832 This phase contains also the preceding preparatory measures, which took place before 1982.

The vertical roles reveal the relationship between the players in conflict situations. Chapter 3.2.4.2 aims to explain why certain players won, and what the impact was on the players who lost and their roles.

3.2.4.1 Motivations and Roles of the Key Players

3.2.4.1.1 The European Community

3.2.4.1.1.1 Motivations

The actions of the European Community were motivated by goals, which were industrial-political by nature. Originally, the EC wanted to improve the position of the European telecommunications sector against external threats. After the Single Market Act had been ratified, there was a slight change of focus. The Green Paper on Telecommunications (1987) emphasized the implications of telecommunications on economic growth in general.[833]

It is common for the relationship between the EC and the GSM system to be presented in the 1990s in such a light, as if the GSM were the most important project in the telecommunications field.[834] This argument is, however, just a belief and it is not viable. First of all, when the European Community outlined the program for its telecommunications policy in 1984, mobile telephony was of minor importance, and even the breaking down to several cellular standards had not yet actually happened.[835] Mobile telephony was defined among the group of privileged on the basis of its relationship with ISDN and the implementation of OSI model.[836] In 1984, the EC identified three infrastructure projects of common interest. These were videocommunication links, high-capacity communications network (ISDN), and 2nd-generation mobile telephony. All were short-term goals, and they had to be completed rapidly. The GSI (ISDN) and GSM Committees were already working under supervision of the CEPT. The "Crown Jewel" of the EC was the future broadband network, and the EC launched extensive support for it by establishing the RACE research programs.

Although the attempts of the EC to bring forward the GSM timetable failed in 1985, and the GSM system was to be introduced around 1990 instead of 1988, the EC seemed, in the end, to be quite pleased with the situation. At least no further actions were carried out. The status of the GSM system was relatively

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833 Waterschoot 1989.

834 E.g. Single Market Review; Bach 2000.

835 It was not until the Green Paper on Telecommunications (1987) that emphasized the scattering of mobile telephony standards in Europe.

836 NR 21-21 Bil 2 Communication of M. Davignon to the Council of Ministers concerning Telecommunications, Brussels 3 Dec. 1984; In August 1984, the Commission of the EC and the CEPT signed the Memorandum of Understanding. The CEPT agreed, in the light of Community priorities; draw up common standards and type-approval specifications. The EC sent a list of priorities to the CEPT. Top priority was given to ISDN standards and standards for the upper layers of the OSI protocol.

decreasing, at least if the amount of interest shown by the EC is used as an indicator. This was clearly reflected even on level of the telecommunications policy, because the Green Paper on Telecommunications actually neglected mobile telephony. It got a very tiny share and was given as a warning example to be "one of the worst examples of the lack of Community-wide compatibility".[837] It should be emphasized that the decrease in status was relative, and the EC supported the GSM system by means of directives just like any other coexistent project.

The status of the GSM system started to rise again in the late 1980s for several reasons. A marketing study was introduced in 1988, subscribers numbers for analog systems started to rise rapidly, the GSM system was going to become available just before the opening of the Single Market, and it was even going to be a pilot involving joint European effort. Specific efforts were launched. In 1989, the EC established the Mobile Experts Group (MEG), which helped the ETSI Strategic Review Committee to compile a thorough and important report concerning the vision on the development of the entire mobile communications sector.[838] But it was not until 1994 that specific measures related to mobile communications were carried out in the form of the Green Paper.[839]

3.2.4.1.1.2 Feasibility phase

Quite often the role of the European Community has been overestimated and thus neglecting basic facts. The starting point was not nothing to be praised. The countries belonging to the European Community were not certainly the forerunners in the implementing of cellular technology. On the contrary, they were strikingly backward, because at the end of 1984 six countries in Europe had operational cellular networks, but only Denmark was a member of the EEC.[840] By the end of 1985, the share of non-EEC countries participating in the work of the GSM Committee varied between 42 to 46 per cent.[841] But the most important fact was that the EC did not identify the need for a pan-European system in time. It was not until late 1984 that EC started taking action. Without national and CEPT activity this would have been too late, because the practical arrangements related to the CEPT mobile band had already been made. The band would have been taken into use for analog systems if the GSM Committee had not existed.

The EC jumped on the bandwagon, which was already moving along a set course. The EC had taken several measures to speed up and improve standardization in general. In practice, the CEPT and other relevant bodies had

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837 Green Paper 1987.
838 See MEG 1990.
839 COM (94) 145 Green Paper on a common approach in the field of mobile and personal communications in the European Union, Fin 27.4.1994.
840 These countries were Sweden, Norway, Denmark, Finland, Spain and Austria.
841 See Appendix 6.

carried out these alterations. Everything had gone smoothly, but the transformation from policy-maker to operational actor was almost too much, particularly because the goals of the EC were not in parallel with those of the GSM Committee. The EC was pushing the objectives of industrial policy, and they fitted rather badly with the current situation in the GSM standardization process. The EC urged the speeding up of standardization by offering funding and requiring the participation of manufacturers.[842] The EC was too ritualistic in trying to implement the same requirement for every objective. It "invited" all the relevant committees of the CCH to a meeting in January 1985 and urged them to speed up standardization. The GSM Committee was required to prune the timetable by two years, which meant that specifications would need to be finished by the end of 1986, in just one year, and the system was to be operational in 1988. The GSM Committee found this to be impossible, unless an already-existing analog system was selected.[843] The EC initiative aroused uncertainty within the GSM Committee, particularly since discussions with representatives of the EC revealed that they had a rather variable impression of the concept of the 2nd-generation system. Some even thought it to be a synonym for existing analog systems operating on the 900 MHz band.[844] This view was held at least by those, who had put their money on the analog technology as the choice.[845]

The GSM Committee interpreted the pressure exerted by the EC as an attempt to take over the entire GSM project. And there were grounds for this supposition. The representatives of the EC had implied that the EC could take steps unless the requirements were approved, and it offered to host a new body, called the Permanent Nucleus. The members of the GSM Committee were also fully aware of the scope of the measures the EC had taken on improving standardization.[846] Although all the aforementioned could be seen only as being a means of power politics to have a demand accepted, a strategic plan prepared by the Analysis and Forecasting Group (GAP)[847] revealed that the intention was not merely a theoretical one. The GAP identified the assessment of continuing work with the CEPT versus possibly more Western or even a member-state-only approach as one of the three most important issues. Regardless of this, the GAP could not cope with this issue, but it untruthfully gave the impression as if

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842 The GSM Committee considered that funding would not remove problems, and it preferred the adding of more human resources. The participation of manufacturers was a difficult question, because the GSM Committee preferred closer cooperation, but it did not find any one overwhelming method. If the manufacturers were allowed to participate, then the gates had to be opened to all manufacturers, which would make the management of the project difficult. The GSM Committee preferred the current cooperation with TMS (joint organization of manufacturers). See GSM # 7, GSM Doc 1/85, 34/35

843 The opinion of the GSM Committee was justifiable. The requirement of the EC just shows that it did not have the valid competence to evaluate modern mobile telephony at all. In early 1985, it still was not sure that a digital system was able to compete with analog systems.

844 GSM # 7, GSM Doc 1/85, 3/85, 9/85.

845 GSM Doc 2/85, 63/86.

846 SA RD Memo from GSM #, M. Hovi and Memo 10th March 1985, M. Hovi.

847 GAP was a sub-group of SOG-T (Senior Officials Group on Telecommunications)

all the twenty-six CEPT countries were involved. The report was extremely arrogant and technocratic in trying to imply that the GSM Committee did not made any progress. A new report replaced even the acronym GSM with MASS[848]. According to a timetable drawn up by GAP, work on the 2nd-generation system should be transferred **from GAP to the Permanent Nucleus of MASS** at the end of 1985.[849]

It is quite typical that on the outset the EC initiative, including the GAP's strategic plans, seems as if it had been struck out from the memory of mankind.[850] It would have wrecked totally the possibility of a common pan-European system. The only digital alternative would have been SEL proposal, and even it would have been only theoretically possible within the timetable, because the required technology was not available. And secondly, several countries would not accept the wide-band solution.

The initiative of the EC to steer the development of the GSM system ceased to have an effect after the summer of 1985. The outcome of the proposal was not what had been sought, but there were unintentional positive results. First of all, the internal cohesion of the GSM Committee was strengthened. Secondly, the Permanent Nucleus (PN) was established, but applying a time table which the GSM Committee interpreted to be appropriate, and it did not turn out to be setting for industrial policy plotting. It was also important that the EC could establish competence, which seemed to be of a totally substandard level, and most importantly from the EC point of view that it started to support the work of the GSM Committee instead of trying to steer it.

3.2.4.1.1.3 Standard production phase

It has been said that the European Community played a supportive role regarding the GSM system.[851] This definition suits the EC role after the feasibility phase. Even after the Single market Act came into force in early 1986, the EC did not any more try to control and lead the actual standardization process.

The EC continued applying measures related to the telecommunications policy. The Green Paper on telecommunications was published in 1987, and one of the suggested measures in it was a new standardization forum called the ETSI, which was officially established in January 1988.[852]

During the standard production phase, the EC focused on securing the implementation of the GSM system, and it launched a series of directives. An essential question here was the following: Were these directives marking a path to be followed, or were they just reinforcements along a trail that had been chosen by other players?

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848 MASS, Mobile radio All-digital Second-generation System.
849 GSM Doc 80/85; emphasizing by A.M.
850 See e.g. Cattaneo 1994; Bender 1996; Garrard 1998; Bekkers 2001
851 Cattaneo 1994.
852 Temple 1991.

In 1987, the European Council launched a directive (87/372) on GSM frequencies. This is generally held to be an important directive as it secured the frequencies for the GSM system.[853] In practice, it was important mainly for the laggard countries, because even in 1990 there were three out of twelve EC countries, which had not fulfilled the requirements of the directive and had reserved the frequencies for GSM.[854] For the majority, this directive was mainly a recommendation in the long term.[855] Already in 1984, the CEPT had issued a recommendation on how to split the 900 MHz band between the interim analog and GSM systems, and it was widely followed by these countries.[856]

Another Recommendation by the Council (87/371) involved the coordinated introduction of the GSM system. Most of this directive was plain liturgy and a mere repetition of the same schedule what was included in the GSM MoU.[857] As has already earlier started, the GSM MoU was a very flexible document, and the coordinated introduction was quite open to various interpretations. Although the EC could in principle have imposed sanctions, it did not do so in practice. In 1990, there were only two EEC countries, which were not planning to observe the minimum requirements of this directive,[858] but actually one in two EEC countries did not open their GSM networks during the first fiscal year when terminals became available (1992). There is no evidence that the EC directed sanctions against these laggards.

The liberalization of the terminal trade was for the most part an important issue for the EC, but its impact especially on mobile telephony was really minimal. In 1987, of all the EEC countries, the terminal trade was a monopoly of the PT only in the Netherlands and Belgium.[859] For example, the four Nordic countries, which even were not members of the EEC,[860] had liberalized the mobile terminal trade already in the early 1970s and thereby created a common market!

The EC was also pushing the issues of acceptance of mutual recognition of terminals and free circulation of terminals across national borders, which were essential from the viewpoint of a common pan-European network.[861] Both of these were also merely political issues, and well suited as responsibilities of the EC.

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853 E.g. Single Market Review; Garrard 1998; Bekkers 1999 (although Bekkers 2001 do not any more accept this view); Bach 2000.

854 GSM Doc 333/90.

855 Because there was no strict deadline when frequencies deployed by analog systems should be released for the GSM. The directive only assumed that it would be realistic to have the entire band for the GSM in January 2001.

856 It should be remembered that of the countries involved, only France, Germany, Portugal and Greece did not have "interim" analog systems on the 900 MHz band. All the other countries had observed the recommendation of the CEPT, and eight countries had already deployed it before 1987.

857 Council Recommendation 87/371/EEC of June 25, 1987 on the coordinated introduction of public pan-European cellular digital land-based mobile communications in the community; GSM MoU (GSM Doc 121/87)

858 GSM Doc 333/90.

859 Green Paper 1987.

860 Denmark became member of the EEC in 1972.

861 Richter 1989; Weltevreden 1991.

Evaluating the importance of each directive separately would perhaps not do justice to the EC, because the greatest impact it made was political. The EC's signal was that a common pan-European standard was going to be introduced. Therefore, it is highly unlikely that a uniform standard was really at risk at the Madeira Meeting in 1987. Particularly since France was a major engine of European integration, which was a far more important issue than the preference of the French Minister of Telecommunications.[862]

3.2.4.1.1.4 Implementation

The EC was aiming to have several mobile communications standards for the opening of the Single Market. In early 1990 it was still considered a possibility to introduce the GSM system in 1991, and both the ERMES paging and DECT cordless standards in 1992. The EC released directives on coordinated introduction in each case.[863] In actual fact, only the GSM system hit the target for the opening of the Single Market, but the activeness of the EC had very little to do with operators opening commercial service on GSM networks.

The EC was planning to liberalize the operator market. The Green Paper on Telecommunications outlined the general guidelines for the future. The core message was to introduce competition in sectors other than traditional voice telephony.[864] However, this intention did not come true, because in 1990 the EC released a directive concerning the liberalization of the telecommunications services, but mobile communications was intentionally excluded from it.[865] This change in policy gave out a negative signal, with Italy, the Netherlands and Spain, which had plans to introduce competition, shelved their plans for several years. On the other hand, those countries, which had introduced competition, had made their decisions before and without any directives. Ultimately, the EC had to cope with the laggards, which were reluctant to break up their monopolies, but this was so late in the piece that it did not have any significant impacts on the diffusion of the GSM system in Western Europe.[866]

In another sector, the EC played an important role by taking steps to dissolve the embargo related to certain algorithms of the GSM system.[867]

In 1994, the EC took steps to promote competition, but at that time the market forces had already taken the lead and the EC was merely again left to confirm circumstances that already prevailed.[868]

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862 There was a clear parallel to the Alcatel case, when the Minister for Telecommunications was defeated by other ministers, who preferred integration instead of the promotion of French national interests in telecommunications. See Noam 1992.

863 Weltwreden 1991.

864 Green Paper C0M(87) 290.

865 Commission Directive 90/388/EEC of June 28, 1990 on the competition in the markets for telecommunications services; Garrard 1998.

866 EC XXVII Report on Competition Policy 1997; see also Garrard 1998.

867 390Y1231(01) Council Resolution of December 14, 1990; Weltwreden 1991; GSM Doc 333/90.

868 Nine countries introduced competition before the release of the Green Paper on Mobile Communications COM (94) 145. The rest were generally slow to launch commercial GSM services. See TABLE 27, page 203.

3.2.4.1.1.5 Conclusions

When the European Community became interested in mobile telephony at the last minute, it gave first priority to general industrial political goals. Its attempt to speed up all relevant standardization projects was a schematic one, and regarding the GSM system it failed because of ill timing. Had the EC succeeded, it is most likely that the entire GSM project would have failed. Its failure to attain the role of a dominant player was understandable; the EC had tried to build a role related to the GSM standardization process and at the same time to assume a role of competence in the standardization of cellular telephony.

It is paradoxical that after the Single Market Act was approved (1986), the EC carried out a major restructuring of the standardization environment by establishing ETSI, but its role in the standardization of the GSM system became an indirect and passive one. In a supportive role, the EC launched a series of directives, but they mostly ratified the prevailing conditions or actions carried out by other players. The passiveness of the role was self-evident, because obstinate countries neglecting to observe the directives were not penalized. It was not until the GSM had became popular that the EC implemented harmonization measures backed up by sanctions.

The question of whether the role of the EC was indispensable is actually irrelevant, because the GSM Committee was able to take advantage of the situation created by the harmful attempts of the EC. It is most likely that the GSM system would have been completed even without the interference of EC, but the goal of a Single Market created positive expectations, and these should not be underestimated.

3.2.4.1.2 CEPT and ETSI

3.2.4.1.2.1 Motivations

There are no signs to indicate that the CEPT in general was driving a special policy related to the GSM system. It seems, quite naturally, that the CEPT was only implementing a policy defined by its members. Earlier land-based mobile telephony had low priority, but this was raised at the 1982 Telecommission meeting, and measures were taken to establish the GSM Committee.

It has been a general trend to criticize the CEPT and label its procedures as clumsy and slow. Mostly this criticism is justified. But at the same it should be remembered that actually the CEPT was not meant primarily to be a standard-setting body, but instead mainly a body responsible for regulatory issues. It was not until the early 1970s, when a special Coordination Committee for Harmonization (CCH) was establish under the CEPT to carry out harmonization tasks.

3.2.4.1.2.2 Feasibility phase

From the viewpoint of development of the GSM system, the CEPT was certainly not a useless organization. On the contrary; during the feasibility phase the CEPT was absolutely essential. First of all, the CEPT played important role in reserving frequencies for land-based mobile telephony on the 900 MHz band. It was the CEPT, which in 1984 approved the proposal of the GSM Committee to divide the 900 MHz band between analog systems and GSM, and this became the basis for all further activity. Secondly, the CEPT was the only body in Europe level for the standardization of mobile telephony. Standardization of the GSM system got started under the supervision of the CEPT, because European telecom administrations were not able to find any other alternative during the one and a half years after the Paris meeting of 1980. And as a matter fact, the establishing process of the GSM system was relatively fast, because it took only six months from the presenting of the idea to have the first meeting of the GSM Committee being held.[869] It should also be remembered that the CEPT provided the assistance of other committees to the GSM Committee.

The CCH Committee, which was above the GSM Committee in the hierarchy of the CEPT, chose a very stiff approach to controlling the GSM Committee. But most of this nuisance was caused by CEPT's rules. These included prohibition to establish Working Parties and direct relationships with bodies outside the CEPT organization. The most severe setback was in the interpretation of the schedule. The Nordic countries proposed the original GSM schedule, but this was cut by two years, because one member country insisted on it, and later on this opened the way for the EC to interfere in the GSM schedule.[870]

The behavior of the CCH was understandable prior to 1985, because it was acting along decisions, which had been approved, but it came into strange light when the EC started to pressure the GSM Committee in early 1985. The CCH organized emergency meetings at the urging of the EC, and the CCH did not back up its own committees against the pressure. On the contrary; it seems that the CCH was assuming a place subordinate to outside organizations. The GSM Committee did not accept this, and chairperson Thomas Haug sent an exceptionally sharp protest to his superior, the chairperson of CCH. Haug criticized the emergency meetings for not being an efficient way to make progress, since they were impeding normal procedures. Haug emphasized that the emergency meetings were not serving the goals of the CCH, but merely the objectives of the EC.[871] Under the surface, dissatisfaction with the chairperson of the CCH seems to have been much deeper. The Finnish delegation's interpretation was that the chairperson of the CCH had independently started to organize relationship between the EC and the various committees of the

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[869] For example, the formal establishing of the COST 207 project was much slower.

[870] This decision was highly unsuccessful, because it cut the schedule, but left the issue related to the work of the deleted period unresolved.

[871] GSM Doc 9/85.

CEPT, and they wanted to decide this issue on level of the Telecommission or at least within the CCH.[872]

During the feasibility phase, the basic requirement of the CEPT, i.e. of reaching unanimous decisions, was not a hindrance to the GSM Committee, because this part of the process was meant to proceed slowly. But the prohibition of establishing Working Parties was starting to slow down the process, because other CEPT Committees carried out much of the work, and they depended on the information supply from the GSM Committee.

3.2.4.1.2.3 Standard production phase

After the incident in early 1985, the CEPT did not cause any more major inconvenience to the GSM Committee. On the contrary; there were signs that the CEPT was willing to be flexible in regrd to its formal rules. In the fall of 1985, the GSM Committee got the permission to establish steady sub-groups for the first time in history of the CEPT.[873] In the spring of 1986, the Telecommission gave out a signal to the effect that it would accept the participation of manufacturers in the work of committees such as the GSM Committee.[874]

The CEPT accepted the requirement of the EC for the overall speeding up of standardization. In 1985, this led to the signing of the Memorandum of Understanding on European Telecommunications Standards in Copenhagen, this memorandum giving a binding character to the terminal equipment standards adopted by the recently established Technical Recommendations Application Committee (TRAC). For the first time, weighted national voting was agreed upon. This change is considered to be a modest one, but at least it signaled a real commitment by the NTAs to Europe-wide telecommunications standards.[875] From the GSM Committee's point of view, the Copenhagen MoU was important, because the equal principle of weighted national voting was transferred to the GSM MoU, thus forming a cornerstone of the GSM MoU already before the ETSI was established.[876]

A new standardization body, ETSI, was created early 1988 to speed up overall standardization by allowing manufacturers to participate and by introducing voting procedures. Although the CEPT is usually seen as a body opposed to the ETSI, in practice there was no major confrontation. Actually, the CEPT was compliant to the changes sought. The CEPT accepted the establishing of the ETSI quite smoothly, unlike CEN-CENL EC.[877]

It is usually understood that the establishing of the ETSI speeded up standardization. It is more difficult to estimate the particular impact on the

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872 SA RD Memo GSM # 7, M. Hovi.
873 Compare to Garrard 1998, who does not identify the chain of changes and its smoothness.
874 GSM Doc 42/86.
875 Temple 1991.
876 See GSM MoU (GSM Doc 121/87)
877 Temple 1991.

GSM system. The establishing of the ETSI in 1988 closed down the CCH, and all the CCH's technical committees were transferred to the ETSI. But the GSM Committee was not transferred until March 1989, and in practice this organizational change did not cause any immediate and abrupt changes. Manufacturers were allowed to participate as of the spring of 1987, and in 1989 their number increased.[878] Voting was not, at least not officially, implemented during the standard production phase.[879] Even the GSM Recommendations were not changed to comply with the ETSI procedures. Without wishing to underestimate the ETSI, it seems that it did not bring about any revolutionary changes, since the transition period had started already before the ETSI was established. The GSM Committee needed to defuse the CEPT limitations, but it did not particularly need the ETSI itself, at least not before the GSM standard was approved. Of course, the atmosphere under the ETSI was more liberal and it delegated responsibility to the Technical Committee, e.g. in the DCS matter. But elaboration of the ETSI was not exclusively positive from the GSM point of view. The organization of the ETSI causd some inconvenience, because the ETSI started to demand that the PN be moved from Paris to Sophia-Antipolis, which generated almost unanimous resistance on part of the PN staff. There was practically nothing in the counterbalance, because the ETSI Secretariat did not offer any assistance to the PN in practical matters.

From the GSM Committee's point of view, it is paradoxical that during the period from the fall of 1985 to early 1989 the CEPT rules represented no hindrance for the GSM process, because the CEPT was willing to consent to modify the rules to respond to the current situation in the GSM standardization process. On the other hand, the new body, ETSI, could not offer anything radically new from the GSM point of view neither in the short term nor the mid term. The advantages of the ETSI were to be exploited when the GSM standard (Recommendations) were approved.

3.2.4.1.2.4 Implementation

Naturally, the ETSI was not involved in the commercial implementation of the GSM, but the advantages of the ETSI procedures became more exploitable during the maintenance and extension development of the GSM. The ETSI better reflected the changed circumstances, because operators became competitors and the role of manufacturers in standardization began to rise.

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[878] It is possible that the move over to the ETSI increased the number of participating manufacturers, but on the whole it was a critical moment for manufacturers decide whether to be in or out.

[879] Interview of Thomas Haug, interview of Hans Thiger, Matti Pasanen, Kari Laihonen.

3.2.4.1.2.5 Conclusions

It is a paradox that the CEPT, so widely slandered, was indispensable, because the European NTAs were not able to find any other means for the joint development of a pan-European mobile telephone system. Even some features, mainly the "old-fashioned" rule for making decisions only when unanimity is reached, seem to have initially served as advantages. During the early feasibility phase, the number of participating NTAs was limited, and the industrial powers (the Franco-German-Italian triangle) could have dictated in decision making had weighted voting been in use. Another disadvantage, that of sluggishness, was actually not a hindrance initially, because during the feasibility phase it was not sensible to lock-in decisions without certainty of their technical implementation.

Of course, the clumsiness of the CEPT was not entirely of benefit to the GSM Committee, because occasionally, and particularly because of the policy of the CCH, limitations made difficult and even aggravated the work of the GSM Committee. But these obstacles were overcome. What was the most essential issue was the transition and its timing. The rules and procedures were not changed, because of organizational changes, but because of the requirements imposed by changes in the standardization process. This meant that changes were made well before the actual organizational changes, and they were carried out smoothly. During the standardization process it was not important who the parent organization was, but instead how well it was able to respond to the current needs of the process.

3.2.4.1.3 Governments

3.2.4.1.3.1 Motivations

The concept of government can have a two-fold meaning; it is either related to the political level and refers mainly to the Ministers for Telecommunications and other ministers, or only to the various governmental agencies, in this case the Postal Service and Telecoms. Although this distinction is fairly simple and naïve, it is an important one, because the participating countries had both kinds of interfacing with the ongoing work on the GSM system.

It has been claimed that national governments were interested in the development of both telecommunications services and domestic industries, meaning consumer electronics or telecommunications.[880] This argument can hardy be disputed as such, but another question is how valid is it related especially to mobile communications. There were actually at least three kinds of convention. Countries such as Germany, France, Italy, and partly the United Kingdom, initiated cellular projects with participating manufacturers being included in them, giving them a clear advantage, as well as the proprietary

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880 Cattaneo 1994.

nature of standards. These projects were clearly inspired by the goals of industrial policy. In the Nordic countries, the goal was to have an open standard, and participating multi-national manufacturers were not chosen on national basis. Joining four NTAs together relegated industrial policy goals to secondary status. The third group consisted of countries, which had obtained the required technology from somewhere else. This division into different procedures was basically valid for the GSM system as well. Industrial policy goals usually required back up from the political level, while the second and third kinds of procedures mentioned were able to function on the administration level.

3.2.4.1.3.2 Feasibility phase

Governmental influence, which had a notable impact on the GSM system, was visible in the actions of the three parties involved. In the United Kingdom, the Department of Trade and Industry was involved, but there were no organized attempts to industrialize the ongoing research related to radio-access research. Nor was the United Kingdom a keen supporter of European integration. In the Nordic countries, governmental connection was indirect, because Nordic cooperation in general had been agreed upon the political level, but specifically telecommunication was strictly a matter between the NTAs. There was no political interference with the GSM system. The Franco-German cooperation was overridingly political as it was agreed and defined on the ministerial level, and both countries were the foremost engines of European integration.

It has been stated that only France and Germany had an industrial policy strong enough to attempt to impose the standard developed by the Franco-German national champions on other countries.[881] But the essential issue is not the strength or weakness of industrial policy, but instead the appropriateness of the standard-setting policy in relation to the circumstances. The Franco-German attempt was based on a common strategy that prevailed in Europe regarding high-tech projects, with the participating members building national competence in order to practically take over the project. These projects had limited numbers of participants, and the issue of fair return was the ratio between the input into the project and the allocated share in production.[882] The Franco-German strategy was appropriate for the commercial arena, which was far from the CEPT environment in which decisions were taken unanimously and a large number of participants were involved.

The Franco-German project did not succeed for several reasons. First of all, it had several structural weaknesses. The project was defined on political terms and conditions, not according to needs or possibility of implementation, and this produced an unrealistic schedule. Competition between France and Germany made itself felt all the time, and this had already wrecked the interim

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881 Cattaneo 1994.
882 See Muller 1990.

analog project. Attempts were made to solve the problems by means of generous funding and by leaving practical matters in the hands of a competing consortium of manufacturers, they were left to decide the basic technology. Since this choice was a fundamental one, it did not merely define the choice of technology, but also the system's features.

The declaration of Franco-German cooperation was extremely arrogant, because it openly "let it be known" to their poor European cousins, that they were going to noble-mindedly provide them with a system, which they were going to design. Naturally, no manufacturers other than Franco-German ones would have to take the trouble to participate.[883] Since it was the politicians who composed the declaration and because it was meant to arouse a spirit of integration in the two countries, it was suitable for this purpose, but hardly a good start for negotiations in the GSM arena.

The most crucial difference between the Franco-German pool and its opponents was connected to the substance of mobile telephony itself. It has been claimed that the United Kingdom and the Nordic countries were service-oriented, while France and Germany were focusing on technology.[884] While this observation is correct, it does not reveal the fundamental issue behind the differences in emphasis. The Nordic countries had already abandoned a policy focusing on controlling demand because of shortage of capacity, and instead they were service-oriented in marketing the NMT system for everybody. Germany, on the other hand was very primitive in its approach in focusing on demand control. The main issue always worrying the Germans was that of capacity. In 1980, they were still speaking vehemently in favour of limiting maximum call duration to two minutes as an essential feature of the future pan-European system.[885] In 1982, they wanted the other NTOs to cease from marketing cellular services, and urged that the mandate of the GSM Committee be made to include a mathematic formula for calculating the capacity of system![886] The Germans included in the GSM Committee were the most passionate opponents of hand-held terminals. The combination of concealed self-awareness due to domestic political back-up and backwardness in understanding modern cellular technology implementation was a devastating combination.

The Franco-German joint venture was not the only endeavor to have an impact on the course of GSM development;[887] the Nordic countries had pursued this very same goal from the very beginning. The Nordic countries had established a joint group (FMK) for 2nd-generation mobile telephony already before the establishing of the GSM Committee, and the schedule of the FMK Group was ahead of that of the GSM. The Nordic countries had also outlined a

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883 GSM Doc 76/84.

884 Cattaneo 1994; Funk 1998.

885 SA RD Memo of Paris meeting 8.-10.10.1980, Ö. Mäkitalo et al 3.11.1980, Memo of Paris meeting 8.-10.10.1980, K. Teräsvuo 21.10.1980.

886 SA RD Memo of meeting 25.5.1982, M. Makkonen and K. Teräsvuo 28.5.1982, Memo of CCH meeting in Florence, 17.-18.11.1982, T. Hahkio.

887 Although authors from Contineltal Europe (e.g. Cattaneo 1994; Bender 1996; Bekkers 2001); do not pay proper attention on Nordic impact

mandate proposal for the GSM Committee and were aiming to take the FMK into use if the GSM should fail. But unlike the Franco-German block, the Nordic countries did not make a declaration regarding the taking over of the development of the GSM system. Instead they operated from the basis of making a major impact on the GSM Committee, and of guiding the process to meet their needs.

3.2.4.1.3.3 Standard production phase

The Franco-German cooperation was at its height in the spring of 1985, when Italy joined the alliance, and this gave the alliance even more political credibility. As regards the operational level, there were no essential changes, because Italtel, which had joined SEL-driven consortia, was only an associate member. But this was leading to situation where a true wide-band candidate proposed by SEL-led consortia attained a status, which in practice could be defined as "governmental acceptance". It was the only truly bi-national venture including both French and German companies.[888] The SEL-led wide-band proposal had practically taken a preferred position,[889] not only because it was the completed candidate, but also because Alcatel and Italtel were companies owned by states of France and Italy respectively.

When the United Kingdom joined the alliance, it did not strengthen the grip of industrial policy, as there were no connections to companies, and it was merely aimed at ensuring the launching of the GSM service.

The rejection of the mainly SEL-developed wide-band candidate may well have been a tremendous shock to France and Germany, but the outcome itself was a logical one, although the decision was not easy to make. It has been claimed that the Franco-German attempt did not succeed, because other countries opposed it, and the German Minister for Telecommunications in the end preferred to act in the interests of the deployment of the service, rather than in the interests of industries.[890] However, this claim is only partly true, because it was not a clear case of service-versus-industry interest antagonism. First of all, SEL proposal was not the only German candidate. Secondly, at the end of 1986 Alcatel had taken over ITT, which was SEL's parent company. The Germans most certainly did not welcome this coup, because SEL was the second most important telecommunications supplier of DBP. Thirdly, the elaboration on a common pan-European standard was at stake, and the Quadriparty (QP) alliance (France, Germany, Italy and the United Kingdom) had launched measures to ensure the implementation of the GSM system.[891]

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[888] Both Bosch-ANT consortium and PKI were German (although the parent company was Dutch), and LCT was French.

[889] Ministers of Telecommunications and the NTAs of France and Germany supported the wide-band candidate proposed by the SEL-led consortium.

[890] Cattaneo 1994.

[891] See Chapter 3.2.2.3.2.

And lastly, the wider political framework would not have tolerated the national solutions of France and Germany.

It is a paradox that governmental activity rose into a position to reject the wide-band candidate, although originally the alliance on the governmental level had aimed at setting a standard. Governments played the foremost role in launching activities to ensure the development of the GSM system and its implementation. The Quadriparty alliance prepared the GSM MoU

3.2.4.1.3.4 Implementation

Governments were in key positions related to the operational environment of the GSM system. When the GSM MoU was signed in 1987, only the United Kingdom had true duopoly on analog systems.[892] Soon after that France started to introduce competition on the country's analog systems. Just a little before the GSM was due to be launched, the governments of Germany, Finland, Sweden, Denmark, Norway and Portugal gave licenses to second operators.

Most of the governments froze the prevailing situation and held back from breaking up monopolies. Even the formal introduction of second operator did not automatically ensure fair competition, because in some countries the only competing private operators were charged license fees, but the PTT operator did not have to pay fees.

Typically the launching of the GSM service was an issue for the NTOs to deal with, but in Italy the government forbade the launching of full-scale commercial operation before the spring of 1995.

3.2.4.1.3.5 Conclusions

The role of governments was most important when their impact on the process was indirect, in funding, in giving support, and in general in building national competence. The example of the Franco-German attempt showed that direct impact on a political basis did not lead to the desired results. Instead, it brought together opposing powers and ultimately undid the Franco-German cooperation. Direct interference had positive results only when it was focused on regulatory issues by introducing competition.

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[892] In Sweden there was a restricted duopoly situation. The competing operator had around 20 000 subscribers and it was not able to impove its competitive position, because it was refused to have a license on the proper system operating on the 900 MHz band. See Karlsson 1998.

3.2.4.1.4 National TeleAdministrations/National TeleOperators

3.2.4.1.4.1 Motivations

The motivation of NTA/NTOs is the most essential question in all motivations related to the players, because up until 1987 the NTAs/NTOs provided practically 100 per cent of the resources allocated to the GSM Committee.[893] Secondly, the CEPT membership was restricted to the NTAs prior to the mid-1980s. The motive behind motivations of the NTAs/NTOs is particularly interesting, because it should reveal the expectations of the NTAs/NTOs, how they reflected on the work of the GSM Committee, and why this form of cooperation was chosen.

According to Cattaneo, the motivations behind the actions of the NTOs were economic by nature and particularly aimed at increasing revenues, and secondarily to take advantage of cooperation.[894] But "business" motives can hardly explain the NTOs' actions, because only a few of them actually gave active support to the GSM Committee. In any case, mobile telephony was in its infancy in Europe, and the economic incentive was insignificant as the estimated numbers of subscribers were low on the markets of large European industrial powers such as the United Kingdom, France and Germany.[895]

Economic issues were not totally irrelevant, but the aim was not to make profit, but instead to save in expenses. It was estimated in the United Kingdom that the size of the domestic market would not make the development of analog cellular standard reasonable on the national level.[896] And as France had proclaimed at the Paris meeting in the fall of 1980 that it would start research in digital technology and possibly introduce such a system in the mid-1980s, there was widely discussion on the possibilities of this new technology. Naturally, the shift over to new technology would require more resources and spending of more funds than would the development of a conventional analog system. It should be remembered, however, that in 1980 only the Nordic countries were about to get a cellular project finished, and in Germany, Italy and France projects had just been started or were soon about to be started. Digital technology itself was not a self-evident acquaintance, because in 1980 the development of digital switches had been managed to be completed only in France, Sweden and Finland.

The most fundamental motive was related to the regulatory role of the combined NTAs/NTOs. WARC 1979 provided a unique opportunity to have a common mobile telephone system, because part of the 900 MHz band was

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893 Including the research facilities of the NTAs and some representatives of the Department of Trade and Industry (United Kingdom)

894 Cattaneo 1994; Bekkers 2001 also shares the same opinion.

895 According to estimates in 1980, all the Nordic countries would have between 160 000 to 200 000 subscribers in 1990, while Germany would have only between 60 000 to 70 000. The United Kingdom would have 200 000 subscribers in 2000 (SA RD Memo K. Teräsvuo 21.10.1980). In 1984, it was estimated France would have 204 000 subscribers in 1994 (GSM Doc 18/84). All these estimates were made by the relevant NTAs.

896 Roberts 1986.

reserved for mobile use in Europe. This gave rise to speculations on how to exploit this band. It was clearly not a topical issue, because at the time of the Paris meeting of 1980 only the United Kingdom and France were planning to exploit the band before the mid-1980s; others reckoned that they would need it sometime in the 1990s. Only the Nordic countries and France were using the 450 MHz band, but others were just then planning to shift from the 160 MHz band to the 450 MHz band.[897] Regulatory interest was by no means surprising, because in the beginning all the countries had a joint NTA/NTO structure, and only the United Kingdom separated the roles of operator and administrator in the early 1980s.

It has been claimed that the example set by the Nordic countries and the failure of cooperation attempts made European countries seek international cooperation.[898] This is a misunderstanding; cooperation attempts at the multinational level[899] and establishing of the GSM system were concurrent events. Already at the Paris meeting of 1980, the participating countries held serious discussions on cooperation. However, there was firstly no suitable format for cooperation, because the CEPT was considered too slow and clumsy. Secondly, only France and the United Kingdom supported swift action due their current needs. When France and the United Kingdom released in the spring of 1982 their intention to introduce common analog system on 900 MHz, exploiting the band in the future for thee common system was placed at risk. Soon the Netherlands made its proposal to establish a joint group under the supervision of the CEPT, and suddenly the CEPT was accepted as forum of cooperation.

The NTAs/NTOs managed to overcome the delimitations of national interest, because they were heading towards having a common system in the future (in the 1990s). Cooperation did not concern the ongoing national projects or the interim standard on 900 MHz, and not a single cellular project was suspended because of the GSM system.[900] Even the potential problem of solving the exploitation of the 900 MHz band was passed soon (in the fall of 1983); the interest of the NTAs/NTOs did not vanish, because all participating countries did not share the same level of interest. There was an active group of countries, which got feedback from national experience, and which were willing to invest resources in the GSM system.

3.2.4.1.4.2 Feasibility phase

The role of the NTAs/NTOs was indispensable during the feasibility phase, because they had exclusive rights to participating in the work of the CEPT.

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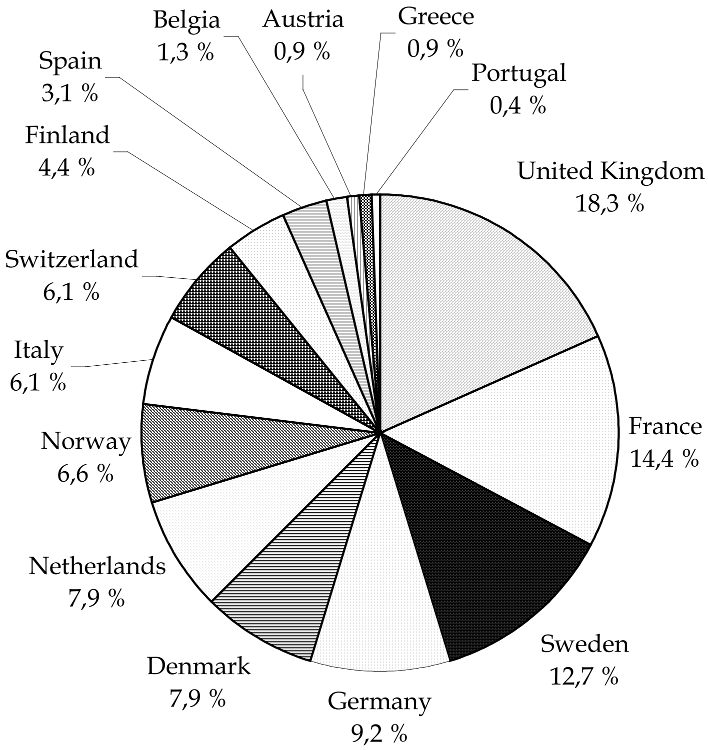
897 GSM Doc 32/83.
898 Bach 2000.
899 France-United Kingdom, and France-Germany.
900 Only the Franco-German cooperation project on 900 MHz was cancelled in the fall of 1984. This was quite logical since Germany did not really need an interim system at that moment as it would have replaced the C-450 system (running on 450 MHz), which was not even finished yet.

Allocating resources for GSM was particularly important, because the work of the GSM Committee was focused on the sessions during this phase,[901] and the participants were mainly NTAs.[902] Secondly, only fifteen out of twenty-



Remarks: NTA/NTO = National Telecom Administration/National TeleOperator
Sources: GSM Documents
FIGURE 14 Relative numbers of NTA/NTO participants in GSM plenaries # 1 to #70

six of the CEPT countries participated in the work of the GSM Committee, and in actual fact this number was even less, because representatives from eleven countries participated more regularly as opposed to representatives of those four countries, which participated only sporadically.[903] The main burden was carried by the United Kingdom, France and Sweden, which accounted for

[901] Working Parties (sub-groups) assembled only during the plenary sessions of the GSM Committee.

[902] Representatives from joint NTAs/NTOs including their research facilities. The United Kingdom was an exception, because quite often also the DTI representative was present. When competition was introduced, an independent regulatory body was created thus generating a peculiar situation with the representatives of British Telecom and Cellnet (joint venture of BT and Securicor) being able to participate, but competing operator Racal being prevented. Racal participated in the 6th meeting of the GSM Committee, and this generated widespread disfavor, because in addition to Racal not being a member of the CEPT, it was considered to have a dual role as operator and manufacturer.

[903] Regular participants were Denmark, Finland, France, Germany, Italy, the Netherlands, Norway, Spain, Sweden, Switzerland and the United Kingdom, while Austria, Belgium, Greece and Portugal participated occasionally.

nearly half of the manpower as is shown in FIGURE 14. The relatively little interest shown by the industrial powers of Germany and particularly of Italy was evident, since even their joint share was not equal to that of the United Kingdom.

In addition to quantitative resources, the qualitative dimension of activities was also important, but it was not a surprise that the same players were active on both fronts. During the early stages, the initiative role of the Nordic countries and the Netherlands was emphasized and they were keen to promote the idea. Also France and United Kingdom were active. Still, the Nordic countries were not worried about the limited number of participating countries, because of the interest of large countries, such as the United Kingdom, France and Germany, which focused on interim (analog) systems running on the 900 MHz band.[904] When Franco-German cooperation on the joint digital project started in late 1984, the situation changed, and Germany stepped up its activity. One essential indicator of this was the organizing of research on technology related to the air interface. By the fall of 1984, research had been initiated in all the Nordic countries (except Denmark), the Netherlands, France, Germany, the United Kingdom and Italy. In France and in Italy research was concentrated in the research facilities of the NTAs, whereas as in Sweden and Finland it was decentralized within the NTA, universities and industry. In Germany, industry (SEL) had the leading role.[905]

The contribution of the NTAs/NTOs to the work of the GSM Committee was moe than just the sum of parts. Two pools were formed, and both had an impact on the GSM process. The Nordic pool consisted of Denmark, Finland, Norway and Sweden, while the other brought France and Germany together, both being industrial engines of European integration.

3.2.4.1.4.3 Standard production phase

The NTAs/NTOs enjoyed a privileged status up until February 1987 (GSM # 13), but they retained the predominant share of participants in the plenary meetings up until March 1989 (GSM # 22). Thereafter the share of representatives of manufacturing industries exceeded one third. Although the role of the plenaries changed after the fall of 1985 (GSM # 9), when the establishing of permanent Working Groups was allowed, the plenaries retained their importance.

The beginning of the standard production phase had an impact on those countries, which earlier had shown only minor interest, since now they started to participate more regularly, and from 1986 onwards the number of participating countries varied between 14 and 16 (earlier 11 and 15).[906]

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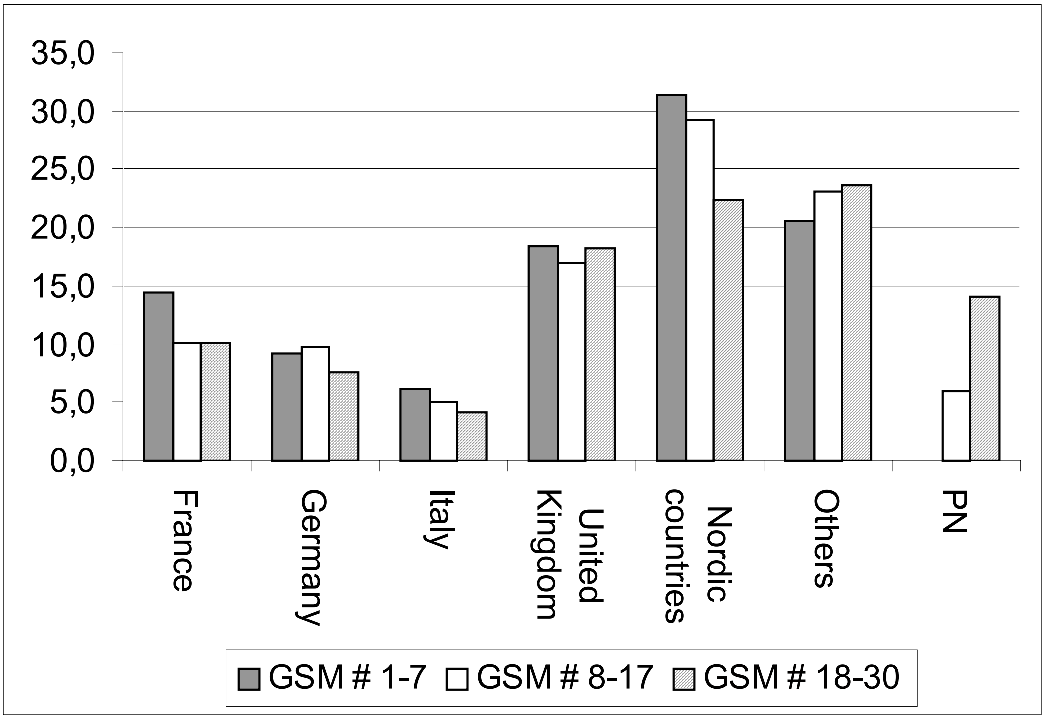
904 NR 17; Report from FMK # 5; the Nordic countries were also developing the NMT-900 system, but unlike others, they had organized a group (FMK) working on the digital project, and these systems did not compete with one another.

905 GSM Doc 78/84.

906 See Appendix 6.There were actually 17 participants at Meetings #27 and #28 as Hong Kong

The United Kingdom again reserved the largest number of representatives for itself. As FIGURE 15 shows, it was a general trend that relatively the national shares decreased, but this was not the case with the United Kingdom, which brought in representatives of several operators on the GSM Committee. The Nordic countries formed clearly the largest coalition. Although the Franco-German alliance was strengthened in the spring of 1985 by Italy, this did not really reflect on the work on those countries on the GSM Committee.[907]



Remarks: Feasibility Phase = GSM Meeting # 1-7; Standard Production Phase = GSM Meeting # 8-30; PN = Permanent Nucleus of GSM
Sources: GSM Documents
FIGURE 15 The share (percentages) of NTA/NTO participants in GSM plenariers by country

Working Parties became more important, because they were responsible for practical work. In order to get each Working Party going, the NTAs/NTOs had to allocate human resources. The critical begin period of several Working Parties demonstrated that only a limited group was willing to make this investment. As TABLE 39 shows, this active group consisted of all the Nordic countries, France, Germany, Italy, Netherlands, and the United Kingdom. The influence of large industrial powers reflected in the work of the Working Parties

started to send its representatives.

907 France and Germany cooperated closely on the GSM Committee, e.g. when introducing documents and proposals.

TABLE 39 Participants of GSM and COST 207 Working Parties
Remarks: .. = Information not available; ** = Temporary chairperson; x = Participation of NTA/NTO; y = Participated when WP4 started; z = Manufacturer; w = Did not participate the first meetings. Note: Participation is limited to starting period (early meetings) of each Working party
Source: GSM Documents

	COST 207 chaired by R. Failli (I)			GSM chaired by Thomas Haug (S)								
	WG1 Propagation	WG 2 Baseband Processing	WG 3 Modulation	Joint TR3 and COST Expert Group on Speech Coding	Joint GSM and TE Expert Group on Security (SEG)	PN	WP1	WP2	WP3	IDEG/WP4	WP5	BEG
Austria (A)	0	0	0	0	..	0	0	0	0	0	..	W
Denmark (Dk)	X	0	X	x	..	0	x	x	x	0	..	0
Finland (FIN)	X	x	X	x	..	x	x	x	0	y	..	x-z
France (F)	X	x	X	x	..	x	x	x	x	x	..	W
Germany (D)	X	x	X	x	..	x	x	x	x	x	..	x-z
Italy (I)	X	x	X	x	..	0	x	x	x	x	..	X
Netherlands (NL)	X	x	0	x	..	x	x	x	x	0	..	0
Norway (N)	0	0	0	x	..	x	0	x	x	x	..	X
Sweden (S)	0	0	X	x	..	x	x	x	x	y	..	x-z
Switzerland (Ch)	X	0	0	0	..	0	0	x	x	0	..	0
United Kingdom (UK)	X	0	X	x	..	x	0	x	x	0	..	0
Chairperson of sub-group	Lorenz (D)	de Brito (F)	R.S. Swain (UK)	J. Natvig (N)	..	B. Mallinder (UK)	M. Alvernhe (F)	A. Maloberti (F)	J. Audestad (N)	F. Hillebrand** (D)/ G. Crisp (UK)	T.H. van Voorst (NL)	H. Rosenlund (S)
Replaced by (month/year)						E. Haase (D) (01/89)	G. Sandegren (S) (03/91)		F. Panaoli (I) (01/89)			

in such way that the persons selected as chairpersons of the original Working Parties (WP 1 to 3 and PN) were nearly always the representatives of a large country.

The NTAs/NTOs had a crucial role in ensuring the technology choices. Most of the studies were carried out at research facilities of the NTAs, and either they advanced from research to technical implementation themselves or funded the work of manufacturers or universities. It is particularly striking that the most fundamental choice, that of choosing the technology for radio access, was pursued by eight candidates from only five countries, these being Finland, Norway, Sweden, France and Germany. Although the frontline did not pass along the frontlines of the Nordic and Franco-German pools as closely as it is usually thought to do, it was clear that the most prominent non-Nordic candidate was the biggest looser. It was the only joint Franco-German candidate; the other candidates in this pool were either German or French. The original modulation method suggested by Norway was soon, after agreement on the radio-access method replaced by another one. Usually this replacement is considered to have been a political instead of a technology-related choice. In practice, this change did not have a major impact on the competing pools as it was the same method, which the Finnish, the two Swedish and the one French candidate had all suggested.

3.2.4.1.4.4 Implementation

The operators played significant roles in the launching of the GSM system. First of all, by signing the GSM MoU they convinced the manufacturers to start developing equipment. In addition to that, the operators placed orders for test networks, and this provided valuable know-how and gave positive feedback to the manufacturers to carry on with. These contracts were extremely important to the manufacturers. All the major manufacturers of infrastructure involved in the development of the GSM system succeeded in turning their development investments into production of equipment.

Some contracts were especially important and vast risks were taken. Nokia got its first order from Radiolinja, which did not even have a GSM license at the time the contract was signed.[908]

The commercial launchings of GSM networks were truly market-driven, because at the end of 1992 and early 1993 networks went 'on-stream' only in those countries, which had introduced a second operator. These countries were Denmark, Finland, France, Germany, Portugal and Sweden. But existing competition was not a sufficient precondition as the example of United Kingdom shows; there both operators were getting revenues from their analog networks, and therefore they hesitated to open GSM networks.

There was a remarkably clear difference between active operators and tailgaters. Germany remained the overwhelmingly largest subscriber market.

908 Häikiö 1998.

Its share was still 70 per cent in 1993 and 43 per cent the next year. In 1993, the four largest markets were those of Germany, Denmark, France and Portugal, all together accounting for nearly 90 per cent of the total GSM market (TABLE 40).

TABLE 40 Number of GSM subscribers in Western Europe
Sources: FT MC 124/1993 (April 1993), Profile 1995 (December 1993 and 1994)
Remarks: *Italics = DCS1800 operator;* * = estimate by FT MC

Country Operator	Number of subscribers (x1000)			Percentage	
	April 1st	December 31st		December 31st	
	1993	1993	1994	1993	1994
Germany	**330,0**	**974**	**1752**	**70,3**	**42,7**
DeTeMobil D1	*130,0	481	872		
Mannesmann Mobil D2	*200,0	493	850		
E-Plus	-	-	*30*		
Denmark	**10,0**	**109**	**239**	**7,9**	**5,8**
Tele-Danmark Mobil	5,0	72	139		
Dansk Mobil Telefon	5,0	37	100		
France	**9,0**	**89**	**459**	**6,4**	**11,2**
France Telecom	6,0	79	370		
SFR	3,0	10	89		
Portugal	**25,0**	**65**	**158**	**4,7**	**3,8**
TMN	*8,0	31	72		
Telecel	17,0	34	86		
United Kingdom	**1,2**	**41**	**423**	**3,0**	**10,3**
Telecom Securicor	-	-	17		
Vodafone	1,2	10	118		
Mercury One-2-One	-	*31*	*205*		
Orange	-	-	*100*		
Sweden	**8,3**	**39**	**423**	**2,8**	**10,3**
Telia Mobitel	*2,0	12	217		
Comviq GSM	5,3	15	136		
Nordictel	*1,0	12	70		
Greece	**-**	**22**	**161**	**1,6**	**3,9**
Panafon	-	11	83		
Stet Hellas	-	11	78		
Finland	**4,5**	**19**	**112**	**1,4**	**2,7**
Telecom Finland	*1,0	10	62		
Radiolinja	3,5	9	50		
Switzerland	**0,2**	**9**	**37**	**0,6**	**0,9**
Swiss Telecom PTT	0,2	9	37		
Norway	**-**	**8**	**129**	**0,6**	**3,1**
Telenor-Mobil	-	3	58		
Netcom	-	5	71		
Italy	**0,5**	**6**	**49**	**0,4**	**1,2**
Telecom Italia Mobile	0,5	6	37		

TABLE 40 continues

Luxenbourg	**-**	**4**	**12**	**0,3**	**0,3**
P&T Luxenbourg	-	4	12		
Netherlands	**-**	**-**	**68**	**0,0**	**1,7**
PTT Telecom	-	-	68		
Belgium	**-**	**-**	**65**	**0,0**	**1,6**
Belgacom Mobile	-	-	65		
Austria	**-**	**-**	**13**	**0,0**	**0,3**
PTV	-	-	13		
Ireland	-	-	5	0,0	0,1
Telecom Eireann	-	-	5		
TOTAL	388,8	1385	4110	100,0	100,0

3.2.4.1.4.5 Conclusions

The NTAs/NTOs were of crucial importance from viewpoint of GSM standardization, because they were the first to identify the possibility of creating a common European system. Secondly, they were practically the sole providers of resources in the beginning, and even later on their role as provider was of primary importance.

The activity of the NTAs/NTOs was not primarily driven by the business opportunities of mobile telephony, but by the possibility to explore new bands, which would be available to all European countries in principle. This opportunity was an incentive for those countries, which had extensive experience in mobile telephony or had plans to explore the 900 MHz band.

TABLE 41 Key players in GSM development according to four selected criteria
Sources: GSM Documents (Three first criteria); FT 124/1993, Profile 1995 (Implementation)

CRITERION	FOREMOST PLAYERS	SECONDARY PLAYERS
Allocated resources to GSM Committee	United Kingdom, Nordic countries, France, Germany	Occasionally Italy, Netherlands
Input in Working Parties	United Kingdom, Nordic countries, France, Germany, Italy, Netherlands	Switzerland
Input in technology	Nordic countries, Germany, France	United Kingdom, Italy
Early commercial implementation	Germany, Nordic countries, Portugal, France	United Kingdom, Greece

It has been stated that large countries, e.g. the United Kingdom, France, Germany and Italy, were the key players in GSM development, and in addition to them there were the Nordic countries and the Netherlands among the main NTAs/NTOs involved.[909] This view cannot be accepted, even if only considering the standard setting period (1982-1991).

Table 41 evaluates the importance of the participating nationalities by means of four criteria, of which the first three relate to the standard setting

909 Cattaneo 1994.

period, and the last to the implementation of the GSM system. This approach clearly shows, who the foremost players during standard setting period were; they were the Nordic countries, France and Germany. But as these countries comprised of two driving pools, the role of the United Kingdom became prominent on several occasions. Also, when considering the significance of the early commercial use of the GSM system, the importance of the Nordic countries, Germany and France is further strengthened.

3.2.4.1.5 Manufacturers

3.2.4.1.5.1 Motivations

It is quite obvious that the manufacturers were interested in mobile telephony only for commercial reasons. The ability of the manufacturing industry to push the goals of industrial policy was limited, because the companies were competing with each other, and of the leading manufacturers only Alcatel and Matra were state-owned.[910]

It has been stated that the main European suppliers, namely Alcatel, Ericsson, Motorola, Philips and Siemens, were not at first inclined towards the GSM system. The interpretation of their motives suggests fear of opening competition with Japanese[911] manufacturers, lack of belief in the market potential especially during the early years,[912] and preference given to analog systems. According to this view, manufacturers had carrie dout digital research, but it was not until the MoU was signed that they started to invest in the development of equipment.[913] This lack of interest was a fact, although to some it was relative by nature for special reasons, and some did not recognize the possibility of mobile telephony at all.

3.2.4.1.5.2 Feasibility phase

During the feasibility phase, manufacturers were not directly participating in or involved in any other way with the work of the GSM Committee. The GSM Committee informed Task Force Mobile Services (TMS) of the European Telecommunications and Professional Electronics Industry (ECTEL), which was

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910 In early 1987 it was decided to privatize Alcatel and Matra. Italtel was also state-owned, but it did not belong to the group of foremost manufacturers from the viewpoint of the GSM Committee.

911 The concept of "European" is problematic in this context as Cattaneo (1994) clearly defines Motorola among European manufacturers, but not Miusubishi, even though both had subsidiaries in the United Kingdom and both were involved in mobile telephony.

912 Ericsson is given as an example, with the claim that the first Scandinavian system (NMT) started without Ericsson. This is not true, because Ericsson supplied switches for all Nordic networks. It is, however, true that Ericsson was reluctant to some degree, but not overall. It was willing to offer older switches as the basis for MTX, but not so willing to offer the new AXE switch. See Chapter 2.3.3.3.

913 Cattaneo 1994; Bekkers and Liotard 1999.

established in September 1983 as a joint body of the ECREEA[914] and the EUCATEL[915]. In addition to this, the NTAs had contacts with their national suppliers.[916]

The manufacturers were not intending simply to stay outside, because in the fall of 1983 the ECTEL contacted the CCH and presented a vision on technical and service features for the common future system. In addition to this, the ECTEL also proposed to adopt wide-band approach.[917]

All manufacturers did not ignore the possibilities digital technology might offer. The SEL had already in 1979 started a feasibility study.[918] By the fall of 1984 also Ericsson and Thomson had launched studies of their own.[919] Most probably this group also included Mobira, which in 1983 had launched studies. The initial the group of active manufacturers remained small, and the burden was carried by the research facilities of the NTAs.

The signing of the Franco-German cooperation agreement in the summer of 1983 had a harmful impact on manufacturers of both countries, because schedule was so tight that only SEL, which had started digital studies, focused on digital technology. Siemens was working on its C-450 systems, which had to be modified to operate on the 900 MHz band. In France, Alcatel was not interested in mobile telephony.[920] After France and United Kingdom in 1982 declared their intention to implement a joint analog system on the 900 MHz band, Alcatel launched cooperation with an ally of long-standing, Philips, on the MATS-E system.[921] Suddenly, at the end of 1984, France and Germany decided to call of their interim system project (analog on the 900 MHz band) and to launch a joint digital project. Tender invitations were sent out and the responses were dealt with in the spring of 1985. The general idea was to form bi-national consortia. This goal was not properly achieved as SEL-ATR (Alcatel Thomson Radiotelephone)-SAT-AEG was the only one. Matra left the Bosch-ANT consortium, TRT (the French subsidiary of Philips) left PKI (the German subsidiary of Philips), and LCT was originally a plain French bid.[922]

The canceling of the Franco-German early system had a decisive impact on the two national champions, Matra and Siemens, which now had to focus on introducing national systems operation on the 450 MHz band putting both companies out of GSM development for several years.

In 1985, the manufacturers had to do something if they were to take part in constructing radio-access prototypes. In addition to the aforementioned

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914 European Conference of Radio and Electronic Equipment Associations.
915 European Conference of Association of Telecommunications Industries.
916 GSM Doc 83/86.
917 GSM Doc 40/83; GSM # 3. The concept of wide-band seemed to be tottering. More likely EUCATEL was referring to multiple access versus the conventional single channel per carrier systems.
918 Böhm 1989.
919 GSM Doc 83/84.
920 In 1981, Thomson had won a bid to develop an analog system operating on the 450 MHz band, but after the telecom businesses of Thomson and Alcatel were merged, the latter decided to drop the project. See Muller and Tokker 1994.
921 Bekkers 1999, Garrard 1998.
922 See TABLE 21.

manufacturers in their respective countries, research was also being carried out in the United Kingdom, but in the end these endeavors did not lead to prototypes. In Italy, the research facility of the NTA had carried out research too, but apparently there was no transfer to manufacturing industries after Italy joined the Franco-German alliance in the spring of 1985.[923]

During the feasibility phase, keen cooperation with domestic administrations was required in order to get information and funding for projects. This kept the number of involved manufacturers quite small, but this did not jeopardize the GSM project. In actual fact, when the Nordic countries organized the Digital Mobile Radio Conference in early 1985, they found out that manufacturers were well prepared to launch development work on the digital system.[924]

3.2.4.1.5.3 Standard production phase

There were two major issues related to manufacturers during the standard production phase. The relationship between the GSM Committee and the manufacturers had to be rearranged to respond to the needs of the standardization process. Secondly, manufacturers had to be convinced of the need to launch development of equipment.

In June 1986, the GSM Committee met with manufacturers belonging to the TMS at Copenhagen. The manufacturers had wished for the meeting to be arranged, because they had found out that it was difficult for the TMS to represent the views of all the manufacturers involved. This meeting provided valuable information related to questions, which the GSM Committee had addressed mainly concerning several aspects of equipment development.[925]

The GSM Committee found that several manufacturers considered three years as being the minimum time required for development, but some manufacturers with no experience in developing cellular systems were promising shorter development times.

Another important issue was also related to equipment development. SEL and Philips emphasized that as far as they were concerned manufacturers were not interested in equipment development even it was fully funded, unless the results would lead to production! This was an interesting an attitude. Since others did not comment, it is difficult to estimate how widely held this opinion was. It may have been just a tactical maneuver, because both companies were the first to complete their radio-access prototypes, and particularly SEL was rejecting the idea of multinational cooperation in production. But on the other hand, both companies had invested for several years without production. Particularly Philips was in an unpleasant position, because it had developed the

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923 Italtel became associate member of the SEL-ATR-AEG-SAT consortium (GSM Doc 87/85, 92/85). According to Lindmark 1995, Telettra allied with the Bosch-ANT consortium, but documents do not validate this claim.

924 NR 21-11 FMK Report.

925 GSM Doc 63/86.

MATS-E system, which was then not implemented anywhere. During those days, the initial diffusion of systems, excluding the NMT, was a very slow process.[926] At that time there were only two successful European infrastructure manufacturers. Ericsson had supplied networks for several standards and Mobira had supplied mainly base stations for several NMT networks.

There was also one specific problem, which set constrains on the enthusiasm of manufacturers. It was considered that the market volume was divided in the ratio of 75:25:5 between terminals, base stations, and switches. This implied that there would be several terminal manufacturers, with fewer focusing on base stations, and really few on switch manufacturing.[927]

The cautiousness of manufacturers was understandable. It has been said that even Ericsson and Nokia (Mobira) were somewhat reluctant to start work on infrastructure development.[928] While this argument cannot be validated,[929] it is a possibility considering the situations of the two companies.[930] But as for Nokia, there was practically no other choice for it if it was to seek growth in this sector.[931]

Without endeavoring to underestimate the psychological impact of the GSM MoU, it should also be borne in mind that this was not the first positive signal. Actually, the choice of the radio-access method was important, because the number of companies with mastery of wide-band technology was limited. But the choice of narrow-band technology resulted in that the greatest beneficiaries, Ericsson, Nokia and Matra,[932]had far more experience in modern mobile telephony than the competitors, who lost and actually never had designed a successful cellular system nor had been a major player in the related projects.

The choice of the radio-access method made at the Madeira Meeting in February 1987, even though it was still formally an unofficial "Working Assumption", represented a clear change in standardization and manufacturers were given permission to participate directly in the work of the GSM Committee. There were still restrictions, because the ECTEL TMS was allowed

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926 Although the TACS system was implemented in the Republic of Ireland concurrently with the United Kingdom, the actual launch of diffusion took several years. Also, Siemens had to wait until October 1987, until it managed to sell the C-450 system to Portugal (EMC Report November 1987); the system had been ready since 1985. In addition to Portugal, the C-450 system was sold only to South Africa. Matra and Italtel had even less success as their systems were not implemented beyond the home market.

927 GSM Doc 63/86. The NMT experience was similar as in 1986 there were only three MTX suppliers, perhaps six or so BS suppliers, and a dozen or so MS suppliers.

928 Interviewes of Hans Thiger and Kari Laihonen.

929 Ericsson was pessimistic in 1986 about succeeding in digital phones due to the strength of the Japanese chip industry. See Funk 1998.

930 Ericsson was making a loss due to the recent situation in computers, but it was getting rid of its EIS Division, which it sold to Nokia in 1988, and Nokia focused heavily on consumer electronics.

931 According to Koivusalo, 1995, Nokia considered supplying base stations for the TACS networks in 1987, but then rejected the idea.

932 In 1987 Matra and Ericsson had bought LCT's parent company.

to send two representatives and each administration could invite two manufacturers representatives.[933]

At least Working Parties 2 and 3 invited manufacturers almost immediately,[934] but only WP 2 kept records of the participants. It was hardly a surprise, as WP 2 was responsible for the radio interface, that the first participants were those, which participated in radio-access prototypes. The first manufacturers participating in the work of WP 2 were Ericsson, ATR, Mobira, PKI, SEL, and LCT, soon to be followed by Bosch and new companies like BBC and Plessey. During the summer and in the fall the WP 2 was joined by GEC, Siemens, Italtel and Telettra. The most active manufacturers in terms of number of representatives were Ericsson, ATR, Mobira, Plessey, PKI, and SEL (Table 42).

TABLE 42 Manufacturers participating in the work of GSM Working Party 2 (number of participants)
Legend: **bold** = Participated only in the sub-group meetings of WP 2
Sources: Doc 62/87, 115/87, 142/87

ORDINAL NUMBER OF WP2 MEETING	8	9	10	11	12	13	14	TOTAL
Date	March –87	April – 87	May - 87	June - 87	Sept. - 87	Oct. -87	Nov. – 87	
Number of sub sub-groups	3	3	3	3	2	2	2	
Ericsson (S)	2	2	3	3	2	2	2	16
ATR (F)	3	1	2	2	2	2	2	14
Nokia-Mobira FIN)	1	2	2	1	3	2	2	13
Plessey (UK)	0	3	2	2	2	1	2	12
PKI (D)	1	2	2	1	2	2	2	12
SEL (D)	1	1	1	2	2	2	2	11
LCT (F)	1	1	1	1	1	1	1	7
AEG (D)	0	1	1	1	1	1	1	6
BBC (CH)	0	1	1	1	1	1	1	6
Bosch (D)	0	1	1	0	0	1	1	4
Telettra (I)	0	0	0	1	1	1	1	4
Italtel (I)	0	0	0	1	1	0	1	3
GEC (UK)	0	0	0	0	1	1	1	3
Siemens (D)	0	0	0	0	0	0	1	1

Manufacturers had special competence, which they brought, but in addition to that, they started to reduce burden, which earlier was totally in responsibility of NTAs/NTOs. Even as a resource of manpower, manufacturer's role became important to WP 2, because in turn of 1987 and 1988 the share of all participants was 41 per centat the greatest. (Table 43)

The next plenary after the Madeira Meeting was held in June 1987, and it was the first possibility for manufacturers to participate, but there was no rush! Only TMS and Ericsson sent their representatives. All in all, the number of

933 GSM # 13.
934 Kari Laihonen's interview.

participating manufacturers stayed low during the CEPT era. There were at most seven manufacturers present at the one time. In total, there were only twelve participating manufacturers and two of them were present only once representing TMS. Others, with the exception of Motorola, were familiar from WP 2. After the GSM Committee was transferred to the ETSI at the 23rd meeting of the GSM Committee, the number of participating manufacturers began to grow. Actually, these newcomers came in quite late in the piece if they were considering making any impact on the standard, because Phase 1 Recommendations were "frozen" at the 25bis meeting in January 1990.

TABLE 43 The number of manufacturers' and administrations'/operators' representatives participating in the work of GSM Working Party 2
Sources: GSM Doc 62/87, 115/87, 142/87, and 219/88

ORDINAL NUMBER OF WP2 MEETING	8	9	10	11	12	13	14	15	16	17	18	19
Date	March –87	April –87	May -87	June -87	Sept. -87	Oct. -87	Nov. -87	Jan. –88	Feb./Mar -88	April -89	June -88	Sept. –88
Manufacturers	9	15	16	16	19	17	20	20	16	9	15	13
NTAs-NTOs	30	32	31	30	28	27	29	29	28	27	25	28
TOTAL	39	47	47	46	47	44	49	49	44	36	40	41
Manufacturers (%)	23	32	34	35	40	39	41	41	36	25	38	32

The group of manufacturers actively participating in the development of technology in 1986 was limited. There were ten manufacturers involved with radio-access prototypes.[935] The number involved with speech codices was just three, because administration selected the participants from among a large group.[936] In addition to these fundamental selections related to technology, involvement with development of validation systems was particularly important. All major manufacturers of infrastructure were involved, but particularly Motorola was successful in marketing validation systems. Motorola was a relative latecomer. It attended the Copenhagen meeting in June 1986, but after that there is no sign of it. Apparently the lack of "domestic" administration and possible lack of interest kept Motorola away. But Motorola must have become reactivated in late 1987 at the latest, as it had got such a good grip on validation systems. If Japanese manufacturers are considered, they came too late to have any chance of becoming involved in infrastructure development.

935 SEL, ATR, AEG, SAT, PKI, Bosch, ANT, LCT, Nokia-Mobira and Ericsson.

936 These were PKI, IBM (F) and Ellemtel (joint venture of Ercisson and Swedish NTA, responsible for development and marketing of AXE digital switch): In 1990 the manufacturers which had passed pre-selection in the choosing of half-rate speech codec were PKI, Matra, Ericsson, Motorola and AT&T.

TABLE 44 The number of manufacturers' representatives participating GSM plenaries
Explanations: x = participated as a representative of TMS/ECTEL; country in parentheses (location country/nationality of parent company); **Company name** = North American, *Company name* = Japanese
NOTE: Minutes of GSM Committee's #21 and #22 Meetings did not identify the representatives of manufacturing companies. Motorola owned Storno.
Source: GSM Documents (Minutes of meetings # 1-30)

Manufacturer	Number of GSM Meeting and date																	
	14	15	16	17	18	19	20	21	22	23	24	25	25 bis	26	27	28	29	30
	Jun. -87	Oct. -87	Dec. - 87	Feb. -88	Apr. -88	Jun. -88	Oct. -88	Jan. -89	Mar. -89	Jun. -89	Oct. -89	Dec. -89	Jan. -90	Mar. -90	Jun. -90	Oct. -90	Jan. -90	Mar. -90
Ericsson (S)	1	1	1	2	1	2	2	1	2	3	3	3	2	2	3	3	2	3
Mobira-Nokia (FIN)		1	1	1	0	1	?	1	1	1	2	2	2	2	4	3	5	3
SEL (D)	x	1+x	1+x	x	1+x	1+x	0	0	0	0	1	1+x	1	1+x	1+x	1+x	1+x	1+x
Siemens (D)		1	1	1	1	1	1	..	..	3	3	3	5	3	3	2	4	3
PKI/Philips (D/NL)		1	1+x	1	1	1	1	..	1	0	1	1	1	0	0	1	1	0
Motorola (UK/USA)		x	0	0	0	0	0	0	1	1	1	1	1	1	1	2	2	2
Alcatel (F)			1	1	0	1	2	1	1	3	5	3	3	2	3	4	4	3
Matra (F)	X	0	1	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
LCT (F)				1	0	1	1	1	1	0	0	0	0	0	0	0	0	0
OTE				x	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Center					x	0	0	0	0	0	0	0	0	0	0	0	0	0
Schrak (A)					1	0	0	0	0	0	0	0	0	0	0	0	0	0
Orbitel (UK)									1	2	2	1	1	1	1	1	1	1
Thomson - CSF (F)										1	1	1	1	1	1	1	1	1
Bosch (D)										1	1	0	0	1	1	1	1	1
Marconi Italy (I)										1	2	2	2	1	1	1	2	1
FATME (I)										1	1	1	1	1	1	1	1	0
NEC (UK/J)										2	1	1	0	1	2	2	2	2
CEG Plessey (UK)										1	1	2	0	1	0	1	1	1
Ascom/Hassler (CH)											1	1	0	0	0	1	1	1
Mitsubishi (UK-F/J)											2	1	1	1	1	2	2	2
GPT (UK)											1	0	1	2	2	1	1	1
Uniden Europe (B)												1	0	1	1	1	1	1
Storno A/S (Dk/USA)												1	0	1	1	1	1	1
Panasonic (D/J)												1	0	0	0	1	1	1
Telettra (I)												1	1	0	1	1	1	1
Italtel (I)												1	1	1	1	2	2	0
Marconi (UK)												1	1	1	0	1	1	0
IBM Europe (F/USA)													1	0	0	0	0	1
ANT (D)														1	0	0	1	0
GAO														2	0	0	0	0

Table 44 continues

Atea NV (B)														1	1	1	1	1
Sony Telecom (B/J)															1	1	1	1
AT&T NSI (NL-UK/USA)															3	1	2	3
British Aerospace (UK)															1	0	0	0
Northern Telecom (Can)															1	2	1	0
Digital Equipment (F/USA?)																1	0	1
Rohde&Schwartz (D)																1	0	0
Preussen Electra (D)																	1	0
Neutech (D)																	2	0
BIS Strategic Decisions (UK)																		1
BAPT(D)																		1

3.2.4.1.5.4 Implementation

It is apparent that without the interest of significant manufacturers the success of the GSM system may not have been possible. Actually, the GSM system formed by itself a growing circle of interested parties, because the leading suppliers could not afford to neglect it. In 1991, of the six largest suppliers of infrastructure for mobile telephony, three started to manufacture GSM equipment from the very beginning. In 1997. of the seven largest suppliers only one (NEC) was not involved with GSM infrastructure.

The success of the GSM system had another kind of impact on manufacturers as well. Originally, only Ericsson, Nokia and Alcatel were able to supply entire networks. This was not absolutely necessary, since Siemens and Motorola succeeded quite well by splitting orders, but it became the custom to offer the entire infrastructure; Motorola was the only major exception here. By 1996, all the manufacturers supplying either switches or base stations of their own had the capacity for both.[937] The birth of a real mass market did away with the traditional dichotomy of switching and radio worlds, because in the mid-1990s six of the eight biggest suppliers of GSM infrastructure were also the biggest manufacturers of terminals world-wide.

3.2.4.1.5.5 Conclusions

As far as native European manufacturers are concerned, it was no surprise that the majority of them were suspicious during the early period of the GSM

[937] Siemens acquired base station competence from Italtel, Lucent (AT&T) from Philips, Nortel (Northern Telecom) from Matra, and Italtel acquired switching competence.

system, because only two Nordic manufacturers, Ericsson and Mobira (Nokia), had major experience in cellular technology. There were far more disappointments that successes, and although the United Kingdom, Germany, France and Italy ultimately managed to complete their national cellular systems in 1985, three out of four did not turn out to be great commercial successes. Only the diffusion of the Nordic NMT had already earlier got off to a flying start while the others stumbled along. It should be borne in mind that the new digital technology related to switching was mastered only in France, Sweden and Finland at the time when the GSM project was launched.

The number of manufacturers originally launching digital mobile telephone research would appear to be limited to four; SEL, Ericsson, Thomson, and Mobira. It is no surprise then that these, or their parent companies, belonged to group, which had been active early in the piece in matter connected to digital switching.

It was important for the development of the GSM system that six consortia, including ten manufacturers, began to construct radio-access prototypes. All these manufacturers later focused their investment to the development of equipment and ultimately to supplying the equipment. In addition to this, also Italian and British companies, Siemens from Germany, and Motorola started development work on infrastructure in time to catch the first wave.

The group of manufacturers actively participating in the work of the GSM Committee was originally small. This number started to grow only when Phase 1 standard was about to freeze, which meant that the majority were not even trying to have an impact on the standard. They were mostly preparing to start developing terminals. But nevertheless, the number of manufacturers involved in developing infrastructure was large enough, and within a relatively short period of time nearly all major manufacturers were involved in manufacturing at least parts of the infrastructure.

3.2.4.1.6 GSM Committee

3.2.4.1.6.1 Motivations

The birth of a cohesive international group was of critical importance, because the GSM Committee was then able to lay down a basis for compromises to overcome national interests. According to Cattaneo, the GSM Committee acted as the champion of the system, and all innovations needed support from determined individuals.[938] The GSM Committee consisted of a 'Club of Experts'[939] with a pallette of complementing skills and experience related to

[938] Cattaneo 1994; Thomas Haug also emphasized the importance of determined individuals.

[939] Cattaneo (1994) uses the term "champion" when referring to the GSM Committee. The choice of word is unsuccessful, because it bears close resemblance to another term "national champion", which is usually applied to manufacturers such as Alcatel, intentionally established by political decisions.

national circumstances, which most probably provided the self-reliance needed to resist external pressures.

It is a quite obvious that none of the participating countries had superior competence in radio technology. There was one specific sector in which some participants had the edge over others. The Nordic countries were the sole participants with actual experience in and knowledge of multi-national standardization projects (NMT), based on dialog with all interested manufacturers, and they had completed a cellular project before work on the GSM started.[940] The knowledge transfer from the NMT environment to the GSM cannot be overrated. Thomas Haug was appointed chairperson of the GSM Committee and he held this post until 1992, practically covering the entire standard setting period. He had acquired a unique mass of experience while secretary and later as chairperson of the NMT Group, and this was indispensable for the GSM Committee. It was crucial for the cohesion of the GSM to have a chairperson with solid experience, the ability to remain absolutely neutral and resolve disagreements between the various parties.[941]

It is most probable that the small number of participants in part enabled the GSM Committee to maintain internal cohesion, because it was easier to get acquainted in order to build social networks.[942] On the other hand, over a longer term, the turnover of staff was significant. Only chairperson Thomas Haug, secretary Thomas Beijer, Gunnar Fremin (Swedish),[943] and Frider Pernice (German) represented continuity, having participated from the beginning through Meeting #30.[944]

3.2.4.1.6.2 Feasibility phase

Although the GSM Committee was merely a coordinator and a forum for discussions during the feasibility phase, it was the most fundamental player to push forward the idea of a common pan-European system. The foremost task of GSM Committee was to steer the attempts of other players in the direction regarded to be the goal of the GSM system.

The initial situation was such that there was practically nothing by which to predict the success of project. On the contrary; there were several serious obstacles. The most serious ones were consequences of the CCH's activity when

940 This aspect was important, particularly since in the beginning the Nordic countries sent the very same persons to GSM and FMK Committees, most of them being experts in NMT standardization.

941 Thomas Haug emphasized several times in the interviews how indispensable it was for the chairperson to maintain neutrality when several nationalities are involved. Matti Makkonen claimed that nobody ever called into question Haug's neutrality (Interview of Matti Makkonen).

942 Before Meeting #8 the number of participants varied between 30 and 40; from Meetings #8 to #15 the nubmer of participants was between 40 and 50. The numbers started to rise and approached 80 between Meetings #16 and #23. From Meeting #27 onwards there were around 100 participants.

943 Actually Thomas Haug was Norwegian, but he worked for the Swedish NTA.

944 GSM # 1 to # 30.

it eliminated post-1986 tasks from the mandate proposal, restricted the work of the GSM Committee only to technical standardization, denied direct contacts with external bodies of the CEPT and later forbade the establishing of steady Working Parties. It should be borne in mind that the Nordic countries preferred direct submission to the Telecommission, which might have granted the GSM Committee more space in which to maneuver, but instead the GSM Committee was placed regularly under the supervision of the CCH.

The most inconvenient limitation set by the CCH was denial of steady Working Parties, because this would have meant a significant slowing down of the process. The GSM Committee tried to minimize the harm by choosing coordinators for special subjects or by arranging meetings of experts.[945] Although the Working Parties were established again for every GSM plenary, there was more continuity in practice. Of course, the tasks of the Working Parties remained the same until they were changed, but usually the chairpersons of the WPs were the same, they were simply renominated at every plenary meeting.

As regards the role of the GSM Committee from point of view abandoning the post-1986 schedule, a dangerous situation was created by external pressure, because, all in all, it was considered that the GSM Committee would finish the given task by the end of 1986. In practice, the GSM Committee focused on issues of current interest, but it was not going to abandon its post-1986 tasks.

At first, an external threat was caused by the COST 207 project. Already in the beginning, there was a risk that if the sharing of tasks between COST and GSM could not be achieved properly, it would lead to duplication of work. This question was resolved neatly by restricting the task of the COST 207[946] to researcvh. In the fall of 1984, there was an attempt to expand the COST project's activities in radio-access schemes, but Sweden and Finland were opposed.[947] Had this attempt succeeded, it could have taken the most important technology selection out of the GSM Committee's direct control.

Intrigues by the EC became serious threats in a critical situation. At first, the Secretariat for Specifications and Approval (SSA) of the CEPT expressed its will to coordinate the work of the GSM Committee,[948] which in itself was in the role of coordinator. This was strange, because the SSA was not responsible for technical specifications, but instead its task was to reduce the number of options given in them, in order prioritize matters and simplify the mutual recognition of type approval.[949] The timing of this initiative was also quite peculiar; the GSM Committee was actually not even near to commencing to make any specifications.[950] Simultaneously with the SSA initiative, the chairperson of the COST 207 project leaked out information to the effect that the EC had

945 GSM Doc 52/84, 38/85.
946 Only part of the GSM-participating countries take part in the COST 207 project.
947 GSM # 6.
948 GSM # 6; SSA was recently founded on request of EC.
949 GSM # 7.
950 Later SSA declared that it wanted to start solving problems related to legal restrictions on border crossing, see GSM Doc 12/85.

established a group to consider development in the telecommunications sector. Mainly representatives of manufacturers formed the group, because only the Dutch NTA was involved. From the point of view of the GSM Committee's internal cohesion it was symptomatic that the head of the German delegation did not support a joint undertaking with the EC, because he considered Franco-German cooperation adequate enough.[951] In private conversations, off the record, he was even more severe in convincing others of his intention to oppose the by-passing of the GSM Committee, and that Germans had no intention to creating a sidetrack for the EC.[952]

Early in 1985, the EC demanded to cut the schedule of the GSM by two years. This would have made it impossible to choose a system based on digital technology according to the opinion of the GSM Committee. There was also a serious possibility of the EC taking over the GSM project. It was a surprise, at least according to Finnish delegation, that the GSM Committee took a firm attitude right from the start. The delegation of the United Kingdom was the most clear and precipitous opponent of the proposal. Only the head of the German delegation now supported the initiative, because the Director Generals of the PTTs had approved it, and the GSM participants could not be disobedient. But after a while, the head of the German delegation changed his mind.[953] The GSM Committee decided to show its willingness to cooperate, but in practice to do that was impossible, because it would lead to choosing already existing system such as the AMPS, the TACS or the NMT.[954]

The catch in the EC's initiative was the requirement to establish the Permanent Nucleus, which would be a permanent organ not just having meetings, but to be available all the time in order to speed up the process. The EC offered funding, and to host the PN, which was to be established immediately. This would have driven GSM development into the hands of the EC, which was why the GSM Committee unanimously rejected it. The GSM Committee found the PN to be important, but wanted to find the host from among the participating NTAs, and it did not consider the PN as being an urgent issue at the time.[955] The establishing of the PN became the most difficult question that the GSM Committee had to resolve and it took nearly a year to do so. This process clearly divided the participating countries and did the same internally to the Franco-German pool and to the Nordic pool behind scenes.[956]

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951 SA RD Memo # 6 GSM, M. Hovi.

952 SA RD Memo # 6 GSM, T. Hahkio.

953 SA RD Memo # 7 GSM, M. Hovi.

954 GSM # 7.

955 GSM # 7.

956 There was a severe controversy regarding the location of the PN, because it was considered that it could have industrial political influence due to relations with manufacturers. Particularly France opposed the idea to locate the PN in Sweden, and it was supported by Italy, but the Germans did not provide visible support to France. The other Nordic countries supported Sweden, but only Sweden and Norway refused to submit a second best option. Behind the scenes, the Finns were reluctant to increase influence of Sweden, but they could not directly oppose the proposal to locate the PN in Sweden. See SA RD Report on telephone conference of GSM (13 December 1985), M. Hovi; NR 23, 23, 24, 25.

Despite the external threats, or perhaps partly due to them, the GSM Committee managed to preserve its cohesion during the crisis. In normal conditions, the GSM Committee succeeded mainly because decision-making was retained at the national level[957], the group of interested countries was small, and the number of active countries was even smaller. On the other hand, the decisions taken had to be unanimous. This reflected on the development of GSM, because the systems had to satisfy various needs.

3.2.4.1.6.3 Standard production phase

The role of the GSM Committee changed from that of coordinator to that of active forum, and it retained the status of the most important player. The Committee took advantage of all the possibilities to change the procedures to response to the needs of the current situation in standardization. All the changes were timed in accordance with its. These included the foundation of stable Working Parties, the Permanent Nucleus, inviting manufacturers to participate, and to transfer the GSM Committee from the CEPT to the ETSI.

The GSM Committee had to make a crucial decision at the Madeira Meeting; to choose its radio-access method. It has been claimed that the French and German participants kept working towards the goal of making their countries accept the choice, and this did not comply with the wishes of politicians.[958] This is, however, quite a biased outlook. First of all, the GSM Committee was not resisting the politicians or political organizations for the first time. Secondly, it was the GSM Committee, which left doors open, because it wanted to have a common standard. It is true that the French and German participants, as engineers, made the procedure easier, because they did not actually oppose the narrow-band version, which was accepted by everybody else. It should be borne in mind that the choice of technology was done according commonly accepted criteria, and the outcome of evaluation was not questioned. Rejection it would have placed the GSM Committee in to a position of being a mere rubber stamp. Actually, the whole Madeira Meeting was not so crucial from the GSM point of view, because it did not severely challenge internal cohesion. It was more a question of the political level.

The GSM Committee has been criticized, because it did not originally have the IPR policy, which led to difficulties in procurement.[959] This criticism is justified from the procurement point of view, but not so from the

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957 The NTOs had the right to decide when they would implement their GSM service (see GSM # 5), which was designed such that operators were responsible only for their own network (e.g. sharing of networks was not accepted).

958 Cattanneo 1994 also claims that the French and German participants took care to include in the standard the key elements that the French and Germans had developed in order to make the compromise acceptable. However, this is merely folklore, because the major change was related to modulation method, and the newly chosen method was not "developed" by France or Germany. Instead, one French, one Finnish and both Swedish candidates implemented the chosen method!

959 Cattaneo 1994; Bekkers and Liotard 1999.

standardization point of view not. The GSM Committee was aiming for an open standard. If it had originally accepted existence of the IPRs and allowed IPR holders a *carte blanche*, the elaboration of the standard would have become impossible. It should also be noted also that nobody at that moment in Europe actually understood the importance of the IPRs in the correct scale. The GSM Committee merely followed the accepted practice, because there was no time for anything else.

During the standard production phase it was still important to preserve the cohesion of the GSM Committee. Although the GSM MoU had formally violated national decision-making, in practice the adjuncts were so flexible that they enabled operators the freedom to choose the point in time suitable for them to enter the market. The requirement of unanimous decisions meant that the recommendations usually included several alternatives to satisfy national needs, and this feature made them quite complex.

3.2.4.1.6.4 Implementation

The GSM Committee was not directly involved with introduction of the systems into service, because this issue was not part of its mandate. The GSM MoU was created to address issues related to the introduction into service. Indirectly, the GSM Committee was involved with the implementation of the standard, because it made several very important decisions. First of all, the GSM Committee decided to split the standard to two phases in order to have it introduced in time. This phase approach paved the way for the evolution of the standard. The GSM Committee also safeguarded the future capacity problem by assimilating the DCS1800 standard into GSM. This also meant light and relatively cheap terminals for GSM and did away with the necessity of the Personal Communications Networks concept.

3.2.4.1.6.5 Conclusions

The GSM Committee succeeded in elaborating the internal cohesion and in maintaining it, which made in turn enabled it to withstand external pressure. In addition, the GSM Committee was able to intercept attempts, which would have been fatal for the standardization process, and even for the fundamentals of the project, it was able to take advantage of threathening situations and to have inappropriate rules changed to comply with the current status on standardization. The decisions to change procedures were made on urged on by the standardization process, not due to external pressure. It is paradoxical that at the same time external pressure was harmful and even dangerous, it was also necessary as a force altering the circumstances.

Without a determined GSM Committee the project would have drifted or have been taken over by the European Community. The attempt of the EC in early 1985 was the foremost challenge the GSM Committee had to face, and it resulted in a most stressful and contradictory debate. The GSM Committee did not have many tools with which to cope with a situation of this kind. Although the selection of basic technology at the Madeira Meeting was not easy, it was not as difficult for the GSM Committee, and it did not severely endanger its internal cohesion.

3.2.4.1.7 Users

During the time of standard setting (feasibility and standard production phases) users were not considered to be active players as subjects; they were seen merely as objects.[960] Some level of understanding of consumers was necessary. The market studies compiled and released by the ELT group focused on users at the conceptual level, on the Information Society, and market potential. The market surveys carried out by the NTAs provided information on the segmentation of user groups in terms of the existing systems.

Two issues became particularly important from the user point of view. Firstly, the Nordic countries and the United Kingdom were lobbying for hand-held terminals, and they managed to drive this principle through. The debate concerning the definition of networks to match the requirements of hand-held or auto-based phones was a long one. One by-plot was a proposal by the French NTA to introduce two networks: one for car-based phones and the other for Personal Communications devices; this is something that the PACTEL studies of 1981 had already visioned.[961] Luckily, these plans and others like them were buried, and the hand-held vision won. Later on, the United Kingdom introduced the Personal Communications concept, which included emerging essential features, including a relatively small and cheap terminal, compared to GSM, which made it easier for users to choose the GSM system.

Although the Nordic countries and the United Kingdom were user-oriented already in 1980s, it seems that the users themselves were still kept at a distance. Of course, there were quite obvious issues. It was not difficult to draw the conclusion that users would appreciate better quality of speech and security of use against unauthorized use, to take two examples. As voice security was one of the major new features, it is likely that the user vision was still mainly based on the business users' segment.[962]

When the launched of the GSM system was closer, more attention was paid to users. At least the 1989 PEDCR Conference addressed the users, but mainly from retailers' point of view. Two years later, the representative of the

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960 According to GSM plans (1982) user organizations should have been contacted by the CEPT/SF, but it remains unknown what the results were. See GSM Doc 17/82.

961 This was clearly a compromise attempt to please the German delegation, which was strictly in favor of auto-based phones and the associated network.

962 There are no hard facts backing this finding, but when the real mass market was reached in countries, which had high penetration rates, ordinary people were not even trying to keep their use of mobile phones and content of conversations private.

French user organization gave a presentation on the subject of users' points of view.[963]

Once the GSM networks started commercial operation, users came to have a decisive collective role, because originally in many countries the users had to choose between the old technology with its good coverage, light and cheap terminals, and new technology with limited coverage, and heavier and more expensive terminals. Naturally, operators began to offer variable subscriptions and later new kinds of services.

The GSM system introduced personal phones with SIM cards putting an end to the dependency between subscription and terminal. Users were not interested in the technology issues related to the system.[964] Still all manufacturers designed phones, which were all glowing black as regards their technology image, and trying to design terminal as small as possible. This was changed quite rapidly after Nokia discovered that the mobile phone was a personal artifact for the individual.[965]

3.2.4.2 Role play

The key players in the GSM standardization process can be divided to three groups on the basis of the status, which they had in normal situations.[966] STAGE PLAYERS were forums, where acts were normally played, and which operated along officially defined strict rules and goals. In normal situations, Stage Players were just carrying out objectives approved by ACTOR PLAYERS, who were subjects giving content to a play presented on the stage. PROPERTY PLAYERS did not have official right to participate in plays, but they were absolutely necessary in the spectacles presented by the Stages and the Actors. Stage Players consisted of the European Community, the CEPT, and the GSM Committee. Actor Players composed of National Governments and NTAs/NTOs, while Manufacturers were the Property Players.

In a normal situation (or stagnation), the relationships between Stages, Actors and Properties were carried out by customary procedures. There were three kinds of relationship between players: hierarchical submission[967], membership[968] and impact relationship[969] without official deputation. In a

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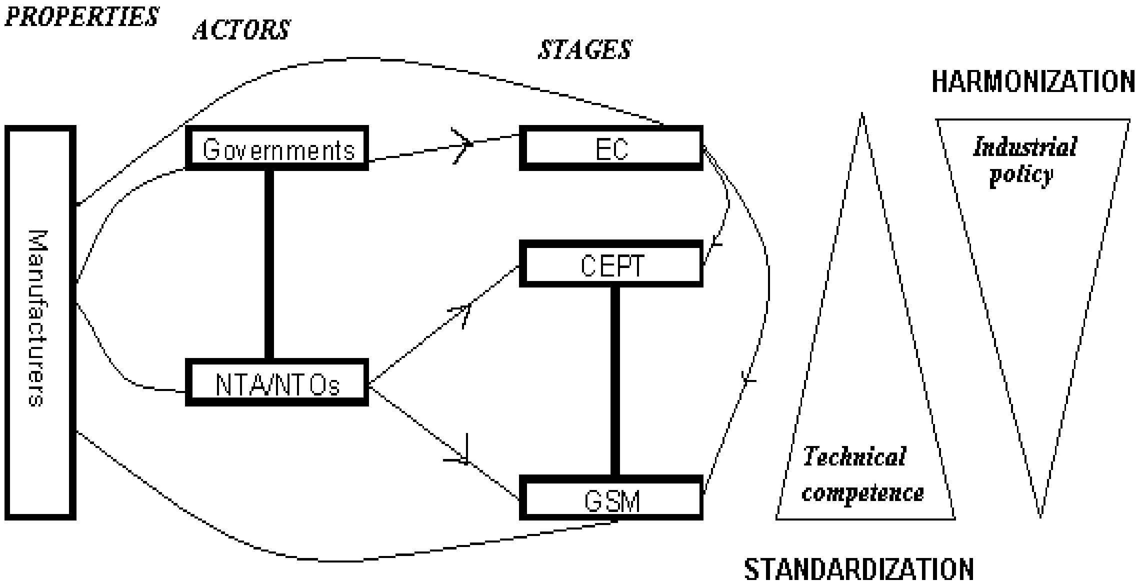
963 Saxton 1989; Berry 1991.
964 Berry 1991.
965 Pulkkinen 1997.
966 This definition relates to the pre-1989 period.
967 Players were members of same organization, and there was a clear hierarchical submission, e.g. between the CEPT and the GSM Committee or between National Governments and NTAs/NTOs. This kind of a relationship did not prevail between the EC and National Gtheovernments, because all the involved countries were not members of EC, and in the 1980s the power of the EC was restricted when compared to the situation that prevailed later in the 1990s.
968 Actor Players were members of Stage entities (Note: all National Governments were not members of the EC, but the EC negotiated with the EFTA and in practice EFTA countries followed Europe's integration process).
969 Impact relationship is an informal intercourse between players.

conflict situation (or transformation) the players started to interpret their roles. Actor Players could create a new side-stage, and Stage Players could be activated into Actor Player roles by interpreting rules and guidelines.



Legend: Bold straight line = Hierarchical submission relationship
Thin straight line = Membership
Curved line = Impact relationship
EC = European Community

FIGURE 16 Relationship of the Key players during the Feasibility phase of the GSM standardization

The causes of the conflicts were structural. On the political level of performance, the European Community, which was pushing goals of industrial policy, did not have an official relationship with the CEPT, which was in charge of standardization. It could only speak on behalf of twelve (ten)[970]countries out of twenty-six countries forming the CEPT.[971] The situation was nearly parallel between the EC and its Member States, because the EC did not have authority in telecommunications (as per the Treaty of Rome). All in all, there was confrontation between the goals of industrial policy and standardization, and this culminated in the GSM Committee, which had the task of strictly limiting to forming technical specifications. It could not carry out the goals of industrial policy. But the GSM Committee was not in a vacuum, because it was depending on resources allocated by the NTAs, which in turn were under the governance of National Governments.

During the feasibility phase, the GSM Committee had at least three potential conflict situations with the COST project and the manufacturers. Each was an attempt at role transformation (creating a side-stage).[972] In the

970 The EC had ten members up to the end of 1985.
971 Naturally, in practice, the influence of the EC was stronger than just the power of ten or twelve countries.
972 The COST 207 project is not classified as a key player, because from the beginning the

beginning, the work tasks of the GSM Committee and COST 207 were arranged before there was a possibility to create a conflict. In the spring of 1983, the manufacturers tried to persuade the GSM Committee to choose the wide-band technology, and in the fall of 1984 the COST project tried to broaden its area of operation into researching radio-access schemes. Particularly the last two attempts would have had far reaching consequences had they succeeded. The GSM Committee did not actually have any noteworthy difficulties in dealing with these attempts, because the manufacturers and COST did not have a superior actor to support them.

There were two major conflict situations during GSM standardization. First, in early 1985, the EC tried to change the course of the GSM project, and the second time, in early 1987, France and Germany were left in opposition when the radio-access method choice was made. On both occasions, the GSM Committee gave a clear signal of its determined stand, it did not give in under pressure, and it made arrangements to proceed.[973] In short, the GSM Committee acted without the support of a superior body or a parent organization, and transformed its role into that of an Actor. But, as on both occasions the threat to the GSM Committee was political by nature, it is highly unlikely that a technical committee alone would have been strong enough to resolve the conflict. A closer look at the conflict caused by the EC provides information on how it was resolved and what the consequences were.

When the EC (the European Commission in practice) started to execute its program of telecommunications policy in late 1984, it started to change its role from that of a Stage Player to that of an Actor Player. At first, the EC only pushed the case of improving standardization in general, which was inspired by goals of industrial policy, and it managed to persuade the CEPT quite easily. This is logical, because the goals of the EC were in general easily acceptable. When the EC started to interfere with the work ongoing in the CEPT projects it took the role of an Actor. Although the EC did not have difficulties in pressuring the CCH to speed up the standardization of technical committees, the GSM Committee took a stand of resistance, and in practice it got indirect support from the Franco-German alliance. The Governments of France and Germany had set up a side-stage, when they launched digital studies in cooperation. This Franco-German cooperation was clearly inspired by the goals of industrial policy, and it was aimed at boosting the Franco-German industries since the manufacturers were given the leading role. Attempts on the part of the EC to take control of GSM did not please France and Germany, which were trying to set a standard. This intra-EC conflict started to unwind when Italy

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relationship between the GSM Committee and the COST project had been arranged, and in practice the work of the COST project was carried under the supervision of the GSM Committee, although they did not have a formal impact relationship. But in practice the most essential part of COST was assimilated as an organic structure of GSM. In general,there was a clear division of labor between GSM and COST, the latter focusing on research.

973 In 1985 GSM Committee took a unanimous stand to resist the pressure of the EC. In 1987, the GSM Committee stretched the CEPT rules, and prepared "Working Assumptions" although unanimous decision was not officially reached.

joined the Franco-German alliance in the spring of 1985, ultimately relegating the EC back to its role of a Stage Player. In practice, this meant that the policy prepared by the civil servants of the EC had to give way to National Governments, which took active and leading roles.

The Madeira Conflict was the ultimate result of the Franco-German attempt to set a standard. Paradoxically it tripped over because of its own cleverness as the Franco-German cooperation had changed in nature. Actually, the substance of the alliance had changed after new members had joined it. Italy was merely a political supporter[974], and after United Kingdom joined it in 1986, this Quadriparty alliance started to focus on introducing the GSM system into service. The Quadriparty had already started measures before the Madeira Meeting, and it took a clear stand on continuing along the approved goals, and it persuaded France to give up on its wide-band candidate.[975] Italy and the United Kingdom did not have a relevant reason to support French and German manufacturers. The Quadriparty strengthened the political influence of the original Franco-German alliance, but by doing so also the industrial political goals had to be discarded. Although the Quadriparty was a genetic descendant of Franco-German cooperation; the goal of the Quadriparty differed essentially from its parent Franco-German alliance. The goal of The Quadriparty corresponded both to the situation that prevailed in standardization process of GSM and to the political situation of the European Community (Single Market). Although the importance of the Quadriparty diminished soon after the GSM MoU was established in fall 1987, the respective Governments did not make way for the EC.

The EC retained its role of Stage Player up to the end of the standard setting period. It could not even be activated to assume an Actor role during the early implementation of the GSM system. Although the EC had outlined to liberalize operator market in 1987, the goal regarding mobile telephony was dropped in 1990, and National Governments were free to either organize competitions or maintain monopolies. According to the plans of the EC,[976] there was meant to be a Green Paper on mobile communications ready by the end of 1991, but it was postponed by nearly three years. It was not until the GSM system had actually made its breakthrough on the market that the EC was able to rise to its Actor's role and cut down the authority of National Governments.

The ability of the GSM Committee to rise in conflict situations from its Stage Player role as a pure technical Committee to that of an Actor role interpreting the current needs of the standardization process, was an absolute precondition for the continuation of the standardization process in accordance with the set objectives. Since the most serious conflicts were political, caused by industrial policy endeavors, they could not be dealt with without side-stages established by National Governments. This lead to a situation where the

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974 Because Italian companies were not on equal rank in the consortiums of Franco-German-originated projects. There is no sign that British companies took part in cooperation.

975 The Quadriparty (governments) outlined the GSM MoU and they carried it out, not EC bodies.

976 390Y1231(01) Council Resolution December 14, 1990.

interests of the European Community had to give way to those of National Governments, which took the leading roles in ultimately mortifying national aspirations of industrial policy.

It was ironical that the GSM standardization process could cope with the political plotting of influential players, but GSM Committee could not ultimately win the manufacturers, which had no political power. Assimilating manufacturers into the standardization process was not actually a major problem, but dealing with the IPR policy of certain manufacturers turned out to be nearly insuperable. The danger represented by manufacturers lay in their traditionally weak role. Most European manufacturers depended on their home markets and the NTAs could prevent the IPR policy of manufacturers by means of procurement policy. European manufacturers did not focus on IPRs, which made them quite ready to accept cross licensing. The GSM Committee had far-reaching plans to arrange procurement, and extreme plans would totally subordinate manufacturers as servants of the operators. When Motorola entered the standardization process, it had two unique advantages, in addition to being the leading manufacturer. First of all, Motorola did not depend on European operators, and secondly, it was accustomed to totally different IPR practices and policies, which prevailed in United States. Motorola was able to rise to meet the open cross-licensing requirement set by the GSM Committee, while European manufacturers could not. In the longer run, this was not the most important outcome, but it acted as a herald of change on the status of role related to standardization process.

3.3 The success factors of the GSM system

This Chapter deals with three dimensions of the GSM system's success. First it relates the GSM standard to other successful cellular standards and finds common features. A successful standard is defined as a standard, which (in addition to being commercially successful) also manages to transfer viable procedures, knowledge and experience for the standardization of the next generation. Secondly, specific factors related particularly to the standard setting of the GSM process are reviewed. And thirdly, different types of approaches explaining the commercial success of the GSM system are discussed and the major shortcomings of these attempts are presented. In conclusion, the Chapter provides a synthesis of the commercial success of the GSM standard.

3.3.1 Basic "rules" in the standardizing of mobile telephony

Although the GSM system was a pioneer in Europe in the field of standardizing mobile telephony, it is unjustified to consider it the only example, unless the GSM system can be interpreted as having created totally new procedures and a new culture of operation. But this supposition can not be justified, because the GSM got its fundamental features from the process of NMT standardization. The uniqueness of the NMT system is emphasized by the point that NMT standardization differed in several ways from the procedures applied in other European cellular projects; it was the only multinational project based on negotiations between several operators and manufacturers (see Table 45).

TABLE 45 Selected features of the standardization processes for mobile telephony in Europe
Sources: Compiled from various sources

Standard	Standard setting method	Nature of project	Participants	Method of industry participation	Central player	Goal of central player
GSM	Negotiations	Multinational	NTAs/NTOs, industry	Vicarious; later direct	NTA/NTOs	Technical standardization
NMT	Negotiations	Multinational	NTAs/NTOs, industry	Dialog	NTA/NTOs	Service introduction
C-450, RTMS, RC 2000	Tender invitations or assignments	National	NTA/NTO, manufacturer	Direct	Manufacturer	Development of system
TACS	Pre-choose/ Cooperation	Semi-national	Government, NTOs, industry	Direct	..	..

Nevertheless, the GSM process was more than just a scaled-up project of the NMT system; there were differences also due to the changed circumstances. In the case of the NMT, the manufacturing industries were negotiated with one by one in order to get the maximum feedback from them, but this was impossible to repeat with the GSM, because the number of manufacturers had risen considerably by then.[977] The method of negotiation gave the NMT Committee the chance to play against reluctant manufacturers, because there were always

977 Thomas Haug's interview.

some manufacturers willing to fulfill the set requirements. Especially the NMT Committee took advantage of Japanese manufacturers, but in the case of the GSM Japanese manufacturers were not especially invited. Originally within the GSM Committee, the NTAs communicated directly with domestic manufacturers, and the GSM Committee informed only the representatives of manufacturers' associations. Also, the governance of the project was different, because the NMT Committee was in charge from standard setting to the commercial introduction of the service, while the role of the GSM Committee was strictly limited to defining technical specifications. The NMT Committee was eager to govern everything itself, but this was no longer possible to the same extent during the standardization of the NMT-900.

The tactical goals of the projects were also different, because the GSM Committee was forbidden to produce an interim standard, while the NMT Committee first defined the interim system in order to eliminate market pressure. The most vital difference was related to the way the research was conducted. In the case of the NMT Committee, it identified major research undertakings, and delivered them to be carried out by external bodies, or by the participating NTA or the NMT Committee itself. With the GSM Committee, industrial competition was evident and only identification of studies was done jointly, but the implementation of set tasks was done on the national level.

Despite a number of differences, the NMT and GSM as processes were fundamentally alike. It is interesting to identify these similarities, and compare them to other cellular projects, because the shared similarities of successful processes form the general rules of standardization in cellular telephony and are among the prerequisites for success.

The development span of all the first cellular systems, including the NTT[978], the AMPS and the NMT was around ten years (Table 46) and it was during that period that the concept was determined, too.[979] It is especially interesting and noteworthy that, in the case of NMT standardization, the estimation period of ten years was a conscious choice,[980] not just a coincidence due to factors delaying process. The same cycle was later adopted in the mandate given to the Nordic FMK and to mandate of the GSM Committee drafted by the Nordic countries. The fact that an adequate period of time, around ten years, was set aside for the development process can be called Rule #1.

The development of the first cellular systems (AMPS, NTT, NMT) took a long time, because work on the projects was started before the required technology (microprocessors) was available, but on the other hand these systems entered the market early compared to other systems. In Germany (C-450), Italy (RTMS), and France (RC 2000), the development of 1st-generation systems actually started when the first cellular systems were already about to

978 The official name of the first Japanese cellular system was MCS-L1, although usually the acronym NTT is used. The export version of the NEC is known as the NAMTS.
979 Thomas Haug's interview.
980 The Swedes estimated that the development of technology could take around ten years, and this estimation was applied in the mandate given to the NMT Committee.

enter the pre-operational testing, thus entering market too late to become major commercial successes.[981] The only successful analog systems, which were developed in short, time, were the British TACS and the Nordic NMT-900, but

TABLE 46 Standardization schedule of selected cellular systems
Remarks: * = The project launched in 1970, but at first it focused on an interim system; ** = Preliminary discussions started in spring 1982, but the actual standardization work started in January 1983; # = The first report by NTT laboratories appeared in 1967 and efforts were accelerated
Sources: GSM Doc 83/86; NMT Doc 86-1547; Sakamoto 1993 (NTT)

SYSTEM	AMPS	NTT	NMT-450	C-450	RTMS	RC 2000	TACS	NMT-900
Country	United States	Japan	Nordic	Germany	Italy	France	UK	Nordic
Launch of studies	1969	1971 #(1967)	*1972 (1970)	1979	1980	1981	1982	**1982
Launch of operational testing	1979	..	1981	1985	..	..	..	1985
Launch of service	1983	1979	1981	1986	1985	1986	1985	1986
Development period in years	14	8 (12)	9 (11)	7	5	5	3	4

they were modifications of already existing 1st-generation systems, the AMPS and the NMT-450 respectively. The long time spent in creating a standard was not an end in itself, but it was absolutely necessary to identify the right moment to launch system development before the required technology was available. Hence, pinpointing of timing constitutes Rule #2.

It is not enough to adhere to previously mentioned rules unless the launching of the work on the next generation project follows closely on the launching of service for the preceding generation. Consecutive generations had to stick to this Rule #3 in order to have a chance of gaining the early status of a leading standard on the markets. Germany, Italy and France did not succeed in timing the switch-over from pre-cellular (0 G) era to 1st-generation, while the United States dawdled, and Japan cancelled adopting the pre-cellular system. The only exceptions were the Nordic countries, which had perfectly mastered this rule already when switching over from 0 generation to 1st generation, and they continued to apply the same procedure in every subsequent every switch-over of generations. France and Germany adopted this at the launch of development work on the 2nd generation, and in general it was adopted when launching work on 3rd-generation systems (Table 47).

Although the United States and Japan managed to identify the appropriate timing in launching development work on the 1st-generation system, neither could take advantage of its pioneer position and transfer this experience to the next generation. Both countries missed identifying appropriate moment to start development of 2nd generation system, which was

981 Nor was the Japanese NTT (NAMTS) system a great commercial success when using diffusion outside the home market as an indicator.

delayed well beyond the point in time when available technology was feasible to be implemented (1986). This inability became glaringly so when discussions on future land-based mobile systems started on the global level,[982] which was already in 1986, two to three years before the United States and Japan had launched their 2nd-generation (digital) projects. It has been explained that the United States had less need for digital technology than Europe and Japan due to its lower population densities and lower volume of telephony traffic, which would not require a more efficient system in regard to use of frequencies.[983]

TABLE 47 Identification of the development launch of mobile telephony generations

Remarks:

Year — Correct timing of project launch

* = The French RC 2000 system was not originally a cellular system, because it lacked the hand-over function. System launch is not equivalent to commercial launch of service

Sources: seeTABLE 46 Standardization schedule of selected cellular systems

	0 Generation	1st Generation		2nd Generation		3rd Generation
	Launch of preceding Pre-cellular system	Launch of project	Launch of system	Launch of project	Launch of system	Launch of project
Nordic countries	1971	1972 (1970)	1981	1981	1991	1986/1990
Germany	1971	1979	1985	1979		
Italy	1974	1980	1985	-		
France	1976	1981	*1985	1981		
United States	1964	1969	1983	1988	1992	
Japan	-	1971 (1967)	1979	1989	1993	

However, this is an outright misunderstanding, because Europe was not focusing on spectral efficiency,[984] but in the United States and Japan it was a most fundamental issue.[985] Though it is true that the launching of 1st-generation systems was quite modest in the United States and Japan, the market situation itself can not explain everything; in Europe, the need for a 2nd-generation system had been identified on a very wide front already before any cellular

982 ITU IWP 8/13 started work in 1986. It was an ancestor of 3rd generation standardization project of ITU.

983 Funk 1998.

984 Europe emphasized service potential digital system could offer. Spectral efficiency had only a lesser importance, because around mid 1980's it was considered that a digital system could offer efficiency rate of two to one compared to an analog system.

985 In United States and Japan 1st generation systems were designed to densely populated areas, and mobile telephony policy in both countries was based on regionalism. – With 2nd generation radio capacity was the most essential issue as User Performance Requirement (1988) stated in United States: "Radio capacity .. is the single most important item that drives this process in the near-term", see Nurse 1989. Also in Japan spectral efficiency was emphasized, see Nishino 1989.

system became operational in Europe.[986] The requirements of the multinational negotiation process aimed at offering multinational services and roaming seem to form a prerequisite for identifying the appropriate moment to launch a new next-generation project. This constitutes Rule #4.

According to Rule #5, the home market needs to be there already when standardization is launched. All 1st-generation systems, excluding the so-called '1+ generation',[987] were targeted at the home market.[988] Yet there was a difference in the procedure regarding how to go about creating a market, because only the NMT standardization process consisted of several operators.[989] The aim of 2nd-generation systems was to expand the home markets. The GSM Committee had a membership of between eleven and seventeen countries, and right from the beginning it was considered possible that all the CEPT countries (26) might deploy it. After Bellcore showed interest, the GSM Committee kept an open mind in lobbying the GSM system world-wide. Also, an operator association called the CTIA was created in 1984 in the United States and the Canadians were allowed to participate in the work of the standard-setting body TR45.3, which was established at end of 1987.[990]Only in Japan was there no expanding of the operator base (see Table 48).

Rule #6 requires that the standardization process be open to all interested manufacturers and that industrial policy aims be rejected. The development of 1st-generation systems was strictly regulated in Germany, France, Italy and Japan, while in the United States mainly domestic manufacturers participated in developing test networks.[991] The NMT system was a clear exception from the beginning, because manufacturers were informed widely of it and all interested manufacturers were allowed to participate. This openness related to both defining the system and manufacturing of infrastructure and terminals. From the manufacturer point of view, it was not crucial to participate from the

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986 France invited European NTAs for a meeting in the fall of 1980. Digital study projects were started in Nordic countries, France and Germany already before establishing of the GSM Committee. Nordic FMK Committee was actually a standard setting body, not just s study project.

987 TACS and NMT-900 could be classified as 1+ generation, because both were improved modifications of AMPS and NMT-450 systems. From European perspective they differed from other systems adopted in Europe, because both operated on 900 MHz band.

988 AMPS was designed to operate on 900 MHz band, which was only nationally allocated for mobile telephony. It was not until WARC 79, when the mentioned band was allocated for mobile telephony in ITU Region 2 (America). NMT operated on 450 MHz band, which in principle was allocated for mobile telephony in all regions, but it was not originally aimed for export.

989 In the United States there were three licenses for experimental networks. Each of them had only one operator (or dual role operator-manufacturer).

990 Nurse 1989; CTIA (Cellular Telecommunications Industry Association)

991 In 1970, the FCC invited industry to respond with specific proposals on how to build a practical cellular system, but Bell Labs was the only organization to submit a proposal by the deadline of December 1971. In 1974, the FCC invited applications for developmental authorizations for trial installations. The first license for a test network was given to Illinois Bell, which selected the companies E.F. Johnsson and the Japanese OKI to develop a terminal. The second license was given to a subsidiary of Motorola, while the third one went to Millicom Services. See Garrard 1998.

TABLE 48 Selected features of standardization of 2nd-generation cellular systems in Europe, in the United States and in Japan

Sources: GSM Documents (GSM); Nurse 1989; Scimmel 1991 (United States); Nishino 1989; Tachikawa 1991; Nakajima 1993; Bekkers and Smits 1999 (Japan)

Standardization process of 2nd-generation cellular system	Regional distribution of:		
	Participating operators	Manufacturers	Time schedule defined by
Europe (GSM)	European; later all interested	European; later global	Estimated demand
United States	North-American	North-American + Japanese + Ericsson	Market pressure
Japan	NTT	Japanese + Motorola and AT&T + Ericsson	Market pressure

beginning, but to be involved to the full when the development of equipment was about to start, as both the NMT (Mobira-Nokia) and the GSM (Motorola) experience had showed. The 2nd generation clearly adopted the lessons of the previous generation, since Europe, the United States and Japan allowed foreign manufacturers to participate. The development of the GSM system differed from the 2G projects of the United States and Japan in that the participation of non-domestic manufacturers was enabled on a far wider basis.

According Rule #7, regulatory measures, especially those relating to prerequisites, had to support the implementation of the standard. Frequencies have a vital dual importance. First of all, it is important how, or actually when, a frequency band is chosen and allocated. In Europe and Japan, the frequencies for 1st-generation systems were the corresponding definitions of the ITU for Region 1 (Europe and Africa) and Region 3 (Asia-Pacific) respectively. In the United States, the band was defined only nationally, and it took up until WARC 1979 when the band was reserved for mobile telephony in Region 2 (Americas).[992] Clearing a band is not a rapid process, and this may have had an impact on the diffusion of the AMPS.[993] The development of the European systems belonging to the 1+ generations (TACS, NMT-900) using the 900 MHz band started after WARC 1979, and they became operational in early 1985 and late 1986 respectively. The early diffusion of both systems focused on Region 1 (Europe-Africa).[994] Another relevance connected to frequencies involved the plan of action for new-generation systems. In Europe, Japan and United States, a new band was reserved for the 1st-generation systems, and the same was repeated in Europe and Japan when moving over to the 2nd generation.[995] In

992 See Ebel and McNaughten 1981, Borman, Dorian, Johnson and Miller 1981.

993 During the first four years (1983-1986), the AMPS system was adopted (networks became operational) in seven countries, and of these only the United States, Canada and the Virgin Islands belonged to Region 2, while Korea, Hong Kong and Australia represented Region 3, where this band had already been previously allocated for mobile use. Israel belonged to Region 1.

994 During the first four years (1985-1988), the TACS was adopted by five countries, and all except one belonged to Region 1, while during its first four years (1986-1989), the NMT-900 was adopted by eight countries, which belonged to Region 1.

995 In Japan, a totally new set of frequencies was reserved, while in Europe the band was

the United States, the bands of 1G and 2G were equal, and the transition to 2G was far slower than in Europe or in Japan.

In addition to frequencies, regulation of the market environment is another foremost issue. It is not merely a question of liberalization itself,[996] but its timing and impact on the industries' structure. Both the United States and the United Kingdom liberalized the operator market for 1G by introducing duopolies, but the principal aim was different. In United States the focus was on breaking up AT&T, which lead to tens of regional operators, without having infrastructure covering hole country.[997] In the United Kingdom, the service providers bore the main burden of competition, while network operators were obliged to provide country-wide service.[998] The timing of liberalization is important; this had been demonstrated by the GSM experience. In Europe, there was no uniform liberalization policy, but countries introducing new competing operators were eager to launch real commercial operation, while other countries dawdled. The liberalization of the terminal market had also had a clear impact on both the popularity of the system and on the manufacturers. As was indicated by the NMT experience, the system itself was not an adequate precondition for success, but instead the environment created by regulation.[999] In the case of Japan, the monopolist operator had also a monopoly over terminals[1000], and could thus control manufacturers and restrict the development of user habits.

Rule #8 states that the standardization process requires adopting of new procedures as the circumstances change, learning from the experiences with the previous generation, and passing on of knowledge and experience to next-generation projects. The primary goal is not to establish new institutions, but to adopt appropriate procedures.[1001]

According to Rule #9, mobile telephony had to respond to societal changes. The 1st-generation NMT system reflected the Nordic countries' countermove to the proposed deepening of European integration although there was no direct connection between the standardization process and

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defined to partitions of 1+ and 2G, although a gap was available for 2G. In the Nordic countries (excluding Finland) an equal switching-over method was implemented when moving on from 0G to 1G.

996 The United Kingdom liberalized the operator market (or more exactly a duopoly was established there) for 1G, but the Nordic countries were able to achieve far better penetration rates through combined cooperation and monopoly structure.

997 See Calhoun 1988.

998 See Garrard 1998.

999 The Nordic countries liberalized their terminal markets, while the Netherlands and Belgium retained monopoly on ownership.

1000 Sakamoto 1993.

1001 For example, the Cellular Telecommunications Industry Association (CTIA) was established in the United States as an open forum for operators already back in 1984, but it took until September 1987 until the CTIA implemented the first measures towards launching the development of the digital standard. In Europe, old-fashioned NTAs and the CEPT organization identified the need for the digital standard and carried out work up until the spring of 1989. At that time, with the GSM Committee being transferred under the new open organization the ETSI, which was established in early 1988, the working procedures of the GSM Committee had been modified already before this transfer, which was merely an organizational change.

political decision makers. 2nd-generation GSM reflected increased European cooperation in information technology, although there was no direct connection with it, and the GSM system coincided with the movement for European integration, which even surpassed the goals of creating the Single Market. It is hardly a mere coincidence that discussions with the ITU related to future systems and talks on launching global business were begun at about the same time.

Rule #10 implies that the standardization of new generations becomes increasingly more complex, and is most likely going to require more time than before for a system based on new technology to be established, unless the globalization trend is disrupted. However, but this requires basic changes in the concepts of national state and world economy.

Some standards not fulfilling the requirements of above rules have become commercial success, but they have not managed the switch-over from one technology generation to the next. It is rather shortsighted to evaluate a standard's degree of success as if it would not have an impact on the subsequent technology generation. As a matter fact, to date only the NMT systems have fulfilled the requirements of all the ten rules. Moreover, the GSM system has fulfilled most of them, but the switch-over to 3G (UMTS) has not yet taken place, and there are uncertainties created by regulatory measures. But for as long as mobile communication requires installed infrastructure and uses radio frequencies, it is most likely that these basic rules will hold in the future as well.

3.3.2 Specific factors explaining the success of the GSM standard-setting process

The basic rules of standardizing cellular telephony constituted unavoidable presuppositions for the success of the GSM system. In addition to them, there were factors related specifically to the standard-setting process of the GSM system. GSM standardization has been explained based on the path-dependency theory. According to Cattaneo, the fundamental driving forces involved in GSM development were the historical process, motivations, and the roles of they key actors. The fundamental key success factors of the GSM were defined as follows:[1002]

- A strategic vision of allocation of frequencies to mobile systems; in the European perspective this having taken place starting in 1979.
- The existence of a group of champions of the GSM concept, the international team forming the core of the GSM Group.
- The ability of a relatively small group of actors (the TOs of the main countries) to make the crucial decisions for the take-off of the system, by committing themselves and creating a critical mass of consensus towards its implementation.

[1002] Cattaneo 1994.

- The manner of implementation: no single international network, but nationally compatible systems.
- Common perception of a strong demand.
- Correct timing: before investments in diverging technologies, with key decisions close enough to provide positive feedback and expectation of success.

This kind of list of factors explains only certain aspects related to some players and selected points in time of the process, and some of above factors are highly contentious.[1003] Although the above factors explain partly the outcome of standardization, they tell very little about the standardization process itself. The reason for this lies in the interpretation of the historical process, which is seen as a string of selected highlights, which brought something fundamental into the development of the GSM system. Due to this, post-1985 years of actions becoming more visible is heavily emphasized. Also, the interpretation of the roles of the key players is approached from the point of view of outcomes, not of the process, which leads to all fundamental players having had convergent goals and acting in concert.

When the GSM standardization is considered from the process point of view, the focus is different. The process was not a collection of event, but instead it consisted of clearly identifiable functional phases, partly overlapping. The shift from one phase to another was possible only when circumstances to proceed prevailed. These phases may be identified as:

- 1979 WARC (launching of preparatory actions)
- Exploring forms of cooperation in 1980-1982
- Organized cooperation (Discussion: goals and feasibility) 1982-1985
- Choices 1985-1987
- Preparations for and ensuring implementation 1987-1991
- Implementation from 1991 onwards

The above phases consisted of decisions, which made the process to continue in line with the set goals. These decisions, which are presented on Table 49 can not actually be placed in order of preference, because they were equally important for the progress of the process. Yet some decisions were more important than others, because the most fundamental decisions involved aspirations, which would have steered the GSM Committee to a sidetrack had they succeeded. These were as follows:

- Neglecting to follow the schedule put in disorder by CCH

[1003] Factor # 3 relates to the Quadriparty. It was important while creating political pressure, but establishing the MoU organization to ensure the implementation of the GSM was not difficult. It was far more important to have a small group of countries willing to pledge themeselves to the development of the GSM system by offering resources, transferring experience, and carrying out research, which was further exploited. Factor # 5 is highly relative, because the assessments compared to the NMT experience were quite modest, even though compared to pre-cellular era the expectations were high. Factor # 6 is only partly acceptable. The timing was correct, but investment in "diverging technologies" (if it means development of TACS and NMT-900 systems) gave positive feedback to the GSM project. Once the method of dividing the 900 MHz band had been approved, these systems did not severely compete with the GSM project.

- Rejecting the intentions of the EC to introduce the GSM system in 1988 and possible take-over of the GSM standardization
- Avoiding the Franco-German industrial policy's intentions (to turn the GSM project into normal industrial cooperation such as prevailed earlier in the EEC countries)

The standard-setting process can be also divided into three major passage points, which had to be cleared successfully in order to successfully conclude the set task. The first was to create critical mass. Only a small number of countries were really active in giving resources and carrying out research and development.[1004] These countries were willing to invest in the GSM system. On the other hand, this group was bigger than in earlier cellular projects, and it was able to provide a large enough base for a new standard. However, the potential market was in fact far bigger if one takes into account the number of less active countries. It was quite obvious that existing and planned cellular systems gave positive feedback on the activities of the participating countries, because both groups were nearly equal.[1005] The second point was in setting the standard (or defining the basic parameters and choosing the techniques). Setting the quantity of the criterion resolved the task, and basic standard was chosen in accordance with them.[1006] The benefit in selecting the criterion lay in that they paid attention to cost and complexity factors, which lead to selecting of sufficiently sophisticated technology, but still such as could in time be realized both technically and economically. In short, such a standard was selected as could be accepted by all the countries involved. The third point relates to ensuring the implementation of the GSM system as the GSM Committee was not responsible for it. Politically influential industrial countries (i.e. the Quadriparty) launched measures to ensure the implementation of the standard although the proposed standard was not in line with the national interests of France and Germany.

The foremost precondition for the progress of the standard-setting process was the acceptance of the decisions made. As with the choice of the radio-access

[1004] The Nordic countries, the United Kingdom, France, Germany, the Netherlands and Italy.

[1005] If the above mentioned group of most active countries is enlarged by including in it countries giving resources to the Working Parties (i.e. Austria and Switzerland) it is nearly equal to the group, which was active in cellular telephony in general. Only Spain is missing from the former group of countries active in the GSM Committee. Belgium and the Netherlands were relatively early adopters of cellular telephony, but they were not active in the GSM Committee.

[1006] It has been stated (by Garrard 1998, 129) that the final agreement owed as much or more to political compromise as to "engineering assessment". However, if this claim refers to only one feature, capacity, it is true that the most efficient method was not chosen. But the set criteria took into consideration many other features as well, and the basic choice (of radio access) was done in accordance with set criteria. There is no doubt about this. Another question is that certainly there were many discussions, but they did not have great influence. The political compromise referred to relates to the modulation method, which was clearly changed at the request of politicians (Ministers of the Quadriparty), but this did not have a fundamental impact on the standard. It would be much more relevant to claim that the criteria themselves included compromises, because the requirements were contradictionary.

TABLE 49 Fundamental decisions of the GSM-standardization process
Note: PTT is equivalent to NTA
Source: Chapter 3 Elaboration of the GSM standard

DECISION	PRESUPPOSITION OR CONSEQUENCE	ACTIVE PARTY
Reservation of frequencies from 900 MHz for mobile communications	WARC 79	CEPT, NTAs
Establishing Nordic FMK committee	Future demand and interest shown by European countries. Knowledge and physical competence transfer from NMT committee	Nordic Radio Committee, NMT Committee
Introducing an idea of common Pan-European mobile telephone system	Possibility to exploit released 900 MHz band	French PTT (NTA)
Establishing GSM committee within CEPT	Risk to loose possibility to use frequencies for common system	Dutch PTT backed by Nordic PTs
Realistic setting of goals (particularly time span)	NMT experience	Nordic PTTs in cooperation with Dutch PT
Neglecting restriction set by CCH	Time span set by CCH was impossible	GSM Committee
Partition of 900 MHz band between interim (early) systems and future GSM	Early analog systems on 900 band could not be avoided	UK initiative supported by GSM and approved by CEPT
Organizing transformation of digital studies to evaluate possible technologies	At least part of studies already existed	NTA/NTOs, COST
Joint Franco-German digital study project	Early analog systems on 900 band could not be avoided	Political level: Ministers; GSM: Franco-German delegates; Industrialization: manufacturers
Rejecting proposal to create standard on USA-Europe level	Schedule could not be synchronized	GSM Committee
Interception of EC intention to accelerate finalizing specifications by two years	Unrealistic goal. Did not even fit the goal of recent Franco-German industrial policy goal	Unanimity of GSM Committee
Establishing steady sub-committees for GSM	The second proposal of GSM was accepted, because it took advantage of EC's proposal to prune schedule	GSM Committee
Preservation of national decision making	Balance could be maintained	GSM Committee
Setting criteria to evaluate competing techniques (avoiding too complex technology)	Fair evaluation	GSM Committee
Denial of proprietary technology (no IPRs without licensing)	Kept standardization process	CEPT, GSM Committee
Evaluating "broad avenues" insted of specific candidate of manufacturers/NTA for Radio access	Selected method was acceptable to all	GSM Committee

TABLE 49 continues

Optimization of the most promising technologies	Securing development work	GSM Committee
Permenent Nucleus as an essential tool instead of industrial policy theatre	Rejecting EC's threat	GSM Committee
At Madrid meeting GSM proceeded based on working assuption even there was no formal unanimity	The chosen technology was acceptable by all participants	GSM Committee
Allowing manufacturers to participate directly	Telecommission of CEPT turned positive to idea	EC; GSM (timing)
4Q (France, Germany, Italy, UK) ministers pressured France to accept decisions of Madeira meeting	Made true European standard possible	Particularly UK and Germany
MoU was established to give manufacturers an incentive to start developing equipment for GSM	Positive signal	Various
Distribution of work between GSM and MoU without reciprocal struggle	Mainly same participants in both bodies	GSM; NTAs
EC's activity to ensure start of GSM	Role changed from competitor to supporter	EC
Partition of Recommendations to two phases		GSM Committee

method, the GSM Committee reduced the possible methods to four (FDMA; narrow- and wide-band TDMA; and CDMA with slow frequency hopping),[1007] which provided sufficient alternatives, but at the same kept the evaluation on a reasonable level. All the participants were pleased with the situation, although some suggested methods were excluded from this list.[1008] Once the most appropriate method had been chosen, nobody diverged and went on alone with its own proposals as had happened in the United States. The most probable reason for why the GSM Committee was able to maintain unanimity after the difficult decision was in the nature of the standard-setting process. Unlike in the United States, Europe had a variety of players, not just manufacturers and operators. These players had specific statuses and roles, which enabled the forming of blocs.

The fundamental players had specific roles, which took shape during the process. The European Community created positive expectations by approving the Single Market Act and by synchronizing the EFTA countries through economic integration. The CEPT offered broad organizational support in the form of Technical Committees, and it was ultimately prepared to bend some of its stiff rules. After the ETSI replaced the CEPT as the standardization forum, it made development of the GSM system after Phase 1 easier and speedier. The

[1007] GSM Doc 39/84.

[1008] At least some of the Nordic countries preferred the Time Division Duplex, but it was not accepted as an alternative. See the GSM # 6; the GSM Doc 64/84, 65/84.

National Governments of the Quadriparty supported the creating of a pan-European service in place of industrial policy goals, and later they actually created a market for equipment suppliers by deciding how to regulate the GSM operator market. National Tele-Administrations/National Tele-Operators bore the burden by awarding resources exclusively during more than four of first years of the project, and they also carried out formidable research. Manufacturers applied their insuperable knowledge in commercializing the GSM system by developing equipment and investing in further development of the standard. The GSM Committee did not just make specifications as it also had a formidable role in intercepting undesirable aspirations. I was of fundamental importance in synchronizing the changes of procedures to respond to the needs of the current situation on the standardization process. Although users did not initially have an active role, they were able to provide positive feedback on the development of the services and equipment once the GSM standard become operational.

There are grounds for considering certain countries to have had specific roles, because they clearly had visible impacts on the process. The Netherlands launched important initiatives (establishing the GSM and offering to host the Permanent Nucleus). The Nordic countries brought in their experience, which they had gained in NMT standardization. The Franco-German alliance of cooperation accelerated the input on radio-access prototypes. The United Kingdom was a source of proposals[1009] and also a pointer against political pressure. It seems that Italy, although there is no direct evidence for this, was a spokesman for a truly pan-European system in place of Franco-German aspirations.

The aims of the players were not in line with the goals of the GSM Committee. The role-play players tried to exert their impact and even control the standardization process. The contradiction of goals led to conflict situations, which (after being resolved) led to the goals being made parallel. Resolving of conflicts would not have been possible had not the the GSM Committee taken a clear stand to resist the pressure, and while doing so it rejected its normal role as the Technical Committee responsible for defining specifications and adopted an active role in interpreting the needs of the process. On the other hand, as most severe occasions of pressure were political by nature, the GSM Committee would not have managed by itself. It needed the support of other players with political influence. This mechanism turned the Franco-German cooperation into a force counterbalancing that of the EC, which tried to take over the GSM project. National Governments, first that of Italy and a year later that of the United Kingdom, allied with France and Germany in creating the Quadriparty. These actions relegated the EC to secondary role as a plain supporter of the policy outlined by National Governments. But after the Quadriparty had been formed, the substance of the alliance changed, as it then aimed to ensure the

[1009] Including settling a method for exploiting of the 900 MHz band, emphasizing the complexity factor as one of the selection criteria, introducing the PCN concept, and proposing the transfer of the work on 3G (UMTS) to the GSM Committee.

implementation of the GSM System, and France and Germany were no longer able to promote their industrial policy goal.

3.3.3 Commercial success of the GSM system

3.3.3.1 Selected explanations

3.3.3.1.1 Monolith explanations

It would be tempting to adopt the view that the GSM system became widely adopted, because it was the "formal standard" accepted by a recognized standardization body (the ETSI), and made mandatory by directives of the EC.[1010] It has been claimed that EC regulations made the choosing of a non-European standard impossible.[1011] If this claim relates to the digital system, the argument is acceptable, but also theoretical, because there were no competitors when the first contracts for the GSM networks were entered into. But the fundamental question is that of how the GSM system managed to respond to the needs of the market, because most European countries were not legally obligated to choose the GSM system. Before the end of 1994, GSM networks had been launched for commercial service in twenty-two countries, of which eleven were not members of the EC, and seven of the non-EC countries were not even EFTA countries.[1012] In practice, EC could not legally force anyone to adopt the GSM system. As has already been stated in Chapter 3.2.3.1.1, adopting of the GSM system was clearly market driven, because in 1992 GSM networks were launched commercially in those countries, which had introduced new competing operators. And the GSM system was not facing competition from American or Japanese 2G systems, but instead from existing analog systems (+1G systems on the 900 MHz band). These facts clearly show that the success of the GSM system could not be entirely explained by the substance of the standard's "patron".

As the GSM system represented a new technological generation, it would be logical to choose an explanation highlighting its technological superiority. It is paradoxical that a research report, glaringly over-emphasizing the role of EC,

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1010 Bekkers and Liotard 1999. These authors defined "formal standards", produced by certified standardization bodies, and "market standards" (including de facto, proprietary, sponsored, etc), which are truly voluntary in use. Bekkers 2001 do not any more approve that the "mandatory nature"was the most essential suucces factor of GSM.

1011 Bekkers and Liotard 1999. But contrary to the claims of these authors, the Council Directive 87/372 did not make impossible the use standards other than the GSM on the 900 MHz (CEPT) band, because the lower end of the band could be used by analog systems, and the said directive did not define any definite expiry date for this application.

1012 The non-EC countries were Finland, Sweden, Switzerland and Austria. The non-EFTA countries were Hungary, Russia, Turkey, Iceland and Australia. The non-European countries were Hong Kong and New Zealand. All in all, twenty-eight countries (nineteen being Western European countries) had launched their GSM networks before the end of 1984, but many Western European countries did not initially launch a real commercial service.

should find five major factors for explaining why the GSM system became the de facto standard, and none of them of the five is related to the actions of the EC. The proposed factors are as follows:[1013]

- Technical advantages, e.g. wide and growing range of advanced features
- High system capacity
- High voice quality
- Capacity for future integration with fixed networks
- Early identification of services to be progressively implemented

The selected factors clearly focused on technological dimensions, but this approach is hardly acceptable. Factors #1 to #4 can be accepted only if the GSM system is compared to analog systems. If other digital systems form the frame of comparison, then explanation #2 is not valid at all, and explanations #1 and #3 and #4 only in part. It seems that the compilers of the said report themselves noticed the hollowness of their argument,[1014] because it was stated that perhaps the most significant factor favoring the GSM system has been the scale of its introduction and the subsequent impacts on production volumes and roaming capabilities.

In regard to the technology axis, there is the opposite end emphasizing that the features of the GSM system did not contribute to the achieved success at all, and that instead the explanation lay in the incoherence of the standards in the United States.[1015] This is quite a narrow-in-scope way of thinking, because it also totally neglects the existence of the Japanese digital standard, which was earlier implemented commercially on a scale larger than its American counterparts.

3.3.3.1.2 Component analysis

Instead of disconnected explanations, analyzing the structural factors related to the standardization process would be far more sophisticated as an approach. In addition to this, there have been attempts to analyze three different means of digital mobile communication: cellular GSM, ERMES paging, and DECT cordless telephone.[1016] The selected factors include the following:

- Industry support
- Market demand
- Time to market
- Standardization
- Technical capabilities
- Technical constraints
- Licensing, and
- Political support.

[1013] Single Market Review 1997.
[1014] Single Market Review 1997.
[1015] Garrard 1998.
[1016] IDATE – EGIS 1998. The EU also sponsored this marketing study.

Since all the mentioned standards are surveyed in relation to the same factors, this approach should reveal the factors fundamental to ensuring success. But the model has a basic imperfection. Firstly, only the GSM system was analyzed in regard to all eight factors, ERMES in regard to six, and DECT in regard to seven factors. This leads to biased conclusions, particularly since the factor of political support was left aside, although EC gave political support to both ERMES and DECT in the form of directives just like it did during the GSM process.

Secondly, this interpretation is not only imperfect but misleading as well, as can be seen from Table 50, which shows the success factors of the GSM and ERMES systems.[1017] Three factors related to the GSM system were at least in part interpreted too optimistically, while one other factor (in addition to the missing political factor) related to the ERMES system could be called into question.

The main dilemma is not related just to the biased outcome of interpretation, but to the interpretation method itself. The basic shortcoming is caused by the attempt to analyze the standards imagining them to be in a static state without changes and causes behind the changes during the standardization process. This method creates an image of the standard having been a success or a failure already when it is born, because the players involved would not change their minds. But in reality, the factors are related to each other, and what we have is a dynamic state due to the interaction of players. For example, it has been claimed that the commercial launching of ERMES was slow, because there were delays in issuing licenses, lack of paging receivers, reluctance of operators to launch a service in uncertain market conditions when there was available capacity in many existing networks, and potential interference with television and radio transmissions.[1018] But all allegations, except the last one, were valid during the commercial launch of the GSM system. And still it became a success.

Analysis based on the static "component" can not exhaustively explain the success of standard, because it does not take into consideration the point that the players in the standardization process (operators, manufacturers, etc.) make their decisions on a rational basis, and their decisions reflect on the decisions of other players. The ERMES case provides a suitable example for shedding light on the reasons behind the change in attitude among the "factors" (players). Unlike the claim presented in the research undertaking in question (IDATE – EGIS), ERMES initially received quite strong support from operators in a form of signing of the MoU. It was, in fact, on equal basis with the GSM system.

1017 Here only the factors involved in the GSM and ERMES systems are presented parallel in order to simplify their analysis and because traditionally paging and mobile telephone have been seen as substitutes for each other, at least to some extent.

1018 Profile 1995.

TABLE 50 Success factors of GSM and ERMES systems according to IDATE – EGIS
Legend: Grey backround = Disadvantage (according IDATE- EGIS); **Bold text =** Interpretation of IDATE- EGIS not acceptable
Sources: IDATE – EGIS 1998; Criticism of ERMES is based on information provided by Profile 1993 and 1995

CRITERION	GSM	ERMES	QRITICISM
Industry support	Large and co-ordinated action through the GSM MoU for operators; broad involvement of equipment manufacturers in the standardization process, driven by ETSI, to build a common standard.	Less active MoU organization. Very few manufacturers developed products. NEC has been the only one for a long time. Now 10 suppliers manufacture pagers and 6 infrastructure	ERMES MoU was signed on January 1st 1990 by 8 countries and 7 more afret a couple of months, while GSM had initially 15 signatories (14 were operators) from 13 countries.
Market demand	Strong from end users Global pull and support from European operators.	Slow growth and small market installed base in Europe (5% of world-wide). Limited investment from EU operators.	Initially demand for GSM was weak except in Germany which did not had "interim" analog system working on 900 Mhz band.
Time to market	In line with market demand and ahead of competing technologies.	Late in the market already largely dominated by analogue systems, and FLEX outside Europe.	GSM was not inline with market demand, because analog terminals were much more tempting (before prize and size of GSM hand-phones could be lowered)
Standardi-sation	As open as possible leading to a real competitive market, and high manufacturer investments.	..	Standardization of ERMES started in 1987, which was too late.
Technical capabilities	Robust end to end technical solution, with extensive capabilities (international roaming; intelligent networks) and designed to evolve as a backbone for future networks.	Enhanced performance and capabilities compared to analogue and Flex systems.	
Technical constraints	Limited in terms of network capacity at the radio interface level.	Less flexibility than FLEX in terms of possible configurations. No two way paging.	
Licensing	Early, on a wide geographical scale to open large potential market. At least 2 licences had to be awarded to stimulate competition in each country.	No harmonisation of frequencies at world-wide level.	GSM: Initially there were actually two operetors only in six countries, which started commercial operation in 1992
Political support	Clear and strong political goal to create a common standard and a unified market, at least within the European Union.	..	EC gave political support to ERMES by launching Directives (comparable to GSM)

Afterwards it became obvious that operators changed their minds.[1019] As has been observed earlier, the MoU was basically only a manifestation of good will , not an actual commitment to launch early commercial operation; this was just like the GSM experience, too, had shown. The reason behind the change was simple. The actions of the operators and manufacturers are based on evaluating possibilities of system if there is no external threat (e.g. competition) to change the rationale of actions. In the ERMES case, it can be readily seen that the ERMES did not have a real chance of becoming a success; it could not provide a major benefit compared to what the competitors offered:

- Competing paging systems were economically more attractive (as shown by IDATE – EGIS study)
- Paging, in general, was a receding means of mobile communications in Europe (compared to cellular telephony). On the largest paging markets of Europe, cellular telephony surpassed paging at the end of 1989 and early 1990 (except in the Netherlands, see Table 51)
- The GSM system became competitive when the SMS (text messages) function became available; it provided a service similar to that of paging, but implemented in a two-way direction, unlike in the ERMES.

The above example shows that a standard needs to have real substance supported in parallel in concert, and that artificial measures such as directives and the MoU commitment are not adequate to ensure success. This implies that the time dimension and dynamics cannot be disregarded.

3.3.3.1.3 Diffusion patterns

There have been attempts to explain the success of cellular systems by applying the world-wide standard approach, which came in two versions. Both versions include early installation of base and the openness of the standard as prerequisites for success. The first approach links the origins of successful countries or regions with firms,[1020] and the second one focuses on the effect of National Governments on the emergence of world-wide standards by committee and market mechanisms.[1021]

The first approach is based on the concept of a domestic standard. It argues that the success of firms is powerfully related to the evolution of standards. According to it, the most successful firms in each generation of technology are based in countries or regions whose mobile communication systems become world-wide standards. Only a few firms have been able to succeed with a 'non-domestic standard', meaning a standard not adopted at an

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[1019] According to the ERMES MoU, signed on 1st f January 1990, limited operation was to begin in January 1993. In October 1995 the number of signatorues had risen to thirty-seven (representing twenty-two countries, of which two were from outside Europe). The first operator launched its network in October 1994 (France). In 1995, only four networks were opened (two in France and two in Hungary); see Profile 1995.

[1020] Funk 1998.

[1021] Funk and Methe 2001.

TABLE 51 Number of paging subscribers (x1000) on the five largest markets of Europe
Remarks: Selection year of largest markets is 1994. The figures for the Netherlands for 1988 are from 1989 and those for Sweden for 1996 are from 1995. * = author's estimation.
Sources: ITU YSTS 1988-1997

	1988	1990	1992	1994	1996	Surpassed by cellular telephony
United Kingdom	575	640	716	800	1125	1989
Germany	172	269	414	551	1076	1990
Netherlands	206	256	350	421	644	1995
France	132	242	294	304	987	1990
Sweden	..	122	126	249	120	mid-1980s*

early stage in the firm's home country. Since the country or region serving as the source of world-wide standards has changed each time the technology has changed, only a few firms (i.e. Ericsson, Motorola, and Nokia) have had a large degree of success in more than one generation of technology.[1022]

The above attempt belongs to a common group of on/off approaches, which gives neat results by forgetting unpleasant facts, because it picks the zenith of standard as the point in time of observation. For example, the claim is made that Japanese firms did not manufacture terminals for the AMPS and TACS systems, or terminals and infrastructure for the NMT system, or terminals for the GSM system, which helps in constructing a uniform picture.[1023] But Japanese manufacturers were involved in all the above standards. In actual fact, the 1980s were a period of time when Mitsubishi, NEC and Panasonic manufactured terminals for a number of systems (NTT, NMT, AMPS and TACS), while Toshiba and Oki focused on AMPS-TACS. The product ranges of Motorola and Mobira (Nokia) included all the mentioned standards plus the French RC 2000 and the German C-450, while Alcatel focused on the domestic system and the C-450, and Siemens on the domestic system and the NMT. Philips manufactured NMT and C-450 terminals, and Ericsson only NMT terminals. This clearly shows that the firms selected their standards, and most successful firms had a wide product range.[1024] The firms were not involuntary armor-bearers of their home countries or regions.[1025] The selection of a standard by a particular firm's home country was not an automatic lottery prize for the firm in question. It was quite logical for a firm to manufacture products for the home market, but there was no straightforward mechanism of success. The "Dutch"[1026] Philips did not have (limited) success[1027]

[1022] Funk 1998. This approach does not explain why certain manufacturers became successful despite technologies changing.
[1023] See Funk 1998, Table 3.
[1024] Pulkkinen 1997.
[1025] Despite the Nordic example, NTAs had to provide incentives a couple of time to retain the interest of manufacturers.
[1026] It is somewhat inappropriate to classify Philips as a Dutch company, because it was clearly a multinational corporation. In the mid-1980s, the telecom sector of Philips was re-organized and mobile telephony was concentrated on the German subsidiary (PKI).

with the NMT simply because the Netherlands was an early adopter of the system. Philips had been involved in NMT manufacturing for several years before the Netherlands made its a decision to buy the NMT system.

Although it is clear that firms acquired significant competitive advantages when their home countries created a system, which eventually became a world-wide standard,[1028] the relationship is not a passive one of the standard-setting country and the firm. In order to clarify this relationship, it would be necessary to replace the concept of domestic standard by the dual concept of domestic market and market choice. Particularly in the early 1980s, domestic markets were very important, because the scale of the world-wide market was still small. For the suppliers of infrastructure, the NMT was the only possibility before the launch of the AMPS and the TACS.[1029] Yet initially only three Japanese, one German (TeKaDe)[1030], one Israeli, and three Nordic firms were interested in manufacturing base-stations. Motorola submitted its bid after the tender bid was expired. The bids clearly demonstrated that only the Nordic manufacturers and Mitsubishi, which was only Japanese manufacturer with facilities in Europe, were willing to make attractive bids.[1031] The Nordic firms were willing to keep their hold on the domestic markets, although they did not have the advantages of series production and previous experience in cellular technology, which the Japanese had.[1032] It is quite obvious that the manufacturers were not able to see the trend of expansion in the switch-over from the pre-cellular era to the cellular era. The domestic market in Japan was limited, because it consisted originally of two city networks, which may have had an impact on the miscalculation of the Japanese manufacturers.[1033] It is extremely likely that Japanese terminal manufacturers were aiming for the huge potential markets of the United States, which kept the opening of networks to commercial service waiting for years. But at the end of 1985 half a dozen or so Japanese manufacturers[1034] had taken over half of the United States' terminal markets.[1035]

It has been explained that certain firms, referring particularly to Motorola, Ericsson and Nokia, became most successful because they were export oriented.[1036] This is true from the result point of view, but it does not explain why they became export oriented. All the said companies focused on mobile communications and cellular technology very early in the piece. Motorola had

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1027 Funk classified success as "low".

1028 Funk 1998.

1029 The NTT was a closed standard (both terminals and infrastructure), the C-450 and the RC 2000 were closed as regards infrastructure, and the RTMS was practically closed regarding both infrastructure and terminals.

1030 Multinational ”Dutch” Philips owned TeKaDe.

1031 Mitsubishi had a grip on the Nordic market (excluding Finland) already before the NMT, because it manufactured base stations for the manual MTD system.

1032 See Chapter 2.2.3.2.5.

1033 In August 1983 there were only 97 base-stations in Japan compared to 381 in Nordic countries.

1034 Ross 1986.

1035 Also in United States, the share of Japanese manufacturers of infrastructure was modest.

1036 West and Fomin 2001.

gone global already before the cellular era. It had invested in the development of the AMPS system, which was launched behind schedule, and when commercial service ultimately began its popularity remained well below expectations.[1037] Motorola did not have success on the domestic AMPS terminal market in the mid-1980s, which is noteworthy because it was the biggest worldwide terminal manufacturer for at least thirteen years, as well as being the biggest supplier of infrastructure for the domestic markets.[1038] Like Motorola, Ericsson and Nokia, or more precisely certain parts of these firms, focused on mobile communications, and they had to export if they were to grow. Ericsson concentrated on infrastructure, while Nokia's strength lay in terminals. Most probably, both firms were drawn to mobile communications, because their subsidiaries in charge of the radio sector were not closely and directly incorporated in the parent-consolidated corporation. Both companies operated on the domestic markets, which was highly competed, and they started to create mass and competence in order to respond to the challenge of the NMT system.[1039]

The above examples show the importance of the domestic markets and of market choice. During the switch-over from 1G to 2G, the choices the manufacturers had to made were even more difficult than earlier, because it was not just a matter of selection of focus on the main standard, but also one of a technological leap from one generation to the next. As stated earlier, Europe, the United States and Japan were destined to open their systems almost simultaneously, with Europe in 1991 and the others in 1992. The concurrent increase in demand for analog systems was relevant to all these three major markets, but it seems that European manufacturers suffered less from what turned out to be the last death throes of a disappearing technological generation. Although three countries introduced TACS networks only a couple a years before the GSM network was proposed to begin operation, and the operators in the United Kingdom, which was the largest European market, invested heavily in the TACS, this did not have a fundamentally counterproductive impact on the European manufacturers. The reason for this is logical; in this situation, the TACS was only a response to the current demand, and manufacturers were heading for the GSM. Although this late wave introduced some new entrants to he manufacturing industries, they merely gained competence by licensing the required technology, and made use of the experience gained in manufacturing equipment for the GSM system.[1040]

In the United States, the situation during the switch-over to the 2nd generation was a complex one, because the United States was the world's largest market. At first the North American manufacturers had no reason to

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[1037] See Calhoun 1988.

[1038] Ross 1986; Refers to the end of 1985. Motorola was the 3rd biggest terminal manufacturer on the United States' AMPS market.

[1039] Ericsson chose a strategy of merges, and Nokia established joint ventures, see Chapter 2.3.3.2.

[1040] Orbitel in the United Kingdom, and Italtel and Telettra in Italy acquired licenses from Ericsson to manufacture base-stations. The former was a totally a new manufacturer, while the Italian companies had previously only been involved in the national standard.

doubt the possible success of their "domestic standard", but after selecting the TDMA as the radio-access method, Motorola found itself sidetracked, because it then proposed the FDMA[1041] and started to push the modified and improved version of the analog AMPS system (N-AMPS, narrow-band AMPS). In addition to this, Qualcom later proposed the CDMA technology. It is possible that after the domestic market situation changed, AT&T and Northern Telecom showed more interest in the GSM system.[1042] Motorola was interested in the GSM system a lot earlier even though the United States' digital project had started, and it opposed the method of implementation of digital technology in North America, not the technology itself. But the major outcome of the standard setting process in North America was that local manufacturers focused on the aging technology of the home market, while only Motorola caught the first GSM wave.

In Japan, the situation was even worse than in the United States. First of all, the opening of competition had increased demand, and two TACS networks were opened, bringing the totally new and strange analog standard to the domestic market. Japanese manufacturers had been involved in manufacturing terminals for the TACS, but the simultaneous increase of the TACS market in Europe and domestic plans induced several Japanese manufacturers to invest in TACS manufacturing in Europe during the last two years of the decade. None of the Japanese manufacturers seemed to have plans involving GMS infrastructure. In a way this is logical, because Japan followed the choice of radio access made in North America, and there were plans for cooperation with the United States.

The second approach is based on the concept of market- and Committee-based mechanisms in the creation of standards, and the role of governments. It has been argued that in Europe the National Governments had leading roles in the success story of the GSM, while in the United States and Japan the National Governments did not assume the necessary leadership to create successful digital standards.[1043] Particularly the latter part of the claim regarding Japan is illogical and untrue.[1044] Regarding Europe, it has been stated that the National Governments took the leadership, but this view highly over-emphasizes their role of governments in expense of the GSM Committee, and is acceptable only if the term "government" is seen conceptually as being the opposite of "market forces".[1045] Based on numerous misunderstandings, it has been claimed that the

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1041 Along with AT&T, Northern Telecom was the only major local manufacturer supporting the TDMA.

1042 Both companies participated in the GSM plenaries from June 1990 onwards. They were interested in the European market (switching), but there are no signs that these companies showed early interest in the GSM the way Motorola did.

1043 Funk and Methe 2001.

1044 In actual fact, Japan's 2G standardization was much more closely linked to governmental bodies than was the case in Europe.

1045 In Europe, most of the activity related to governments was "semi-governmental", because it was limited to the NTA/NTO level, although NTAs/NTOs were governmental agencies, they did not act according generally accepted political plans. The Franco-German cooperation was the exception, because it was defined and led on the political level, serving purposes other than the NTAs in the first place. The importance of "governmental" bodies

GSM standard was solely created by the initiative and activity of governmental or supranational bodies.[1046] Regarding Europe and the GSM standard, this approach does not provide a clear picture of what the relationship was like or of the involvement of the committee and market-based mechanisms in standard setting. But according to the interpretation, the United States is believed to have at first had an initial over-reliance on committee mechanisms (or lack of market mechanisms) and that subsequent over-reliance on market mechanisms (or misuse) prevented the digital systems in the United States from becoming global digital standards. The first part of the claim refers to the choice of digital version of the AMPS (DAMPS), with its introduction being left to the existing service providers, who initially only installed it on a limited basis as a capacity-enhancement technology. The latter part of the claim refers to the granting of licenses for Personal Communications Services, with the United States relying too much on market mechanisms and not choosing a single standard.[1047] However, this argument is artificial and it can be seen as being the result of a selected path or substance of "mobile policy",[1048] which solely focused on introducing competition and led to regionalism. When the digital standardization was launched, the most fundamental technological requirement urged towards compatibility between the analog and digital systems on the air interface. This was a logical requirement while a single standard prevailed and a large number of operators had invested in infrastructure. The choice of the DAMPS standard was actually a quasi-choice,[1049] because choosing the TDMA technique already led to dispersal situation. In ´the early stages, Motorola withdrew by introducing the analog NAMPS, and Qualcom introduced the CDMA concept, and even the TDMA got a modified proposal.[1050] Unlike in Europe, the committee for standard creation could not cope with this situation, and it is most likely that no government could have ensured the implementation of the DAMPS by legislative means. A formally clever requirement for incompatibility led to a state of incoherence in standards. When PCS license holders were given carte balance as regarded the

lay in that they supported the standardization process and provided the circumstances (mainly frequencies and investment in R&D and human resources)

1046 For example, it has been claimed that the initial momentum came from the CEPT, German and French firms, and the EC. None of them were initiators and they all reacted on proposals launched by others. As a matter of fact, the European NTAs met unofficially behind the CEPT's back and proposed cooperation in the fall of 1980 with a restricted number of participants, but the proposal did not proceed, because only France and the United Kingdom had an acute need to use the 900 MHz band (lack of market). After the United Kingdom and France invited other countries to adopt the NMT-like system (on 900 MHz), the Netherlands proposed establishing of a committee under CEPT supervision.

1047 Funk and Methe 2001.

1048 Actually, a more precise definition would be "lack of mobile policy" in the United States.

1049 In early 1991 Eric Scimmel, vice president of Telecommunications Industry Association, considered the outcome of the United States digital standard to be unpredictable, because subsequent proposals were introduced, and they had received independent considerations and evaluations from several major system operators. See Scimmel 1991.

1050 The TDMA radio-access method was chosen as in 1989, but in late 1990 there were validation tests regarding IS-54 (United States TDMA or DAMPS), N-AMPS, E-TDMA, and a development test for CDMA (see Paetsch 1993). In March 1992, the TIA established the TR 45.5 sub-group to develop a standard based on CDMA technology.

choice of technology, it was merely the formal acceptance of de facto dispersal that prevailed.

The market-and committee-mechanism approach did not work well in the standard setting processes in Europe, where the division of mechanisms between the market and committee is of little value as possibly only the analog MATS-E system could be classified as being a market-driven standard-setting process, and it failed totally. Also in the GSM standardization process, the Franco-German attempt to set the standard could be interpreted as at least involving quasi-market mechanisms, because the manufacturers were left to their own devices to propose their radio-access candidates. It was not a success.[1051]

The main result of the mechanisms approach boils down to showing how National Governments' actions affected the emergence of global mobile communication standards.[1052] Actually, this was not related to the standard-setting process, but only to the means to ensure and improve diffusion. According to it, global standards were created by governments and firms not overly relying on either market- or committee-based mechanisms, but instead applying a hybrid mechanism or both mechanisms in two ways. Firstly, they expanded their penetration rate by creating a situation where the prices for infrastructure, terminals and services fell. Secondly, the governments and firms could influence the creation of global standards through their efforts in adopting a single open standard, which in the case of the NMT, AMPS and the GSM systems dramatically increased the number of predicted installed bases.[1053] The general idea was to create a model for forecasting installed bases,[1054] and not to explain the actual mechanisms for why the GSM system succeeded.[1055] Of the mentioned measures, liberalization of the handset market was not a new idea when the GSM was launched. Although it is true that committing to creating a single open standard increased the number of forecasted installed bases of the GSM dramatically, and the forecast figures increased even more when countries awarded licenses to multiple service providers, this did not automatically lead to the bandwagon effect. The above explanation assumes that the GSM system was introduced in a vacuum, with existing previous standards not having any influence on it.

1051 Compared to the Nordic countries, which used the committee mechanism (NTA- or NTA related facility proposed candidate or cooperated with manufacturer).

1052 Referring to NMT, AMPS and the GSM.

1053 Funk and Methe 2001.

1054 But it does not take into consideration issues such as license fees, impact of auctioning licenses (direct and indirect or special problems related to switch-over from technology generation to another.

1055 Introducing a concept of agents of diffusion is one of the few examples given. This concept considers that any outside manufacturer helps the legitimacy of system to third-party governments and increases diffusion. But the given examples show that this idea did not work in practice. For example, importance of Mitsubishi and Motorola as agents of diffusion for the NMT (infrastructure) was very limited, for the former it was zero and for Motorola limited as it sold one NMT network. But the picture is a different one if the "agent" is a significant manufacturer, as was Motorola in regard to terminals or Ericsson in regard to the AMPS or TACS (their infrastructure).

Generally, it is not very fruitful to adhere strictly to the unadulterated concepts of committee-and-market-based mechanisms, although several studies dealt with the benefits and weaknesses of both procedures. The foremost criticism of the committee-based standard setting processes is that they tend to support the current or known-art technologies over emergent or new technologies.[1056] But particularly regarding cellular telephony, this observation can be seen as not being valid. The NMT Committee chose sophisticated technology, although the market forces (manufacturers) opposed all features, which eventually became the prerequisites of success.[1057] The same pattern was repeated in the early phase of GSM standardization with several manufacturers supporting analog technology in favor of digital technology.[1058] Experience with NMT and the GSM clearly shows that the dilemma was not in the standard-setting method, but in the presuppositions of the standard setting process. Both the NMT and the GSM Committees reserved sufficient time, around 10 years, and the timing of launching of the projects was appropriate. In short, the NMT and the GSM Committees followed the basic rules of standardization of mobile telephony, which allowed them to choose the most appropriate technology. In the United States and Japan timing had been late and the reserved time was determined by market pressures (both internal and external), which did not allow much freedom of action. This leads to another criticized feature of committee mechanisms: the long periods of time required for standard setting, but in the case of a single standard environment, this is merely a question of timing. Cellular systems necessitate huge investments when developing the system and constructing the infrastructure, and it is then not even desirable to artificially to shorten the life span of a standard.

Although neither of the referred approaches is appropriate in explaining success of the GSM system, the prerequisites of both approaches are valid in principle. Arguments to the effect that the openness of standard and early installation base have important impacts on the possibility of the standard to become a success[1059] are easy to accept. But the definition and use of the concept regarding openness is problematic. According to the implementation of the concept, openness is measured in terms of the extent to which the following requirements are fulfilled:[1060]

- The system's specifications are made available to all interested parties.

[1056] Funk and Methe (2001) did not mean to confront pure concepts. The criticisms related to technology refers to Sirbu and Zwimmpfer 1985, although none of the above authors classified criticism.

[1057] Storno suggested tone signaling and opposed hand-over, while Motorola opposed roaming. The SRA (Ericsson) did not originally support the development of a sophisticated system responding at all to the specific needs of operators. The company wanted to deliver a system (or at least components) straight off the shelf in order to eliminate the competition coming from Japanese manufacturers.

[1058] From a purely commercial point of view, opposing digital technology was quite logical, because even analog technology was in its infancy in Europe. The incentive to invest in digital technology was low for those manufacturers, who lacked any experience in cellular technology.

[1059] Funk 1998 referring on general observations in standardization.

[1060] Funk 1998.

- The standard setting process is clear and participation is open to all firms including foreign firms.
- The reasons for decisions within the standard setting process are specified in the resulting. specifications.
- The rules concerning intellectual property rights are made clear.

Literally taken, only the NMT standard and the standard-setting process fulfilled these requirements 100%.[1061] The use of the concept is not only discriminating but purpose-oriented also as the Japanese PDC is classified as being a non-open standard, with only the air interface being defined. However, the AMPS/DAMPS standard is considered to be open, although only the air interface is specified.[1062] But the essence of dilemma related to the concept of open standard is in its viewpoint, because the concept is defined from the angle of the manufacturer; i.e. whether a manufacturer can participate in and acquire the standard freely. From the operator's point of view, the issue is not so straightforward, because systems with only the air interface being specified lead to a reliance on a single manufacturer; the supplying manufacturer can block others, unless manufacturers cross-license their technologies.

Open standards with all fundamental interfaces specified for them appear to have had contrary impacts on the 1st and 2nd generations. The Nordic NTAs/NTOs created totally open standards in order to make the purchasing of equipment from several sources possible, and thereby increase competition. Naturally, the Nordic NTAs/NTOs had to build up competence in cellular technology while conducting the standardization process, but many less-experienced operators were willing to procure from a single supplier. Ericsson became a supplier of entire network infrastructures after the initial period, and in practice it became the sole supplier of exchanges for a while. Ericsson tried to oppose the Nordic countries in their implementing of the NMT-900 system, because it had developed the infrastructure for the TACS system, which did not allow competition between suppliers of base stations.[1063] Competition in regard to base stations had been quite intense, and Ericsson faced more than an equal match from other Swedish manufacturers and later from Mobira (Nokia). Ericsson's reluctance in regard to totally open standards was not a unique phenomenon, because other manufacturers also tried to safeguard their market situation by supplying modified NMT systems.[1064] The switch-over from analog systems to the GSM also meant a discontinuity point of technology, and both operators and manufacturers benefited from the total openness of the specifications. Most operators procured equipment from several sources and as

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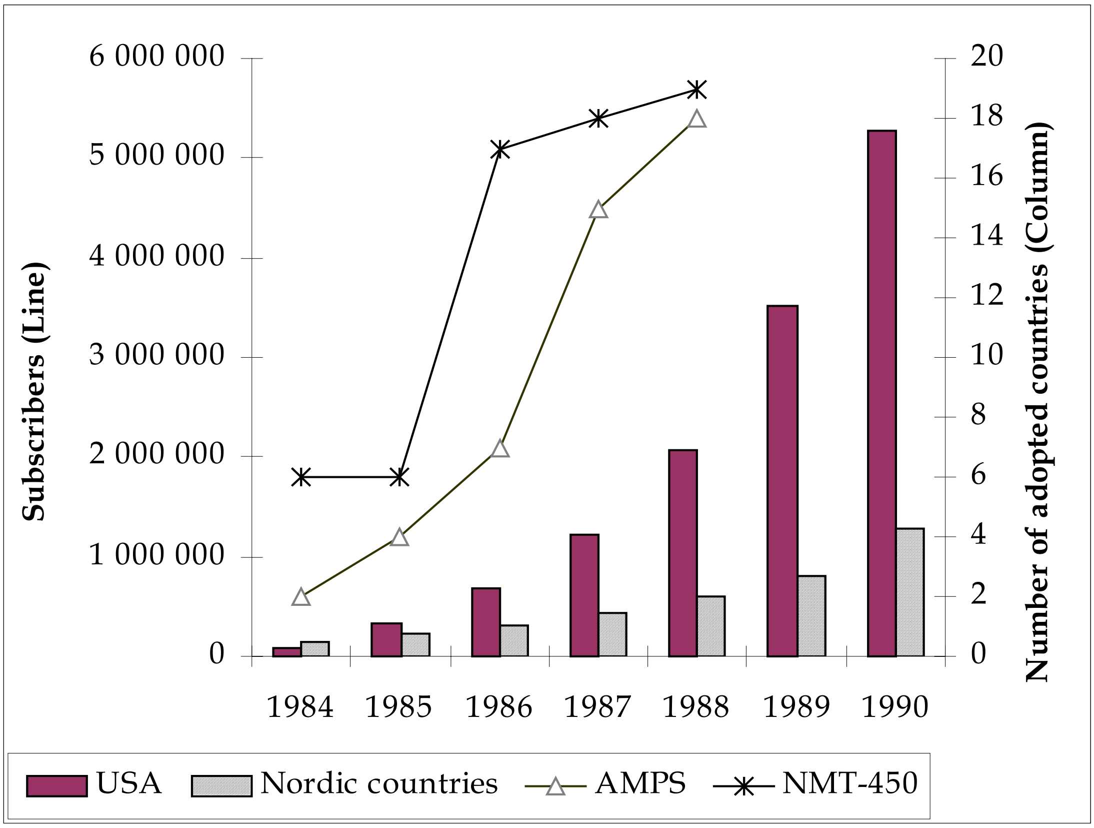
[1061] For example, the AMPS and the GSM standardization processes were not fully open from the beginning. In the case of the AMPS, foreign manufacturers did not participate in defining its basic parameters. The Japanese company OKI participated in developing equipment for the test network. In the GSM, the manufacturers were not directly involved from the beginning, but phase-related development of the equipment was in practice for all seriously interested parties.

[1062] Funk 1998; according to Garrard 1998, the AMPS and DAMPS standards had only their air interface specified.

[1063] See Chapter 2.3.3.3.

[1064] For example, Motorola supplied a modified NMT system to Austria and Nokia to Turkey.

they had previous experience of cellular systems, while most manufacturers were developing equipment in cooperation. The openness of the specifications was an advantage for "non-European" manufacturers and especially for Motorola, which basically focused on supplying base stations.



Sources: Paetsch 1993 (AMPS); TN NMT Statistics (NMT); World Reports 1992-1994
FIGURE 17 Installed base and diffusion of the NMT-450 and AMPS standards

Generally, the success of cellular systems was related to the openness of the standards[1065] and early installation base. The importance of early installation can not be denied. Particularly the diffusion of the AMPS and TACS standards accelerated once the subscriber numbers started to rise.[1066] But the case of the NMT system differed among the 1st-generation systems, because Saudi Arabia had deployed the system before the Nordic countries, and Spain adopted it in 1982, which was before the installed base had had any effect. This actually gives rise to a fundamental question: What is sufficient in regard to installed base? Although the present study does not endeavor to answer the question, it does lead to another issue: Are the installed bases of two standards belonging to same technology generation comparable? Using the NMT-450 and AMPS standards as examples, these being the early and the late dominanats of 1st-

[1065] If an open standard is seen widely as the opposite to a proprietary standard. But contrary to Funk assumption, the C-450 and RC 2000 systems could not be classified as being totally closed standards, because there was competition on terminals, and this also included non-domestic manufacturers.
[1066] Funk 1998.

generation standards, it is possible to examine the relationship between an installed base and the diffusion of a system. However, FIGURE 17 shows that the relationship clearly depends on the historical situation, because the diffusion of the AMPS, measured in terms of the number of countries adopting the system, did not start to grow although subscriber numbers on the home markets in the United States exceeded those of the Nordic markets in 1985 and doubled by the next year. It took until the end of the 1980s for the AMPS standard to become more widely adopted than the NMT-450 standard. It is also worthwhile to note that having early installation of the base is not a sufficient criterion for success. The NMT-900 and CDMA standards were able to provide the initial launching of an early installed base more rapidly than competing standards of their generations, but both the NMT-900 and CDMA entered the markets too late to achieve the status of a leading standard (see Appendix 8 regarding CDMA).

3.3.3.2 Reasons for successful industrialization of the GSM standard

The approaches dealt with thus far have not addressed the relationship of consecutive systems belonging to different generations. This leads one to a false assumption as the preceding generation would not have an impact on the diffusion of the following system,[1067] although in practice new systems entering the markets had to compete with older technology. The feedback on the preceding generation could be evaluated by using the concepts of lifespan and regional distribution. The leading systems belonging to the 1st generation had different focuses regarding their lifespans. The early diffusion of the NMT, AMPS and The TACS systems were relatively slow (Table 52), but the zenith of diffusion was different when comparing the NMT-900 and the TACS to the AMPS. The diffusion of the European TACS and NMT-900 slowed down in the early 1990s, with only three new countries adopting the TACS and two new countries adopting the NMT-900 after 1991, which meant that these standards were not competing in the infrastructure market with the GSM standard. The lifespan of the AMPS standard did not show signs of weakening. On the contrary; the number of new countries adopting the AMPS more than doubled between 1991-1996, when it was already evident that a new generation was entering market (Table 53). From the GSM point of view, it was important that the AMPS was not actually able to penetrate the market in Africa, Middle East or East-Europe before the 1990s.[1068] Six newly-independent countries of the

[1067] "Diffusion approaches" (Funk 1998, Funk and Methe 2001) notes only the point in time when the adoption of the new system surpasses the adoption of the old system.

[1068] Before 1991 only one country in the Middle East and two countries in Africa adopted the AMPS. Countries of the former Soviet Union started to adopt the AMPS from 1994 onwards.

TABLE 52 Diffusion of selected analog (1G) and digital (2G) cellular standards

Sources: Compiled from TN NMT Statistics; EMC Reports, Paetsch 1993, Garrard 1998, Funk 1998, Cellular & Mobile International February 1997, Bekkers and Smiths 1999, European Mobile Communications Report 150, EMC CDMA Mobile Communications Report January 2001, the GSM Association (www.GSM.world/membership/networks_complete_page.html).

Note: *global figures; ** estimate based on information provided in World Report '97 (Cellular Business April 1997). The CDMA was first adopted in Hong Kong in 1995 and then next year in the United States and South Korea.
-The numbers related to adopting the CDMA vary a lot. According to the CDMA Developers' Group (www.cdg.org), the CDMA had been adopted by 38 countries in 1998, but this figure probably includes countries having only the WLL systems and trial systems as well.
-Adopting of the system does not necessarily mean launching of a real commercial service

Standard		Home market (number of countries)	Start of service	Number of countries adopting standard during first 4 years of service					Subscribers on home market after 2 years of service		Population of home market (x1000)		Subscribers globally (x1000)	No. adopted countries
				1st	2nd	3rd	4th	Total	x1000	Penetration (per mille)	1988	1996	1G: in 1991 2G: in 2000	1G: in 1991 2G: in 2000
1G	NMT-450	Nordic (4)	1981	3	3	0	1	7	36	1,58	22 729	23 608	893	24
	AMPS	USA (1)	1983	1	1	2	3	7	92	0,38	245 021	265 453	8 174	42
	TACS	UK (1)	1985	2	2	0	1	5	64	1,12	57160	58780	2 215	21
	NMT-900	Nordic (4)	1986	4	1	1	2	8	121	5,32	22 729	23 608	907	9
2G	GSM	Europe (17)	1992	8	9	20	19	56	1341	3,49	359 933	384 774	442 912	124
	DAMPS	USA (1)	1992	4	..	..	..	**30	*80	0,30	245 021	265 453	65 192	**45
	PDC	Japan (1)	1993	1	0	0	0	1	200	1,59	122 610	125 864	50 798	1
	CDMA	USA (1)	1995/ 1996	1	3	1	4	9	1500	5,65	245 021	265 453	82 289	30

TABLE 53 Diffusion of leading analog cellular standards
Sources: Cellular Business May 1992, April 1997; Bekkers and Smits 1999.
Remarks: In 1991, there were in fact only eleven countries, which had adopted the NMT-900, because Greenland and the Faroe Islands are not sovereign states.

STANDARD	ADOPTED COUNTRIES			INCREASE %		SUBSCRIBERS (THOUSANDS)		INCREASE %
	1988	1991	1996	1991	1996	1991	1996	1996
NMT-450	19	24	37	26	54	893	4 677	160
NMT-900	6	9	13 (11)	50	44 (22)	907		
AMPS	18	42	86	133	105	8 174	44 755	448
TACS	5	21	24	320	14	2 215	15 793	613

former Soviet Union purchased the AMPS when the 1G was already aging rapidly, especially in Europe. On all export markets, excluding Latin America, the rise of the AMPS occurred after 1990.[1069]

The timing of the GSM system with regard to analog systems was not the most suitable, because several countries had recently invested in TACS networks, and NMT-900 networks had surplus capacity as well. But this was only a short-term problem, because the diffusion of European standards on the 900 MHz band had slowed down. The timing regarding digital systems was beneficial, because the GSM was the first digital system entering the markets and it managed to fulfill this goal.

The switch-over mechanism relates to the plan of how and why a system was going to be introduced to market was in favor of the GSM. The GSM Committee was not affected by market pressure, because it based its plans to introduce the GSM on assessment of need. The essence of the GSM system was to offer sophisticated services responding to the needs of the 1990s and the capabilities of the PSTN/ISDN systems, and to provide pan-European roaming. The issue of market pressure was left to be resolved on the national level by introducing "interim systems" (TACS, NMT-900, C-900, MATS-E). The European approach resulted in competitive advantage, whereas in the United States and Japan the market pressures were the determinant factor, because national projects were launched only when shortage of capacity became evident. In the United States and Japan, the importance of the digital system was focused on increasing capacity and thus neglecting the sophisticated services the new technology could provide. In United States, there was a requirement for compatibility between the AMPS and the IS-54(digital TDMA or DAMPS), and IS-54 would thus provide a clear benefit only if the analog AMPS system had already been adopted.

The expectation of the switch-over was also a clear factor. It has been claimed that most of the countries, which were early adopters of the GSM, did not have acute shortages of capacity, and particularly outside Europe it was regulatory changes, technology hype, etc., which impacted on selection.[1070] It

[1069] Calculations based on World Report 1992-1996; Garrard 1998; EMC Reports January 2001, February 2001, March 2001 and April 2001.
[1070] Garrard 1998.

was before the end of the 1980s that Europe, the United States and Japan presented plans to introduce digital systems. Europe's goal was to do so in 1991, while the latter two aimed at 1992. Since early 1988, several European countries had been purchasing infrastructure, and plans were being put into practice. When making decisions to purchase systems, operators had to choose between aging and new technology. The former was a secure choice, but new technology could provide new means of earning revenues. Making the choice between technology regimes was important, because it meant making investments extending over the next ten years.

Product attractiveness was an advantage of the GSM system, because already it was clear already clear that its development would be extended to Phase 2, which would be backward compatible and provide more sophisticated services. Also at the same time, the PCN concept was being assimilated to the GSM standard to provide more capacity and cheaper and smaller terminals.

Market creation was on far more extensive and broader base in Europe than in the United States or Japan. In Europe, the potential market had been created since the beginning by having all interested European countries involved. This group varied between eleven and seventeen countries, and the ultimate goal was to offer the GSM system to all twenty-six CEPT countries. The population of the participating countries was 350 million compared to 280 million in the United States and Canada and 120 million in Japan. The market expectations were later confirmed institutionally by creating the MoU and politically by the EC. But market creation was not just a matter of potential customers. The large number of countries and operators would share the development costs, and with thorough testing over they would ensure that the adopted technology was a mature product.

A single open standard was one of the advantages of the GSM system. It was possible for its evolution (the GSM Phases) and the system concepts (PCN) to be maintained on the GSM path, thus avoiding the dispersal of various standards, which had prevailed in the United States already before the granting of PCS licenses. Also, possible substitutes did not cause severe threats for the GSM system, because the CT-2 Telepoint system turned out to be successful only in France. Later on, the digital paging system ERMES achieved relatively low popularity (France being the main exception) and the launching of the cordless DECT system was postponed and thus it did not impact on the GSM system. The openness of GSM specifications was another advantage and incentive for manufacturers. However, in United States it was formally known by the spring of 1992 at the latest that there would not be a single digital standard.

Early installed base is generally considered to be important for the diffusion of standards. Yet the GSM system had to face a situation where National Governments had very little to do in regard to trying to manipulate the markets indirectly or directly. During the first year, Germany’s share of the total GSM market was around 90 per cent, and even next year the share was around 70 per cent. Germany was one of three exceptions amongst the early commercial adopters of the GSM system, because it did not have an analog system operating on the 900 MHz band. Thus Germany did not have low-price hand-held portables and the pricing of the services was rather high, providing thereby the best opportunities for the GSM system to compete with the native analog system. Then in 1993 terminal prices started to fall. The formation of an early installed base would have failed had not the governments of Sweden, Germany, Finland, Denmark, Portugal and France not introduced competition according to their national plans. Only those countries, which gave licenses to practically new operators (including those who had not earlier competed on even terms with analog systems), launched commercial services in 1992 and thereby compelled the PTTs to also open networks for commercial services, although analog systems had surplus capacity. This early group was extended by Norway, Greece and the United Kingdom, which also introduced competition. Without the initial pull of the German market and the early introduction of competition the installed base would have been postponed, but these two factors caused the subscriber numbers to grow in 1994. The early installed base was extended by domestic market in Western Europe.

4 THE NORDIC IMPACT ON THE STANDARDIZATION OF MOBILE TELEPHONY

The Nordic countries were unique in the sense that no other country had internalized and adopted the combination of societal need and social shaping of technology in the context of mobile telephony already during pre-cellular era. The view of the Nordic countries was that mobile telephony was useful for society at large assuming that the networks could provide nation-wide coverage. Thus, mobile telephone networks could provide an infrastructure useful for the economy, the authorities and the citizens. The National Telecommunications Administrations also stood to benefit, because nation-wide networks were seen as a practical tools to stop the ever-increasing popularity of Private Mobile Radio. Several parallel PMR networks were wasting frequencies, and leading to a situation where there would have been no frequencies available in the future.

The Nordic countries were not the only ones to understood the value of nation-wide mobile telephone networks, but they were the only countries able to adopt the best method to implement this goal. Germany was a keen advocate of nation-wide mobile telephone network, but in the late 1960s it clearly adopted a technological push approach in developing mobile telephony. System B, which was adopted in 1971, was automatic and included features (e.g. digital signaling) which made the system very expensive. Although the system was modern when it entered service; it was not a cellular system and could not provide the advantages of a cellular system. The Nordic countries adopted a totally different approach. Technology was not given a dominant position; instead, the idea of mobile telephony was socially shaped. Decisions were made to construct nation-wide networks by adopting manual switching. Formally, the Nordic countries chose a "backward technology", but in practice manual systems provided several advantages compared to automatic systems: infrastructure and terminals were cheaper and with the current technology available it was difficult to implement an automatic system to respond to the requirements of nation-wide networks in a reasonable manner. Ultimately and in the larger perspective, the Nordic countries had an evolutionary strategy.

The Nordic point of view was one in which it was not relevant to emphasize the switch-over from pre-cellular to cellular era, because on the mental level the switch-over was seamless. There were no changes in the basic approach to mobile telephony. This was an exceptional advantage, because in addition to the Nordic countries, only Japan and the United States were able to launch their cellular projects in time. But contrary to the Nordic countries, Japan and the United States were not able to identify the societal importance of mobile telephony, nor were they able to choose the social approach to implementing of the set goal. Both countries selected a relatively high frequency band (800 MHz), which in those days was not favored when constructing wide area networks. The systems were most suitable for high-density traffic in urban areas. The networks were city networks. The main difference compared to pre-cellular networks was in using several base stations (cellular concept) instead of one transmitter. It is a paradox that the new technologies enabling new opportunities were not used in providing the roaming service. Whereas Japan and the United States failed only partially, because they were not able to see the new service possibilities, many countries failed totally. Germany, France and Italy adopted automatic systems in the early 1970s and constructed nation-wide networks; this turned out to be the wrong choice, because they were not able to launch cellular projects in time. The time lag was approximately ten years compared to Japan, the United States and the Nordic countries, and that was definitely too long.

The Nordic success with the cellular NMT system cannot be separated from the path selected during the standardization of the pre-cellular systems. The Nordic countries were able to acquire larger customer bases than any other country in Europe. This promoted the status and importance of mobile telephony, and it was not left in the shadow of paging as was the case nearly everywhere else. The large customer base brought in revenues for the state (not for the operator!) and most probably made decision to invest in constructing the NMT networks quite easy. Moreover, pre-cellular networks provided invaluable experience in serving large numbers of customers, and this ultimately led to customer orientation instead of controlling of the capacity.

The establishing of the NMT group marked the beginning of a new era in the standardization of mobile telephony, because the group introduced a number of atypical principles and practices. These included:

- Reserving an extraordinarily long time (ten years) for development work
- Multinational cooperation
- The NMT group outlined common mobile policy; regulatory measures were not connected to specific technology (VHF or UHF) but to secure inter-Nordic operability
- The NMT group was not aiming to define a system in a first place, but instead to enable inter-Nordic service possible
- The NMT group was not just standardizing a system, but introducing it to use as well
- To define specifications totally open for everyone
- Cooperation with a large number of manufacturers without clause for most favored manufacturer; all interested manufacturers were welcomed regardless of country of origin
- Sharing information on equal basis
- Excluding goals of industrial policy
- Defining required services; technology on how to implement them was not important unless it did not increase the cost (at time when the system would be operational)

The success of the NMT system was not repeatable just by cloning the procedures and principles applied, because the work of the NMT group also depended on circumstances that changed over time. The atmosphere changed and economic incentives turned out to be far stronger than they were in the early 1970s. Yet there was a lot that did not depend on the circumstances. As a matter fact, standardization of the NMT system introduced several features, which were either directly or after minor changes applicable in the standardization of the GSM system and even of the 3rd generation. These became the basic elements of the standardization process.

The primary pre-requisite in the standardization of mobile telephony was to identify the right moment for launching the standardization of the new generation. This timing was related to recognizing the prevailing social demand. With the NMT, it was the trend of Nordic economic integration and of increased needs for mobility (particularly transportation). With the GSM system, the corresponding social demand was the unique possibility to create a pan-European service and an atmosphere supporting European cooperation in information technology. The work on 3rd-generation standardization was launched in parallel with the aim of liberalizing world trade.

The second step was to appoint a multinational standardization body instead of a national attempt to set a standard. There had been a clear cumulative tendency from Nordic via European to global standardization. The original idea was to share the risks and expenses and at the same time offer increased incentives for manufacturers to become involved.

The third step was to purposefully reserve a long enough time for the work. This period had been settled at approximately ten years. It made it possible to wait for technology to evolve to facilitate the realization of the requirements.

The fourth step was to select the social approach. It included defining the requirements for making the NMT and the GSM systems service focused. The technology itself was not a driving force; it was only used as a tool to make the required services possible. In addition to this, no technical requirement (e.g. capacity) was put in a domineering position.

And lastly, standardization was based on the idea of sharing information. The aim was to impact on standardization by increasing inputs or through negotiations, but not by trying to take control of the project. This included the point that industrial policy aims should not be put in an overwhelming position.

Naturally, a standardization process also included more than just the said basic elements. The participating players made inputs in the processes. According to the predominant viewpoint, it was Sweden in the case of the NMT system and the Franco-German alliance in the GSM system that acted as the major driving forces. The former view is acceptable to some extent. But the main issue is that the Swedish NTA alone could not have carried out the task successfully. The NMT technology was a result of cooperation including far more than just inputs in technological research. For example, the sole Swedish project might have introduced NTA-ownership of terminals, combined (and expensive) NMT-MTD terminals, and possibly only two terminal manufacturers. It is highly questionable as to whether the national project would have got the green light in Sweden. In any case, there would not be an economic incentive for manufacturers nor for the NTA to carry out novel services.

The GSM case is much clearer then the NMT case. The view that the Franco-German alliance was the sole driving force is absurd. This becomes evident simply based on the laws of physics. In actual fact, the Nordic countries laid the basis for the GSM system by outlining the preliminary requirements for the system, which were basically the same as for the Nordic NMT-2/FMK (digital system), and by introducing the fundamental principles of NMT standardization. It is true that not all the plans of the Nordic countries were accepted, but they managed to reject the technology-driven approach (e.g. a mathematical formula for defining system capacity). It should also be also borne in mind that the Nordic countries had already launched their project in late 1981, and that the Franco-German joint attempt was elaborated nearly three years later! This was such a dominating fact that the Franco-German alliance had very little to do in order to be able to have a major influence on GSM standardization. In striving to do this, the alliance adopted an approach, which turned out to be a total failure. Firstly, the strategy was wrong, because of its industrial policy goal and because even the political goals predominated and they did not fit in with the cooperative nature of the project. Secondly, the actual (although not the only) Franco-German proposal was a wide-band system, and it was not suitable for countries, which had adopted an analogue "interim" system operating on the 900 MHz band. Ultimately, almost all the countries involved with the GSM Committee had taken an "interim" system into use by the early 1990s. The major exceptions were France and Germany. Thirdly, the timing of the Franco-German project was unrealistic. It would not be very useful to speculate as to what may have happened had the Franco-German alliance managed to get its proposal and views accepted. According to the German obsession, the GSM system would have been merely auto-based when installed, and hand-held terminals would have been strictly forbidden. The users of this system would then have been confined only to France, Germany and possible a couple of their former colonies! The aim of this criticism is not to claim that the Franco-German input was useless. On the contrary, it particularly induced the Nordic countries, which were the only ones able to response, to take the attempt seriously and invest in their proposals. Neither is it correct to claim that the Nordic countries alone made the GSM system a success.

State intervention and misinterpretation of it is another constantly repeated issue. With the NMT system there was no direct intervention on political level, although the Swedish and Finnish NTAs influenced the unwillingness of certain manufacturers to launch development of equipment, but in general there was no interference, and the NMT Group had fairly free hands to run the project. As regards the GSM system, it had been convenient to claim and see the European Community as pulling the strings behind the scenes. This mysterious illusion totally neglects the impotence of the EC in the telecommunications sector before the mid-1980s. It is true that the EC actually tried to take over the GSM project, but this attempt was foiled by the cooperation of National Governments and the unanimity of the GSM Committee. After its failure, the EC had to adopt a secondary role, and it was not until the Maastricht Treaty (which came into effect in November 1993) that the EC got an opportunity and the power to really steer the telecom field.

More than other countries, it was the Nordic countries, which influenced the elaboration of the basic forms and procedures regarding standardization of mobile telephony, and most of them were transferred to the standardization of following generations.

Ultimately, it is ironic that the Nordic countries were able to shape the every-day life of "modern people", but this "power" was not based on exceptional skill and knowledge in technology or engineering. The world was full of competent engineers even in those days. The Nordic engineers that launched the NMT process were not "inventors" in the sense that they would have invented something technically innovative and revolutionary. But they were the "enforcers". They had the sense to see what was going on in society and to understand the social fundamentality of mobile telephony.

ACRONYMS

ADPM Radio access prototype of ELAB (/Trondheim Technical University) for the GSM
AMPS Advanced Mobile Phone System; the United States
ARP Autoradiopuhelin (Car Radio Telephone); Finland
ATR Alcatel Thomson Radiotéléphone
BS Base Station
BSC Base Station Controller
BT British Telecom
CCH Coordination Committee for Harmonization (CEPT)
CCIR International Radio-communications Consultative Committee (ITU)
CCITT International Telegraph and Telephone Consultative Committee (ITU)
CD 900 Radio access prototype of ATR/SAT/SEL/AEG consortium for the GSM
CDMA Code Division Multiple Access
CEC Commission of the European Communities
CEN European Committee for Standardization
Cenelec European Committee for Electrotechnical Standardization
CEPT European Conference of Postal and Telecommunications Administrations
COST Cooperation in the Field of Scientific and Technical Research
DCMS 900 Consortium of Bosch, ANT and PKI to develop and market the GSM infrastructure
DMK Consortium of Siemens and DCMS 900 to market the GSM infrastructure
DMS-90 Radio access prototype of Ericsson for the GSM
DTX Discontinuous Transmission
EC European Community
ECR 900 Consortium of Alcatel, AEG and Nokia to develop and market the GSM infrastructure
ECREEA European Conference of Radio and Electronic Equipment Associations
ECTEL The European Telecommunications and Professional Electronics Industry; joint body of ECREEA and EUCATEL
EFTA European Free Trade Association
ESPRIT European Strategic Programme for Research in Information Technologies (EC)
ETCO European Telecommunications Consultancies Organization
ETSI European Telecommunication Standardisation Institute
EUCATEL European Conference of Association Telecommunications Industries
FDMA Frequency Division Multiple Access
FMK Framtidens Mobila Kommunikationer (Future Mobile Communications), The Nordic 2nd-generation mobile telephone project

GAP Analysis and Forecasting Group, a sub-group of SOG-T (EC)
GSM Groupe Spécial Mobile (CCH/CEPT, from 1989 onwards ETSI)
IPR Intellectual Property Right
ISDN Integrated Services Digital Network
ISMOC Integrated Services Mobile Communications, Unofficial name for NMT-2, was replaced by FMK, see FMK
ITU International Telecommunication Union
JEG Joint Experts Group on Security; the GSM
LCT Laboratorie Central des Télécommunications
MASS Mobile radio All-digital Second-generation System; term used by GAP in 1985
MATS-D Radio access prototype of PKI for the GSM
MATS-E Analog cellular system, developed by Philips in cooperation with Alcatel
MAX Radio access prototype of Swedish Televerket (later Telia) for the GSM
MoU Memorandum of Understanding
MS Mobile Station, Mobile telephone terminal
MSC Mobile Switching Center
MTX Mobile Telephone Exchange
NET European Telecommunications Standard
NMT The Nordic Mobile Telephone
NMT-2 Original term of FMK, see FMK
NR The Nordic Radio Committee, former NTR
OSI Open Systems Interconnection
PCN Personal Communication Networks
PKI Philips Kommunikations Industrie, Germany
PLMN Public Land Mobile Telephone Network
PN Permanent Nucleus of the GSM
PSTN Public-Switched Telephone Network
PT12 See PN
R&D Research and Development
RACE R&D in Advanced Communications Technologies for Europe (EC)
S 900 D Radio access prototype of Rober Bosch/ANT Nachrichtentechnik for the GSM
SEG See JEG; the GSM
SFH 900 Radio access prototype of LCT for the GSM
SFH Slow frequency hopping
SOG-T Senior Officials Group on Telecommunications (EC)
SSA Secretariat for Specifications and Approval (CEPT)
TACS Total Access Communication System
TDMA Time Division Multiple Access
TMS Task group Mobile Services, TMS/ECTEL
TRAC Technical Recommendations Application Committee (CEPT)
WP Working Party, sub-group of the GSM Committee

APPENDIX 1

List of the most fundamental documents

TM Report of Swedish NTA 1967 (Landmobil radiokommunikation. Betänkande avgivet av arbetsgruppen för mobiltelefonsystem. Stochkholm august 1967)
ULA MTC Report 1975 (Införande av landsomfattande, automatisk mobiltelefon, MTC. Utredningsrapport juli 1975)
ULA MTD report (Förutsättningar för införandet av manuellt mobiltelefonsystem MTD)
ULA NMT # 1-9; 26-33; 43-46; 51-75 Minutes (1971--1985)
ULA NMT Draft Minutes # 9-23, 27-30
ULA NMT Reports to 1971, 1973 and 1973 Telecommunication conferences
ULA NMT Reports V/1973-X/1978
ULA NMT Documents 1971-1986
ULA GSM # 1-30 Minutes (1982-1991)
ULA GSM Documents 1982-1991
ULA NTR # 2-14 Minutes (1972-1978)
ULA NR # 29-41 Minutes (1986-1989)
ULA Minutes of Telecommunication conferences
SA RD VTT Radio Technical Laboratory, Annual Reports 1961-1971
SA RD Minutes of Consultative Committee of VTT Radio Technical Laboratory 1961-1971
SA RD Mobile telephone report 18.8.1967 (Yleinen siirtyvän liikenteen radiopuhelinverkko, 18.8.1967 K. Teräsvuo)
SA RD Mobile telephone report. Overview. (Yleinen siirtyvän liikenteen radiopuhelinjärjestelmä. Yleiskatsaus)
SA RD "ARP Documents"
SA RD NMT # 1-4 Minutes
SA RD Memos from NMT # 1-4 Meetings
SA RD NMT Reports IV/1979-VIII/1985
SA RD ISMOC/FMK # 1-2 Minutes (1981-1982)
SA RD ISMOC/FMK Memos (1982-1985)
SA RD ISMOC/FMK Reports to NR
SA RD Memos from the GSM # 1-6 Meetings
SA RD NR # 2-25 Minutes (1981-1985)
SA RD Internal documents of Radio Department (procurement etc)
SA RD Steering Group of Finnish NTA (JORY) Decisions
TN NMT # 12-16; 78-102 Minutes (1973-1991)
TN NMT Documents 1971-1991
TN NMT Statistics

TN NR # 26, 42-50 (1986; 1990-1991)

TM Telemuseum, Stockholm, Sweden
ULA Uppsala Provincial Archives, Archive of Radio Division of Swedish NTA (Televerket), Sweden
SA RD Sonera, Archive of Radio Department of Finnish NTA (Tele, Telecom Finland), Helsinki, Finland
TN Telenor, Archive of Norwegian NTA (Televerket), Oslo, Norway
NTR, NR The Nordic Radio Committee

Legend to footnotes

NMT # 1 = Minutes of NMT Groups' First Meeting
NMT Report III/1974-II/1975 = Report from March 1974 to February 1975

APPENDIX 2

List of the GSM Meetings

#	Date	Year	Place	Country	GSM Doc #
1	7.-9.12.	1982	Stockholm	Sweden	32/83
2	23.-26.3.	1983	Hague	Netherlands	52/83
3	11.-14.10.	1983	Gothenburg	Sweden	24/84
4	28.2.-2.3.	1984	Rome	Italy	56/84
5	26.-29.6.	1984	Berne	Switzerland	85/84
6	12.-16.11.	1984	London	UK	33/85
7	25.2.-1.3.	1985	Oslo	Norway	44/85
8	10.-14.6.	1985	Paris	France	120/85
9	30.9.-4.10.	1985	Berlin	Germany	22/86
10	17.-21.2.	1986	Athens	Greece	56/86
11	9.-13.6.	1986	Copenhagen	Denmark	64/86
12	29.9.-3.10.	1986	Madrid	Spain	31/87
13	16.-20.2.	1987	Funchal	Portugal	82/87
14	9.-12.6.	1987	Brussels	Belgium	117/87
15	12.-16.10.	1987	London	UK	200/87
16	14.-18.12.	1987	Hague	Netherlands	16/88
17	1.-5.2.	1988	Florence	Italy	59/88
17E	15.-16.3.	1988	London	UK	78/88
18	25.-29.4.	1988	Vienna	Austria	134/88
19	20.-23.6.	1988	Espoo	Finland	203/88
20	24.-28.10.	1988	Paris	France	300/88
21	30.1.-3.2.	1989	Munich	Germany	107/89
22	6.-10.3.	1989	Madrid	Spain	187/89
23	5.-9.6.	1989	Rönneby	Sweden	279/89
24	2.-6.10.	1989	Fribour	Switzerland	386/89
25	11.-15.12.	1989	Rome	Italy	484/89
25 bis	23.-25.1.	1990	Hague	Netherlands	48/90
26	12.-16.3.	1990	Sofia-Antipolis	France	143/90
27	11.-15.6.	1990	Stavanger	Norway	226/90
28	1.-5.10.	1990	Corfu	Greece	339/90
29	14.-18.1.	1991	Saarbruecken	Germany	119/91
30	11.-15.3.	1991	Bristol	UK	201/91

APPENDIX 3

TABLE 54 Participants of NMT Group 1971-1975

Participant	Administration	1 Stockholm 14.-15.1. 1970	2 Oslo 11.-13.3. 1970	3 Copenhagen 27.-29.4. 1970	4 Stockholm 5.-7.10. 1970	5 Oslo 20.-22.1. 1971	1971 Rep	6 Copenhagen 25.-27.5. 1971	7 Stockholm 2.-4.10. 1971	8 Helsinki 16.-16.3. 1972	9 Oslo 30.5.-1.6. 1972	10 Copenhagen 5.-7.9. 1972	11 Stockholm 5.-7.12 1972	12 Helsinki 8.-10.5. 1973	1973 Rep.	13 Oslo 25.-27.9. 1973	14 Copenhagen 2.-4.4. 1974	15 Stockholm 2.-6.9. 1974	16 Helsinki 4.-6.2. 1975	1975 Rep
Olesen, P.K.	Dk	x	x	x	x	x	x	x	x	x	x	<--x	na	na	x	-	-	-	-	-
Jacobsen, M.	Dk	-	x	x	x	x	x	x	x	X	x	na	na	x	x	x	x	na	x	x
Sterndorff, P.	Dk	-	-	-	-	x	x	x	x	0	0	na	na	x	x	x	x	na	x	x
Nielsen, S.	Dk	-	-	-	-	-	-	-	-	-	-	x-->	na	x	x	x	x	na	x	x
Aagaard, P.	Dk	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x-->	x	x
Jalli, E.	FIN	x	x	x	x	x	x	x	x	<--x	0		na	na	x	-	-	-	-	-
Svensson, R.	FIN	-	-	-	x	0	x	0	0	0	0	na	na	0		-	-	-	-	-
Nikkilä, J.	FIN	-	-	-	-	-	-	x	0	0	0	0	0	0	+	-	-	-	-	-
Valle, J.	FIN	-	-	-	-	-	-	0	x	x	-	-	-	-	-	-	-	-	-	-
Takala, P.	FIN	-	-	-	-	-	-	-	-	x-->	0	na	na	0	x	-	-	na	x	-
Merontausta, K.	FIN	-	-	-	-	-	-	-	-	-	-	x-->	na	x	x	x	x	na	x	x
Räsänen, E.	FIN	-	-	-	-	-	-	-	-	-	-	-	-	x	+	x	x	na	x	x

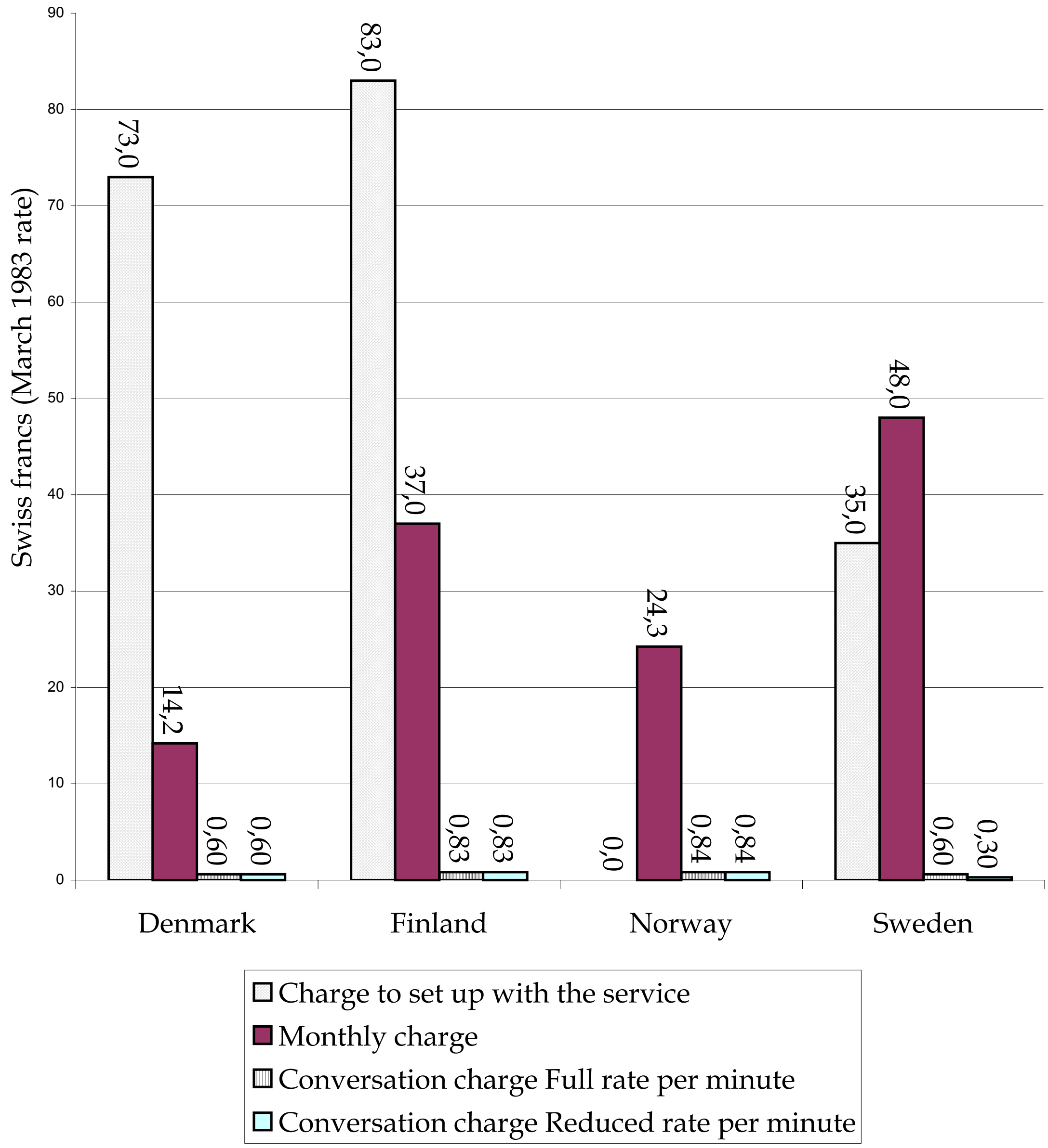
TABLE 54 continues

Teräsvuo, K.	FIN	-	-	-	-	-	-	-	-	-	-	-	-	x	-	x	0	na	0	+
Kangasluoma, M.	FIN	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x-->	x	x
Grimsmo, N.A.	N	**X**	x	x	x	x	x	x	x	**X**	x	na	na	x	x	x	x		x	x
Torvik, R.A.	N	**X**	x	x	x	x	x	0	0	0	0	-	-	-	-	-	-	-	-	-
Böe, A.	N	-	x	0	x	x	x	0	0	0	0	na	na	0	0	0	0	na	x	-
Lund, G.	N	-	-	-	-	x	0	x	x	x	x	na	na	0	x	x	x	na	0	x
Midtsund, R.	N	-	-	-	-	x	0	x	x	x	0	na	na	x	x	x	<--x	-	-	-
Hadland, O.	N	-	-	-	-	-	-	-	-	-	x	na	na	0	+	0	0	0	0	+
Skarbovik, D.	N	-	-	-	-	-	-	-	-	-	x	na	na	-	-	-	-	-	-	-
Öwre, T.	N	-	-	-	-	-	-	-	-	-	-	-	-	x	+	x	-	-	-	+
Wien, P.	N	-	-	-	-	-	-	-	-	-	-	na	na	na	-	-	-	na	-	+
Bö, K.	N	-	-	-	-	-	-	-	-	-	-	na	na	na	-	-	-	na	-	+
Wilsson, P.	S	**X**	x	x	x	x	x	x	x	x	x	na	na	x	x	x	<--x	na	-	x
Haug, T.	S	**X**	x	x	x	x	x	x	x	**X**	x	na	na	x	x	x	x	na	x	x
Bokstam	S	**X**	x	x	x	x	x	x	x	**X**	x	na	na	x	x	x	x	na	x	x
Björnsjö, K.	S	**X**	0	0	0	0	x	0	0	0	0	na	na	-	-	-	-	-	-	-
Bengtsson, G.	S	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
Lönn, T.	S	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
Wallén, M.	S	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
Mäkitalo, Ö.	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x-->	na	x	x

Sources: NMT Minutes; NMT reports to 1971, 1973 and 1973 Telecommunication conferences

Note: **Bold** = Frequency expert; x = Present; 0 = Absent; na = Information not available (Meetings # 10-12 and 15)
- = Did not yet or any more participate; + = Some kind of contribution to work according Telecommunication Reports
←x = Participation ended according Telecommunication Report
x→ = Participation started according Telecommunication Report

APPENDIX 4



Source: GSM Doc 33/83
FIGURE 18 NMT Charges in the Nordic countries

APPENDIX 5

NMT-450 Statistics on the Nordic countries

	BASE STATIONS				RADIO CHANNELS				SUBSCRIBERS			
	Dk	FIN	N	S	Dk	FIN	N	S	Dk	FIN	N	S
1982	26	0	61	26	141	0	189	76	1400	0	1670	1344
1983	27	28	153	117	177	109	594	475	7150	2648	11059	11084
1984	35	66	171	151	352	281	835	797	16058	8655	23473	27118
1985	57	102	286	203	707	607	1477	1318	30679	17865	39050	47565
1986	78	147	385	293	1153	1075	2089	2531	46098	32309	63185	75998
1987	102	215	436	358	1753	1762	2881	3660	56311	49603	86925	112644
1988	125	333	531	453	2091	2688	4083	5561	56816	69560	111167	153120
1989	129	466	673	556	2186	3724	5839	7625	55947	89422	125771	192080
1990	135	661	790	666	2226	5407	6983	9352	54162	112046	135257	222780
1991	146	882	905	770	2146	7210	7907	10748	53085	133666	143346	240032
1992	169	1002	1006	866	2267	8217	8517	11411	51244	149573	147307	245628

	RADIO CHANNELS PER BASE STATION				SUBSCRIBERS PER BASE STATION				SUBSCRIBERS PER RADIO CHANNEL			
	Dk	FIN	N	S	Dk	FIN	N	S	Dk	FIN	N	S
1982	5,4	0,0	3,1	2,9	54	0	27	52	26	0	61	26
1983	6,6	3,9	3,9	4,1	265	95	72	95	27	28	153	117
1984	10,1	4,3	4,9	5,3	459	131	137	180	35	66	171	151
1985	12,4	6,0	5,2	6,5	538	175	137	234	57	102	286	203
1986	14,8	7,3	5,4	8,6	591	220	164	259	78	147	385	293
1987	17,2	8,2	6,6	10,2	552	231	199	315	102	215	436	358
1988	16,7	8,1	7,7	12,3	455	209	209	338	125	333	531	453
1989	16,9	8,0	8,7	13,7	434	192	187	345	129	466	673	556
1990	16,5	8,2	8,8	14,0	401	170	171	335	135	661	790	666
1991	14,7	8,2	8,7	14,0	364	152	158	312	146	882	905	770
1992	13,4	8,2	8,5	13,2	303	149	146	284	169	1002	1006	866

Sources: TN NMT Statistics

Note:

Dk = Denmark
FIN = Finland
N = Norway
S = Sweden

APPENDIX 6

National breakdown of NTA-NTO members at GSM meetings

DELEGATION	GSM MEETING #							TOTAL NUMBER
	1st Stockholm	2nd Hague	3rd Gothenburg	4th Rome	5th Berne	6th London	7th Oslo	
United Kingdom	7	5	5	5	4	10	6	42
France	4	5	5	4	5	6	4	33
Sweden	6	4	4	3	3	5	4	29
Germany	3	2	2	2	3	5	4	21
Denmark	2	3	2	2	2	3	4	18
Netherlands	2	6	2	2	2	2	2	18
Norway	2	2	1	2	2	3	3	15
Italy	1	1	1	4	3	2	2	14
Switzerland	2	3	3	3	1	1	1	14
Finland	1	1	2	1	1	2	2	10
Spain	0	1	2	1	1	1	1	7
Belgia	0	1	0	1	0	1	0	3
Austria	0	0	0	1	0	1	0	2
Greece	0	0	0	1	0	0	1	2
Portugal	1	0	0	0	0	0	0	1
Total number	31	34	29	32	27	42	34	229
NON-EEC	11	12	11	14	11	13	12	12
Non-EC%	45,5	41,7	45,5	42,9	45,5	46,2	41,7	41,7

DELEGATION	GSM MEETING #											TOTAL
	8th Paris	9th Berlin	10th Athens	11th Copenhagen	12th Madrid	13rd Funchal	14th Brussels	15th London	16th Hague	17th Florence	17E th London	
Austria	0	0	1	0	0	0	1	1	1	1	1	6
Belgia	0	1	1	1	1	1	1	1	1	1	1	10
Denmark	3	4	3	5	4	4	3	3	3	3	1	36
Finland	2	3	2	1	1	2	1	1	1	1	1	16
France	7	6	4	4	4	4	4	4	4	4	3	48
Germany	5	6	3	4	4	3	3	3	6	6	5	48
Greece	1	0	5	1	1	1	1	0	1	2	0	13
Ireland	0	1	1	2	0	0	0	1	1	1	0	7
Italy	3	2	1	1	2	2	3	2	2	4	2	24
Netherlands	2	1	2	2	3	3	2	2	4	3	1	25
Norway	2	3	3	3	4	3	5	4	4	3	2	36
Portugal	1	1	1	1	1	2	1	1	1	1	1	12
Spain	1	1	2	1	4	1	1	3	3	3	1	21
Sweden	5	7	4	4	4	4	3	4	5	5	2	47
Switzerland	0	2	2	2	2	1	1	1	1	1	1	14
United Kingdom	5	6	6	7	7	6	7	12	8	11	8	83
PN	0	0	0	0	2	4	3	3	4	10	4	30

	18TH Vienna	19TH Espoo	20TH Paris	21ST Munich	22ND Madrid	23RD Rönneby	24TH Fribourg	25TH Rome	25TH BIS Hague	26TH Sophia-Antipolis	27TH Stavanger	28TH Corfu	29TH Saarbrucken	30TH Bristol	TOTAL
Austria	1	1	0	x	x	1	1	1	1	1	1	1	1	1	11
Belgia	2	1	1	x	x	1	1	1	2	1	1	1	1	1	14
Denmark	4	3	2	x	x	2	2	2	1	2	2	2	2	2	26
Finland	1	6	2	x	x	2	2	2	2	2	3	3	2	2	29
France	4	4	6	x	x	5	7	7	5	4	7	6	6	4	65
Germany	4	4	2	x	x	2	5	3	3	5	3	4	7	6	48
Greece	1	1	1	x	x	2	1	1	1	1	1	6	1	1	18
Ireland	0	1	0	0	0	1	1	1	1	1	1	1	1	1	10
Italy	1	1	2	x	x	3	2	4	1	1	3	3	3	2	26
Netherlands	2	1	2	x	x	2	2	2	2	0	2	1	1	1	18
Norway	3	3	3	x	x	4	3	3	1	3	6	3	2	2	36
Portugal	2	2	2	x	x	2	2	2	2	2	2	2	0	2	22
Spain	3	3	3	x	x	2	3	4	3	3	2	2	2	2	32
Sweden	4	5	4	x	x	3	3	3	1	4	6	5	4	6	48
Switzerland	2	2	1	x	x	1	4	2	1	2	2	2	2	0	21
United Kingdom	11	9	10	x	x	8	7	6	7	5	12	11	14	16	116
PN	8	9	9	6	6	7	6	7	6	8	7	7	7	9	102
HK	0	0	0	0	0	0	0	0	0	2	1	1	1	2	7
MoU	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1

Note: HK = Hong Kong; PN = Permanent Nucleus; MoU = GSM MoU organization

Breakdown of the GSM meetings by type of player

PLAYER	8TH	9TH	10TH	11TH	12TH	13RD	14TH	15TH	16TH	17TH	17E TH	TOTAL
Number of participants												
NTA-NTOs	37	44	41	39	44	41	40	46	50	60	34	476
Manufacturers	0	0	0	0	0	0	4	7	9	9	0	29
Total	37	44	41	39	44	41	44	53	59	69	34	505
Percentage												
NTA-NTO (%)	100	100	100	100	100	100	91	87	85	87	100	94
Manufacturers (%)	0	0	0	0	0	0	9	13	15	13	0	6

PLAYER	18TH	19TH	20TH	21ST	22ND	23RD	24TH	25TH	25TH BIS	26TH	27TH	28TH	29TH	30TH	TOTAL
Number of participants															
NTA-NTOs	53	56	50	..	..	48	52	51	40	47	62	61	57	61	650
Manufacturers	8	10	10	..	..	23	30	37	28	31	38	44	52	41	356
CEC	0	0	0	0	0	2	1	1	0	0	0	0	1	0	5
TOTAL	61	66	60	61	66	73	83	89	68	78	100	105	110	102	1011
Percentage															
NTA-NTO (%)	87	85	83	..	88	66	63	57	59	60	62	58	52	60	64
Manufacturers (%)	13	15	17	..	12	32	36	42	41	40	38	42	47	40	35

Sources: GSM Minutes #1-30
Note: Status of participant not available for 21st and 22nd meetings

APPENDIX 7

Plans of European NTAs to exploit the 900 MHz mobile telephone band in December 1982

COUNTRY	160 MHZ	450 MHZ	CAPACITY SUFFICIENT	NEED OF 900 MHZ INTERIM SYSTEM	REMARKS
Germany	X	NY	C-450 up to mid 1990's	NO	
Switzerland	X	NY	Mid 1980's	Issue open	Options: 160/450/900
Italy	X	NY	450 MHz system up to mid 1990's	NO	
Portugal	-	-	160 MHz up to the GSM	NO	
Netherlands	X	NY	NMT-450 up to mid 1990's	NO	
Belgium	..	NY	NMT-450 up to mid 1990's	NO	
France	X	X	NOT	1985-1986	Only alternative
UK	X	- (NA)	NOT	1985	
Ireland	?	NY	Decided to build NMT-450	Issue open	If the United Kingdom deploys NMT-900
Spain	X	X	No need for 900 MHz system	NO	
Austria	X	NY	No need for 900 MHz system	NO	
Denmark	X	X	NOT	Before the end of 1980's or although earlier	NMT on 900 MHz band
Finland	X	X	Until 1990	No commitments	
Norway	X	X	NOT	Before 1987	NMT on 900 MHz band
Sweden	X	X	NOT	1985-1987	NMT on 900 MHz band

Source: GSM Doc 32/83
Remarks:

X = Band in use
NY = Not yet in use
- = Not in use
NO = No need

APPENDIX 8

TABLE 55 Users of digital cellular in 1997 and 1999 (in millions)
Sources: IDATE-EGIS 1998; EMC

Region	1997			1999			1997	1999
	GSM	Others	TOTAL	GSM	Others	TOTAL	GSM %	GSM %
Western Europe	46,3	-	46,3	2,0	-	2,0	100,0	100,0
Eastern Europe	2,6	-	2,6	12,9	0,3	13,2	100,0	97,7
North America	1,3	1,0	2,3	5,4	35,3	40,7	56,5	13,3
Latin America	0,0	2,0	2,0	0,8	17,9	18,7	0,0	4,3
Asia-Pacific	16,5	33,2	49,7	66,6	73,8	140,4	33,2	47,4
Africa and Middle East	3,1	-	3,1	0,2	0,0	0,2	100,0	100,0
Total	69,8	36,2	106,0	236,9	127,3	364,2	65,8	65,0

TABLE 56 Diffusion of digital cellular systems by number of countries adopting them.
Source: EMC Reports

Year	Western Europe			East Europe			Middle East			Africa			Asia-Pacific			USA& Canada			Latin America		
	GSM	US-TDMA	CDMA	GSM	US-TDMA	CDMA	GSM	US-TDMA	CDMA	GSM	US-TDMA	CDMA	GSM	US-TDMA	CDMA	GSM	US-TDMA	CDMA	GSM	US-TDMA	CDMA
1992	9	-	-								-			2			2			..	
1993	5	-	-							1	-		3	0			0			..	
1994	5	-	-	2	2		4	1		2	-		8	1			0			..	
1995	5	-	-	6	0		3	0		6	-		4	2	1		0			..	
1996	2	-	-	9	1		3	0		0	-		2	1	1	2	0	1	1	..	2
1997	1	-	-	4	0		0	0		8	-		2	0	1	0	0	1	1	..	0
1998	2	-	-	3	0	1	0	0		7	-		0	0	3	0	0	0	1	..	4
1999	0	-	-	2	0	0	2	0	1	5	-		2	2	3	0	0	0	1	..	4
2000	0	-	-	1	0	0	0	0	0	6	-	2	0	0	3	0	0	0	7	..	3
TOTAL	29	0	0	27	3	1	12	1	1	35	0	2	21	8	12	2	2	2	11	*30	13

TABLE 57 Major activity of North American companies on the European telecommunication manufacturing market before 1996

Sources: Yearbook of European Telecommunications 1991, 1992, 1995, 1996; The European Telecommunications Fact File 1992 I-II, 1995, 1996; Noam 1992; European Mobile Communication Reports

Company	A) Ownership changes	B) Negative assessment	C) Alliances/ agreements	Remarks
1982 AT&T (USA): 50-50 joint venture APT (later AT&T Network Systems International NSI) with Philips (NL)	-1987: Philips share to 40 % -1989: Philips share to 15 %	-1990: Philips withdrew	-1994: alliance with Philips to market GSM infrastructure -1995: bought Philip's activities with cellular infrastructure	-Originally Philips attained possibility to market digital switching technology -Established subsidiaries in several European countries -1995: AT&T announced to separate operator and manufacturer functions; lost repeatedly orders in Europe (=>Lucent)
	-1989: AT&T bought 20 % of Italtel (I)	-1993: agreement between Siemens and Italtel => -1995: AT&T left Italtel		-A: R&D in digital public switching
1986 Motorola (USA): bought Storno (Dk) from GE			-1991: agreement with Northern Telecom (Can), Alcatel and Siemens to market products based on open system interfaces -cross-licensing agreements with Alcatel (1991), Siemens (1991), Ericsson, Nokia	-A: to manufacture and market NMT and TACS (analog) mobile phones -1988 contracts for GSM validation systems with Cellnet (UK), Nordic countries PT's joint, Spain, German PT

TABLE 57 continues

Northern Telecom (Can)	-1987: bought 27 % of STC (UK) -1991: 97 % of STC=> Northern Telecom Europe Ltd		-1990: agreement between STC and Orbitel (UK) to develop base-stations for DCS1800	-A: supplementing strengths (NT switching; STC transmission); market -May 1991: agreement with Micrtotel (Oragne) to supply a switch for DCS 1800 network
	1992 acquired 20% holding of Matra Communication (F) =>50:50 joint venture Matra Cellular (1993) 1994 raised the share held by Matra Communication to 50% and that of Matra Cellular to 66%			Matra Cellular: to develop, sell and install GSM and PCN systems worldwide

TIIVISTELMÄ (FINNISH SUMMARY)

Ari T. Manninen

NMT ja GSM matkapuhelinstandardien synty. Standardoinnin kehitys järjestelmän filosofiasta sen käyttöönottoon

Tämä tutkimus tarkastelee NMT ja GSM matkapuhelinstandardien syntyä. Tavoitteena on ymmärtää standardin kehityksen kaari järjestelmän taustalla olevasta filosofiasta (ajattelumallista) sen markkinoille saamiseen.

Tutkimuksen keskeisenä tavoitteena on rekonstruoida 1) järjestelmän perusfilosofia; 2) NMT ja GSM standardointiprosessit; 3) prosessien keskeisten toimijoiden keskinäinen vuorovaikutus ja vaikutus standardointiprosessin kulkuun sekä 4) selittää NMT ja GSM standardien menestys. Analysoimalla kahden menetyksellisen matkapuhelinjärjestelmän standardointiprosessit pyritään selvittämään, mitkä olivat erityisesti pohjoismaiset standardointikäytännöt ja –menettelytavat, jotka siirtyivät ensimmäisen sukupolven järjestelmän (NMT) standardoinnista seuraavien sukupolvien standardointiprosesseihin. Pohjoismaisuutta ei ymmärretä pelkästään maantieteellisenä käsitteenä, vaan laajemmin lähestymistapana, jonka keskeisimpiä piirteitä myös monet muut maat omaksuivat myöhemmin.

Standardointiprosessi jaetaan kolmeen jaksoon: 1) valmisteluun; 2) standardin asettamiseen; 3) soveltamiseen. Kehityksen jako toiminnallisesti toisistaan poikkeaviin, erottuviin jaksoihin on metodisesti tärkeää, koska eri vaiheissa erilaisten toimijoiden aktiivisuus vaihteli ja niiden toiminta saattoi olla eri vaiheissa haitallista standardointiprosessin kannalta.

Matkapuhelinalasta on kirjoitettu verraten paljon. Kiinnostus on selvästi ollut yhteydessä alan kehitykseen ja seurannut alan painopisteiden muuttumista. Kirjallisuuden suuri määrä ei ole tutkimuksellisesti myönteistä, koska varsinkin aluksi alan kehitystä tarkasteltiin vain tekniikan kehityksen kannalta. Tuolloin ei kiinnostuttu alan kannalta olennaisista kysymyksistä, jotka vaikuttivat alan kehitykseen tekniikkaa huomattavasti enemmän. Tämän vuoksi ilmiöitä tulkittiin virheellisesti ja virheet kasautuivat julkaisujen määrän lisäännyttyä. Vinoutunut tutkimusote oli ymmärrettävää, koska matkapuhelinalallakin vallitsi tekniikkakeskeinen lähestymistapa pohjoismaita lukuunottamatta.

NMT ja GSM –standardeista on tehty myös akateemisia tutkimuksia, mutta niissä on yleisesti kaksi perustavaa heikkoutta. Tutkimuksen lähetystapa on kansallisesti rajattu, vaikka prosessit olivat monikansallisia. Monet tutkimukset ovat myös niin keskeisesti teoriapainotteisia, että niiden luoma näkemys standardoinnista ei ole yhtenevä historiallisen kehityskulun kanssa.

Siksi tässä tutkimuksessa sovelletaan historiantutkimuksen lähetystapoja ja tutkimus perustuu alkuperäislähteisiin.

Tyypillisesti omaksuttu kansallinen näkökulma ja tutkimusaiheen kansallinen rajaus ei pelkästään typistä tutkittavaa ilmiötä, vaan sillä on tätäkin merkittävämpi seuraus. Yhteistyö oli menetyksellisen standardoinnin kulmakivi, eikä sen olennaisia vaikutuksia prosessin kannalta voi ymmärtää kansallisesta näkökulmasta tarkasteltuna.

Teknologian suhde yhteiskuntaan on avain alan kehitykselle. Yhdysvalloissa ja useimmissa Euroopan maissa omaksuttiin tekniikkaan keskittynyt lähestymistapa, minkä vuoksi järjestelmät olivat kalliita, eikä niiden suunnittelussa ollut huomioitu yhteiskunnallisia tarpeita. Pohjoismaissa sen sijaan lähtökohdaksi asetettiin yhteiskunnan tarpeet, minkä vuoksi yhteiskunnallinen tarve oli tärkeysjärjestyksessä ensimmäisenä. Tekniikkaan ei suhtauduttu itseisarvona, vaan toteutukseen suhtauduttiin joustavasti, kunhan määritellyt palvelut pystyttiin toteuttamaan. Pohjoismaiden omaksuma poikkeuksellinen asenne antoi niille etumatkan muihin maihin nähden.

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[1071] A more detailed list of the most fundamental documents is provided in Appendix 1.

Hans Myhre	Norwegian NTA, Telenor Mobil, Oslo; interviewed on 10 August 1998 by K. Lyytinen, A. Manninen and V. Fomin interviewed on 13 and 14 March 2001 by A. Manninen, K. Lyytinen and V. Fomin interviewed on 14-16 March 2001 by A. Manninen
Östen Mäkitalo	Swedish NTA, Stockholm; interviewed on 22 October 1995 by J. West and A. Andeen
Jorma Nieminen	Salora, Mobira, Benefon; interviewed on 15.5.1995 by J. Knuuttila
Matti Pasanen	Finnish NTA, Sonera, Helsinki; interviewed on 19 Feabruary 2001 by A. Manninen and A. Kivimäki
Hans Thiger	Swedish NTA, Finnish NTA, Sonera, Helsinki; interviewed on 19 February 2001 by A. Manninen and A. Kivimäki
Keijo Toivola	Finnish NTA, Helsinki; interviewed on 17 October 1996 by K. Lyytinen, J.L. King, J. Knuuttila, J. West and A. Andeen interviewed on 3 June 1998 by A. Manninen

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