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THE NMT SYSTEM AND LAND MOBILE COMMUNICATIONS AFTER THE END OF THE BEGINNING

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Swedish Telecom Radio

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Ladies and Gentlemen,

It is a great honour and pleasure for me to be here in London taking part in this conference. What we are all seeing right now is a fascinating evolution in land-mobile telecommunications all around the world. An evolution in which, I am sure we all agree, it is exciting and stimulating to take part.

As the title of this speech, I have chosen the phrase "The NMT system and land mobile telecommunications after the end of the beginning". Indeed with the NMT system we have come to a new era after the end of the beginning, but as I believe that we have reached a point in history in which the land mobile telecommunications in its entirity has somehow reached a stage which can be called the end of the beginning, I would like to devote some minutes to summarizing our yesterdays. Then I will describe the NMT development from different viewpoints before I widen the perspective to the whole of land mobile communications with some thoughts about the medium and long term development.

But first, let me begin by introducing with some few words Swedish Telecom Radio, the company from which I come. (Figure 1)

Swedish Telecom Radio is an independent part of Swedish Telecom, a tele-communications organisation something like British Telecom.

Swedish Telecom Radio has three main areas of business:

* Local, regional, national and international distribution of AM/FM radio and VHF/UHF television programs.

* Fixed radio facilities, such as telephony microwave radio links and satellite earth stations.

* Mobile telecommunications.

Swedish Telecom Radio has 2,300 employees. In 1984, Swedish Telecom Radio had a turnover of 100 million pounds. Half of this was generated in the mobile profit center.

The sector for Land Mobile Telecommunications is by far the most expansive; the turnover has grown 20 times over the past ten years.

Cooperation between the countries in the Nordic area is considerable, particularly the land mobile cooperation. (Figure 2)

History - from local dispatch to advanced international cellular

The development of land mobile telecommunications began in Sweden at the end of the 1930's. At that time, the Swedish Police were equipped with their first mobile radio units. It thus became possible for a Situation Room, via its own transmitting/receiving base station, to guide police patrols on the move. This type of dispatch traffic system dominated developments in Sweden until the end of the 1970's. Speech communication was the only kind available.

Developments in dispatch type mobile radio have certainly led to increased efficiency in industry, trade and public administration, but the weaknesses have become gradually more and more apparent.

Examples of these are: (Figure 3)

* poor use of the frequency spectrum

* poor or non-existant opportunities for inter-network traffic

* no large area coverage

* no direct link with the public fixed telephone network and the enhanced services thus available

* an unfortunate customer cost development for terminals and system equipment as a result of the lack of standardization and thereby small production volumes

* low second-hand market values for terminals, this too as a result of the lack of system and network standards

In order to eliminate at least some of these shortcomings, Swedish Telecom Radio began in the 1950's the development of a first-generation automatic mobile telephone system. This system came into operation in 1955. (Figure 4)

By the end of the fifties, the number of mobile terminals in circulation was approximately 7,000. Almost all of these were in local dispatch systems. Only slightly over 1% were first-generation mobile telephones.

1965 saw the introduction of the second-generation automatic mobile telephone system covering Sweden's three main metropolitan areas. However, by the end of the sixties, mobile telephones still only constituted a couple of percent of the total number of land mobile terminals.

During the sixties, paging was beginning to penetrate the market. Developments were in line with that of mobile radio, i.e. with the establishment of highly localized systems. In 1969, paging had a market share of 17%.

The same year 1969 - the Nordic countries agreed on development of a common, modern and automatic cellular mobile telephone system - the third generation - which was christened MTC, and later re-christened NMT - the Nordic Mobile Telephone system.

Because of the existing market need, and in order to allow adequate time for development of the new system, a more simple, manual Nordic system was introduced in 1971. This was called MTD. At most, in 1981, the MTD system had 20,000 subscribers, i.e. 2.5 mobile telephones per thousand inhabitants.

Although the development expressed in user numbers was quite good, the first real breakthrough in land mobile communications in Sweden came at the end of the seventies with the introduction of the nationwide FM broadcast transmitter subcarrier numeric display paging system, and with the launching of the NMT system in 1981. In March 1982, all Nordic countries with the exception of Iceland were connected to the NMT system.

These two services have constituted a dramatic transition of the market from local dispatch-type systems to nationwide and even international public systems. These systems cancel out the above-mentioned problems in land mobile telecommunication. The two services have transformed market expansion from being good to being explosive. At the beginning of this year, mobile telephones had a 17% market share - an increase of 15% in ten years, most of which was achieved from 1982. The mobile radio share has diminished from 81% in 1969 to 43% in 1984. Paging has increased from 17% to 40% over the same period. The number of subscribers has increased from 54,000 to 375,000. This equates to 47 users per thousand inhabitants. (Figures 4 and 5)

Over the next few years, Swedish Telecom Radio will introduce a number of new, nationwide public services within the three well-defind market areas for the eughties i.e. mobile telephony, mobile radio and paging. The basic philosophy

is to provide access to the surrounding world to people on the move with highly frequency efficient systems, the same level of service as is available in the public fixed networks and with full access to these networks.

The steps from local dispatch to international cellular took some forty years. We have now reached the end of the beginning with regard to land mobile telecommunications and the prospects are excellent.

The NMT system

The market

Based on market surveys, experience from operating our earlier systems and experiences learned from other countries, it was calculated that 45,000 subscribers would join the NMT cellular system over a period of ten years, i.e. by 1991. This forecast was soon found to be inaccurate and has been revised upwards on several occasions. Current growth forecasts indicate a total of 175,000 NMT subscribers in Sweden by 1991. This equates to 22 mobile telephones per thousand inhabitants. With the same mobile telephone density in the other Nordic countries which seems most likely, the total in this area in 1991 would be around 450,000 subscribers. By the end of May 1985, the number of subscribers in Sweden was 59.000 i.e. 7.4 telephones per thousand. This means that within three years, the NMT system had attracted more subsribers than the original ten-year forecast. There are currently no signs of a slackening-off of this trend. On the contrary. In the Nordic countries as a whole, the number of subscribers by the end of May 1985 was approximately 170,000 (8.5 telephones per thousand). (Figure 6)

This subscriber rush has meant that the NMT system has had to be extended far more rapidly than was originally planned, both from the point of view of capacity and that of coverage.

It has been our experience that subscribers place very high demands on accessibility once they have acquired a mobile telephone, both with regard to channel capacity and to area of coverage. We have given priority to extending the capacity of existing base stations. This has led to a certain amount of dissatisfaction when it comes to area of coverage.

If we return for a moment to the development of the land mobile market as a whole, current estimates of the number of subscribers in 1991 is 720,000 (i.e. 90 users per thousand inhabitants). In 1995, the potential market for land mobile services - in industry, trade and public adminstration - will, according to current figures, be in excess of two million subscriber terminals, all figures related to Sweden alone.

The marketing

Swedish Telecom Radio markets the NMT as well as other mobile services energetically. In marketing, the gains to be made as a result of more efficient communication - through the use of mobile teleservices - both in terms of competition and in profits, have consistantly been placed in the foreground.

Swedish Telecom Radio is not in any way involved in the marketing and sale of mobile telephones as such. This is taken care of by a large number of suppliers and their dealers (approximately 700 in number) all over Sweden.

All marketing is planned and takes place in cooperation between on the one hand Swedish Telecom Radio, as service supplier, and on the other the mobile telephone suppliers. (Figures 7-12)

As far as the Swedish market is concerned, there is today an extremely good balance between Swedish Telecom Radio - developing, establishing and maintaining the public systems for mobile communication - and private companies and dealers supplying customer equipment to the systems.

This arrangement means that we have succeeded in avoiding a costly and inefficient double coverage of the cellular mobile telephone structure, something that would be especially problematic in a country such as Sweden, with its many sparcely populated areas. At the same time, the importance of strong, healthy local, regional and national competition between mobile terminal suppliers has not been neglected but has been kept at a very high level. With this single structure, we can afford to maintain a homogeneous system with good coverage throughout most of Scandinavia.

At this time, there are eleven type approved mobiles in several versions on the Scandinavian market priced between 1500 and 2000 pounds. (Figures 13)

International marketing

NMT cellular - 450 MHz as well as 900 MHz - is a mobile telephone system developed and specified in detail by Swedish Telecom Radio and its counterparts in the other Nordic countries. There are no exclusive rights in existence between Nordic operators and the suppliers of NMT network equipment. (Figure 14)

The NMT system has been extremely well recieved in many countries outside Scandinavia. Among countries that either operate or have planned for an NMT system, I can mention (Figure 15)

The Netherlands	Iceland	Tunisia
Spain	Switzerland	Thailand
Austria	The Republic of China	Indonesia
Malaysia	Luxemburg	
Saudi-Arabia	Belgium	

I would particularly like to point to the possibilities that NMT has given to a country such as Malaysia, where the Nordic cellular has now been adopted as a rapid alternative to the timeconcuming development of a fixed telephone project.

Due to the international success of the NMT cellular system, many suppliers of exchanges and base stations, etc have shown interest in the system. Among these suppliers, I can mention: (Figure 16)

* Ericsson
* ITT
* Motorola
* Telenokia
* Mitsubishi
* Philips
* Mobira
* Radiosystem
* Magnetic

Pricing, traffic habits etc

The subcription fee is 140 pounds per year (175 US Dollars) and each minute costs 0.30 pounds (0.4 US Dollars) between 8 am and 6 pm. The off-peak rate is 0.20 pounds (0.25 US Dollars) per minute. The traffic costs are the same from and to mobiles and are bourne by the caller.

The charges are the same throughout the Nordic area.

Overseas calls are charged as normal overseas calls.

Extra services such as call diverting carry a separate charge.

Short messages to and from NMT subscribers can be relayed without charge by a secretary service. More comprehensive messages are charged by length. The secretary service is much appreciated, and the number of calls per day to the four secreterial centres is currently approximately 8000.

The average NMT subscriber makes 630 calls and recieves 270 per year, a ratio of 70/30.

The average total annual NMT-subscriber spending is around 400 pounds (510 US Dollars). The total income including that from fixed subscriber calls, thus generated for Swedish Telecom Radio is about 510 pounds (655 US Dollars) per year and subscriber.

Billing of subscribers is based on registration tapes from the mobile telephone exchanges. Billing has generally operated satisfactorily, even inter-Nordically. However, some cases of incomplete or incorrect information from the exchanges have resulted in billing delays. In the case of large subscriber numbers, such delays although small can result in considerable losses of revenue.

Establishing status and coverage area

Because of its growth, the development of NMT has been greatly accelerated. In Scandinavia, at the end of March 1985, there were: (Figure 17)

* 7 exchanges
* 737 cells
* 4707 channels

and in Sweden

* 2 exchanges
* 233 cells
* 1631 channels

These figures show that the average number of channels at a base station is 7,1 while the average number of subscribers per channel is 36.

The NMT system today covers all of Denmark, the greater part of Norway and Sweden, and about half of Finland. The total land area of Scandinavia is about 1100 000 square kilometers.

The system has complete automatic roaming (and charging procedures) between all exchanges in Scandinavia.

To begin with, the maximum capacity of each exchange was assumed to be about 50,000 subscribers. With today's traffic density of 18 mE per subcriber at peak times, the capacity limit is about 40,000 subscribers per exchange. (Figure 18)

The NMT system currently has at its disposal 180 duplex channels in the frequency band 450 MHz. In the original forecast, this number of channels was estimated to be sufficient for a long period of time using a traditional hexagonal small-cell structure in areas of dense traffic.

As I mentioned earlier, the use of mobile telephones grew far more rapidly than anyone imagined. The number of channels available was no match for the degree of traffic that resulted. This led to capacity problems at peak times particularly in the city centers.

The NMT small-cell concept for high density traffic areas

Today, these problems have been solved by means of a new small cell system, but not of the usual hexagonal type. Swedish Telecom Radio solved the problem using directional antennas in which the area coverage of the base station is in the form of circle sectors.

The design of the cellular structure in Stockholm is based on a shrewd knowledge of the nature of mobile telephone traffic. More than 50% of the traffic in the Stockholm area is in the city centre. The closer to the centre, the higher the number of calls. In the suburbs and surrounding areas, the relative number of calls is far lower. (Figure 19)

In order to obtain optimal use of hexagonal cells, traffic should be evenly distributed between them. Since traffic density is far higher in the city centre, the smallest cells must be there and the larger farther out.

Traditional hexagonal cellular structure do not meet this need. The hexagons can not be increased in sizes rapidly enough to compensate for a reduction in traffic intensity.

A hexagonal cellular structure would either mean insufficient capacity in the centre, or the existence of an oversized network in the suburbs and rural areas. An optimal network is one in which the capacity can be adjusted to traffic density through the entire network. This has now been achieved.

The base stations for the NMT system in Stockholm are equipped with log periodical antennas with a directional radiation pattern. The stations are set up in rings, with the antennas directed outwards from the centre. (Figure 20)

180 frequencies in the 450 MHz band are available to the NMT system, and each frequency can be repeated in every ring. In a hexagonal cellular system, two cells must be jumped over before a frequency can be repeated. In Stockholm, the radiation direction for antennas operating on the same frequency is shifted 120 degress from one ring to the next. Even allowing for the antenna's back lobe, there is still sufficient distance between them to avoid interference.

All the antennas for the innermost ring are located in the same place, at the hub of the system. The six innermost antennas are sited on the roofs of two adjacent tower blocks in the centre of Stockholm.

The new system of base stations in Stockholm was brought into operation at the beginning of 1985, and the previous problems of system overload have now been remedied. (Figures 21 and 22)

The work of designing, testing and installing the new base stations for the Stockholm small-cell structure took place for the most part in 1984 and under great pressure, since the work entailed not only designing a system for the future, but also remedying the acute, existing traffic problem. We are now able to claim that the operation was a success.

At present, the new Stockhom system utilizes 100 of 180 frequencies available in the 450 MHz band. This means that we can handle 10-12,000 subscribers in Stockholm, given the present level of traffic and a 5 % blocking rate. But if all the frequencies are utilized, we can accomodate around 20,000 subscribers. This capacity cannot be extended further by using more frequencies but there are contingency plans to increase the density of base stations in the city center by introducing additional rings. Such additions would increase capacity since the coverage area for each base station would thus be reduced.

NMT 900

But even the very efficient 450 MHz NMT small-cell will be insufficient after 1987/88 at the present rate of growth and the available number of channels. From the end of 1986, the NMT system therefore will be extended to the 900 MHz band. A parallell network of base stations will be established which shares the same exchanges as the 450 MHz system.

The NMT 900 cellular has been modified on some counts. Among other things a compander/expander function is included. The hand-off time is reduced to less than 0.4 seconds. But the main innovation is that the NMT 900 has a battery saving function and thereby will be the first cellular mobile telepone system with a good basis for the introduction of hand portables.

I talked earlier of the first breakthrough around 1980 in land mobile communications which came with the introduction of the nationwide public numeric paging and the cellular mobile telephony.

My belief is that the next breakthrough is the very moment when you at a reasonable price level can get rid of the 1500 kg you have to attach to the mobile telephones of today and that this very moment will arrive with the hand portable. A new dimension will be brought into the world of mobile communications.

The future

Then let me widen the perspective a little, both in time and in terms of mobile teleservices.

What we will be witnessing over the next 5 to 10 years in Scandinavia, in Europe and in many other parts of the world is the zenith of the analogous era.

We have advanced from isolated mobile radio devices to largescale general services for mobile telephony and paging. Today, the systems are linked to the public telephone system, and better satisfy the customers' requirements of accessibility to and from the outside world. The services are available to all proffessional and trade subscribers.

Considerable investments in such land-mobile systems, based on analog radio technique, are being made all over the world. System operators and terminal suppliers naturally have demands for a return on their investments and the life cycle of the systems will reach well into the nineties. A good return on investments is also important for creating preconditions for coming generations of mobile systems using other technologies. More about that later.

What does this mean in practical terms for a country such as Sweden? The development of mobile telephony, I have already described. NMT in the 900 MHz version will be the last mobile telephone investment using an analog system. The NMT service will of course be refined in many ways. For example, data transfers of different kinds will certainly be common in the future.

However, no radical changes in the NMT system are planned. The great marketing innovation that awaits us is the introduction of portable battery-powered handset type telephones. For the NMT system, a decrease in prices - both for using the system and for terminals - is also to be expected. One of the main factors contributing to this trend is the worldwide growth of the system.

For internal company dispatch-type traffic - mobile radio - Swedish Telecom is expanding a network of local base radio stations which are connected to the public telephone network and which are for multi-subscriber use. In this system, mobile units can be reached from an ordinary telephone, but the caller must know which base station is to be used. The mobile unit can call up to twenty numbers via the base station in which the numbers are programed. This type of mobile unit is cheap - between 500 and 900 pounds (650-1100 US Dollars). The subscriber is charged a fixed amount of 130 pounds (165 US Dollars) annually. The service, which is called MRG, is primarliy aimed at small firms with a geographically restricted area of activity. MRG is only used for speech communication.

The largest single sector of land-mobile communications today still is that of dispatch type such as communications between field personnel in mobile units and their dispatch centres. Most of the communications is in the form of speech. Each company has its own radio system and has been assigned a frequency channel shared with other companies in the same area, or its own frequency channels. In most cases the radio channel effciency is very low.

The growing demand for land mobile communications and the limited number of frequency channels available have caused a shortage of frequencies in many geographical areas. The only solution to this problem is to employ the frequencies more efficiently.

One approach is to transmit as much information as possible as digital data, another is to use trunked frequency channels for speech. In a shared system with trunked channels, the spectrum utilization can be improved by a factor of 2-7. At the same time, the total investment for the base radio station network can be reduced, or the user can get a more efficient communication system for the same outlay. However, the benefits of the trunked system must not cause loss of the advantages of private system, such as short call set-up times and scope for tailoring to specific demands of the user.

The Swedish Telecom Radio is now developing a new radio communication system that takes these facts into account. The system is known as MOBITEX.

In MOBITEX, data and text can be sent as digital data and speech calls are set up on a number of trunked schannels, shared by the users. The infra-structure (base radio stations and exchanges) is installed and operated Swedish Telecom Radio. This part of the system can be regarded as a transparent link for data and speech between the output of one terminal and the input of another. The user can design his own communication system by designing the terminals (mobile and fixed) to suit his needs. The terminals merely use MOBITEX as a communication between them.

The flexibility built into the system and the facilities for tailoring the terminals to the user's requirements make the system economically attractive to many radio communication users, who now run privatly owned radio systems. New user groups may also emerge, such as those who have not used radio communications so far because of economic reasons or because radio communication systems have not offered the facilities they needed, e.g. for data and text communications.

But still, MOBITEX is an analog system.

In the area of paging, we have the numerical display paging service (subcarrier) mentioned earlier. A week ago, we started a service very similar to the POCSAG-code based paging service here in the UK. The system is named MINICALL. We will soon have an alpha-numeric display paging service in operation based on the same POCSAG-code. In addition, the Scandinavian countries have agreed this spring to develop a digital highspeed alpha-numeric paging service.

With the analog services mentioned above, we can satisfy most of the market needs with regard to the need for land-mobile communication for the remainder of the eighties and a part of the nineties.

Much has been said and much has been written in recent years about the development of information technology and the social revolution that this will lead to. But there is an aspect that is often ignored in this line of reasoning: the enormous changes that will come to pass as a result of being able to liberate oneself from the limitations created by the length of cable between the terminal and the infrastructure itself, the network. Widening this distance - this limitation - is probably the most fundemental long-term goal that we who work in the field of mobile telecommunications have ahead of us. And the path leading to this goal surely goes via digital radio.

Let me outline a possible scenario.

Today, the area of land-mobile communications has three well-known mainstreams: mobile radio, mobile telephony, and paging. There is a broad range of systems and services of different degrees of advancement. The trend towards generalized systems that are well-integrated in the total telecommunications structure is obvious on the national level and also, to some extent, on the international level. The NMT system is a good example of this. All systems are analog and their life-cycles are likely to stretch well into the nineties.

At the same time, digital radio systems are being developed. Digital radio will provide smaller, lighter, easier to produce and cheaper subscriber terminals which have more functions than those we have today.

This development is under way today for example within the CEPT-GSM and within the industry. Let us hope that this will lead in the future to at least a common European standard and a common European system, since mobile communication - like all other types of communication - is dependent on universalization for its success.

The GSM system will be a mobile ISDN for professional users and the borderline between mobile radio and mobile telephony will cease to exist.

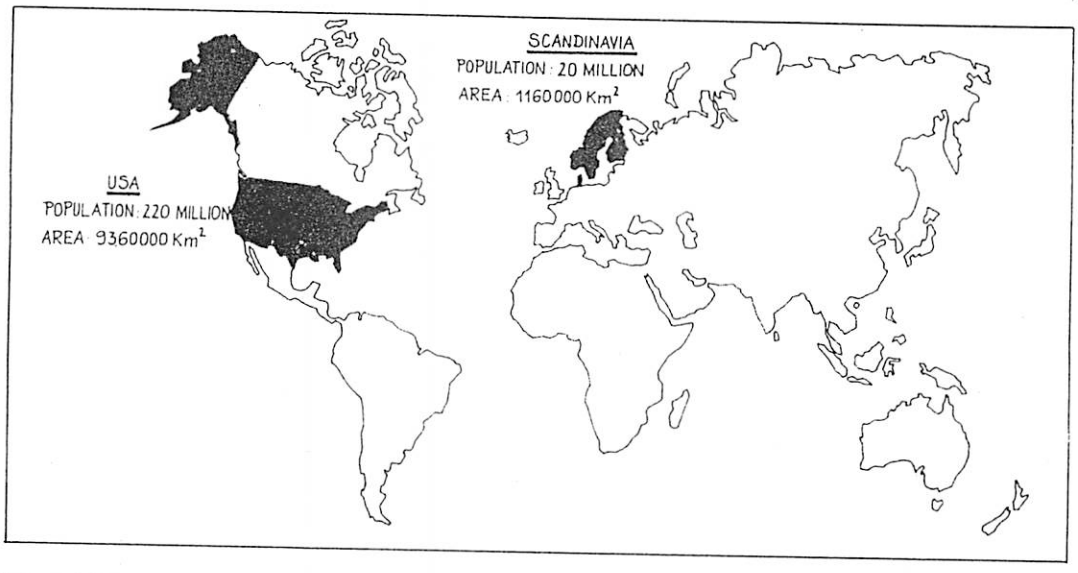
The development of the digital GSM will also lead to spin-off effects which can be exploited in a simpler digital personal telephone system. A system that is attractively priced and which will in time result in a situation where the telephone as we know it today will be mor or less obsolete. The size of the personal telephone will allow it to be carried around anywhere. In this way, the need for paging devices will also be removed.

What remains is two infrastructures for mobile telecommunications: one for advanced users, and one for private subscribers. Both systems digital and with the potential to constitute a revolution in the area of information technology and in society as a whole.

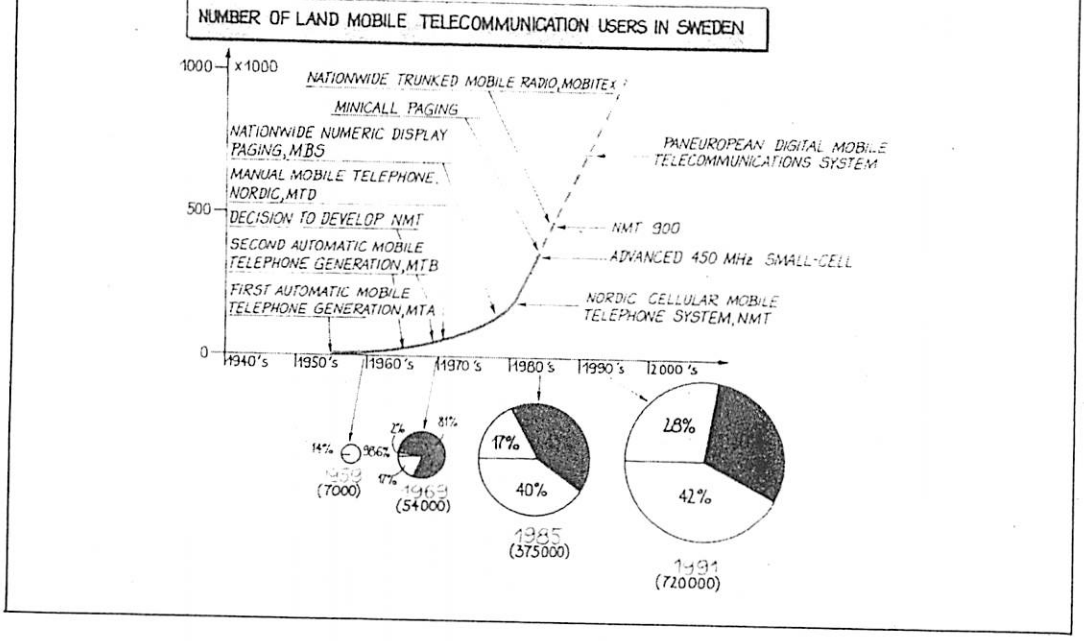
However, by that time, we have come a long way from the end of the beginning.

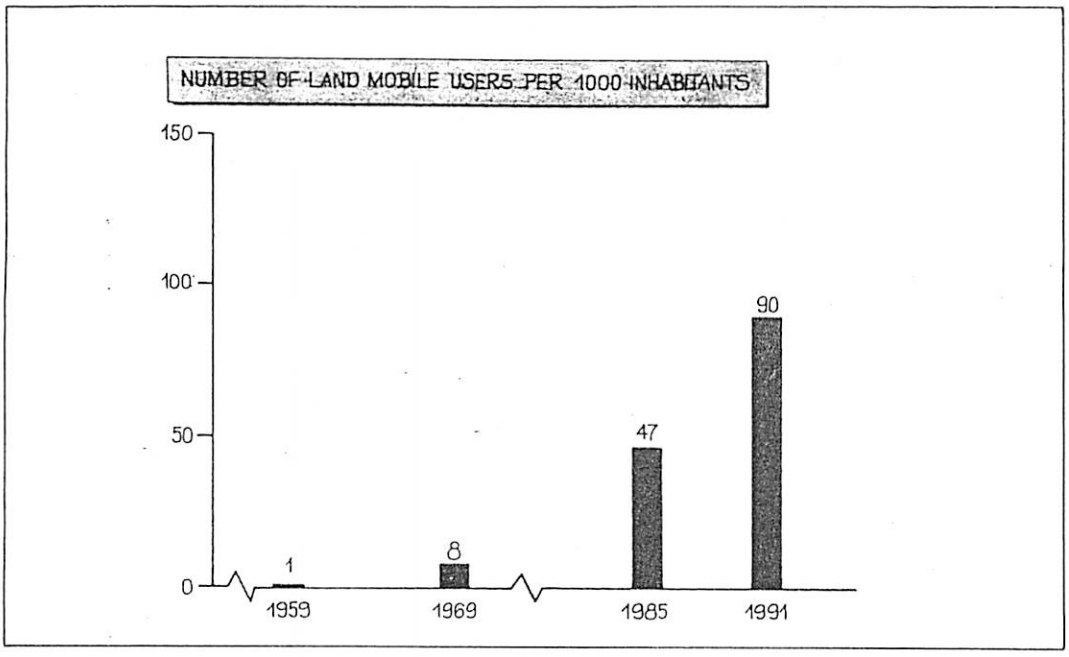
Ladies and Gentlemen - thank you very much for giving me your attention.

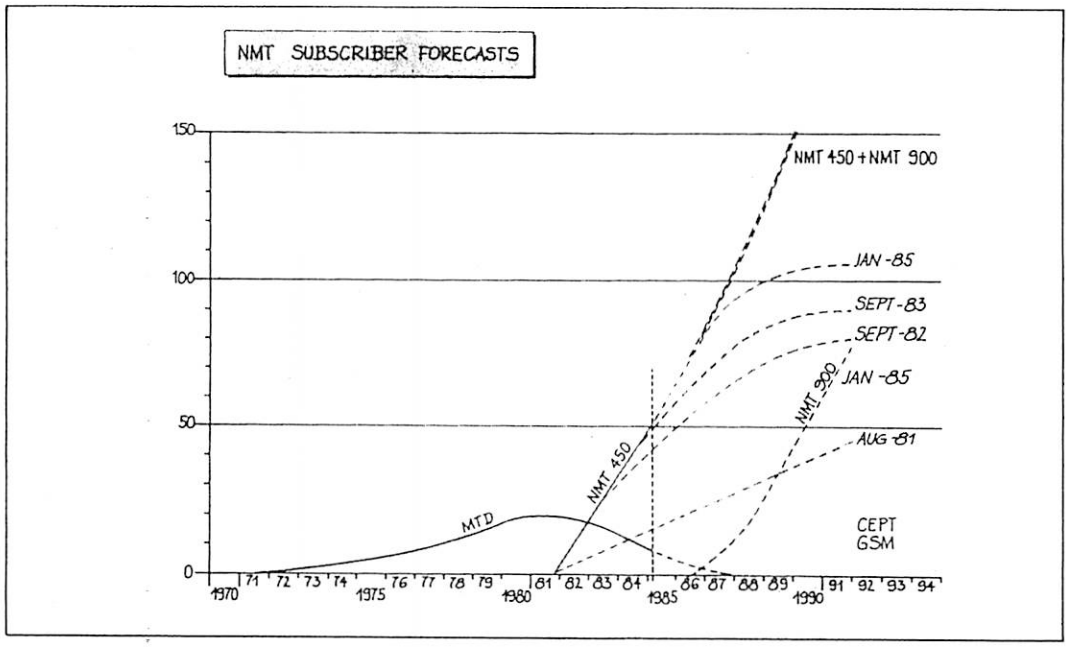
Swedish Telecom Radio



- POOR USE OF THE FREQUENCY SPECTRUM
- NONE OR POOR OPPORTUNITIES FOR TRAFFIC BETWEEN DIFFERENT NETWORKS
- NO DIRECT LINK WITH THE FIXED PUBLIC TELECOMMUNICATIONS NETWORKS AND THE ENHANCED SERVICES THUS AVAILABLE
- AN UNFORTUNATE CUSTOMER COST DEVELOPMENT FOR TERMINALS AND SYSTEM EQUIPMENT AS A RESULT OF LACKING STANDARDIZATION AND THEREBY SMALL PRODUCTION VOLUMES
- LOW SECOND-HAND MARKET VALUES FOR TERMINALS (AS A RESULT OF LACK OF SYSTEM AND NETWORK STANDARDS)




NUMBER OF LAND MOBILE USERS PER 1000 INHABITANTS
150
100
50
0
1
8
47
90
1959
1969
1985
1991


NMT SUBSCRIBER FORECASTS
150
100
50
0
NMT 450 + NMT 900
JAN -85
SEPT -83
SEPT -82
JAN -85
NMT 900
AUG -81
NMT 450
MTD
CEPT
GSM
1970
71 72 73 74
1975
76 77 78 79
1980
81 82 83 84
1985
86 87 88 89
1990
91 92 93 94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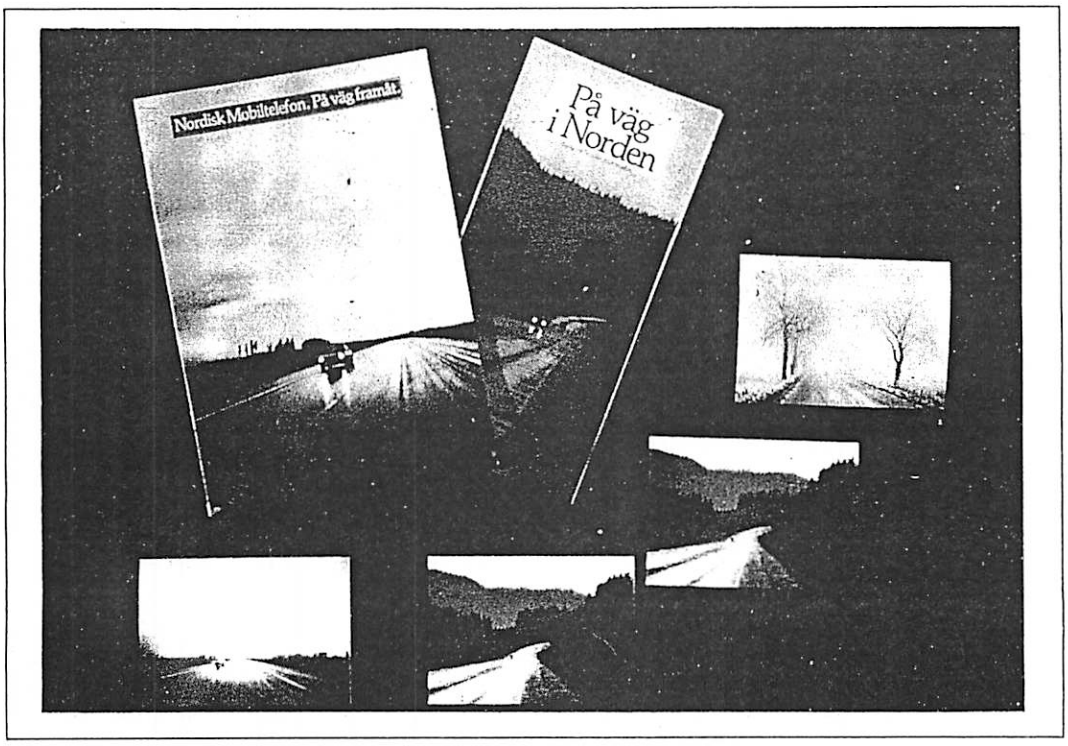
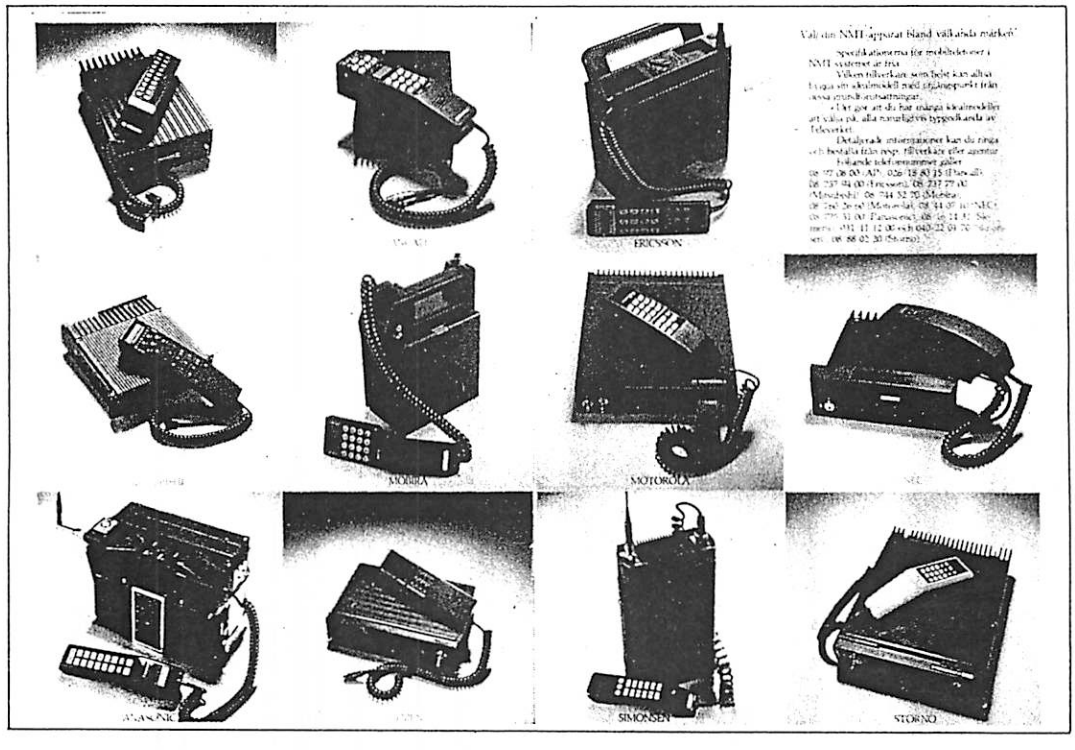
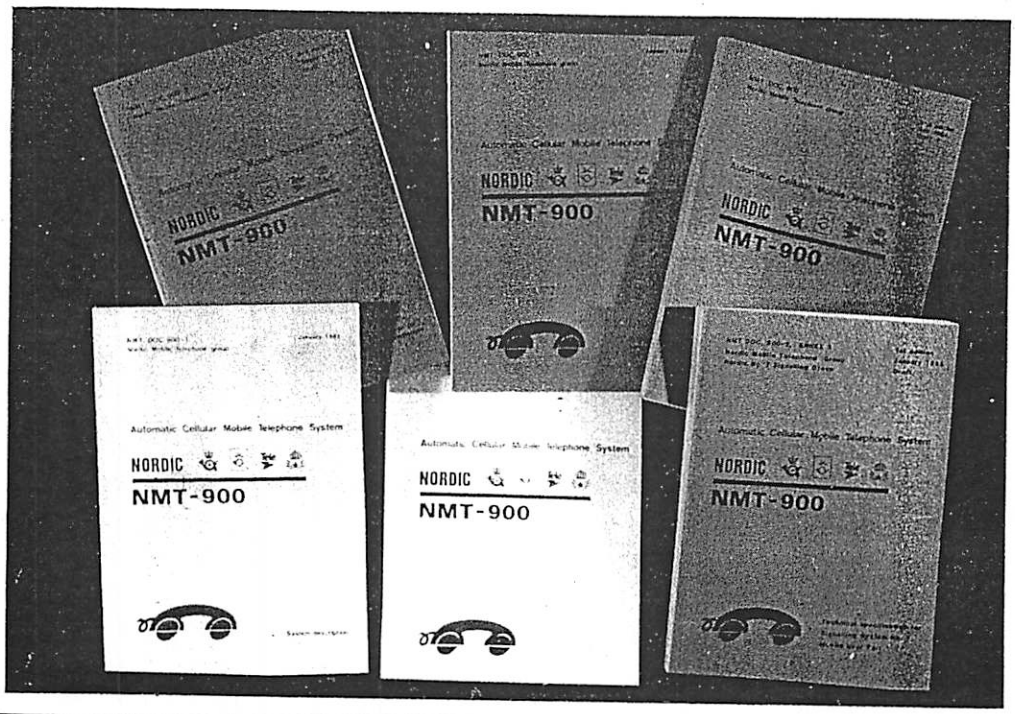
TOTALKOMMUNIKATION SOM ERÖVRAR VÄRLDEN

نورديسك موبيل تليفون
TELEVERKET RADIO


Nordisk Mobiltelefon. På väg framåt.
På väg i Norden


Välj din NMT-apparat bland välkända märken!
ERICSSON
MOBIRA
MOTOROLA
SIMONSEN
STORNO



COUNTRIES WITH OPERATING OR DECIDED NMT-SYSTEMS

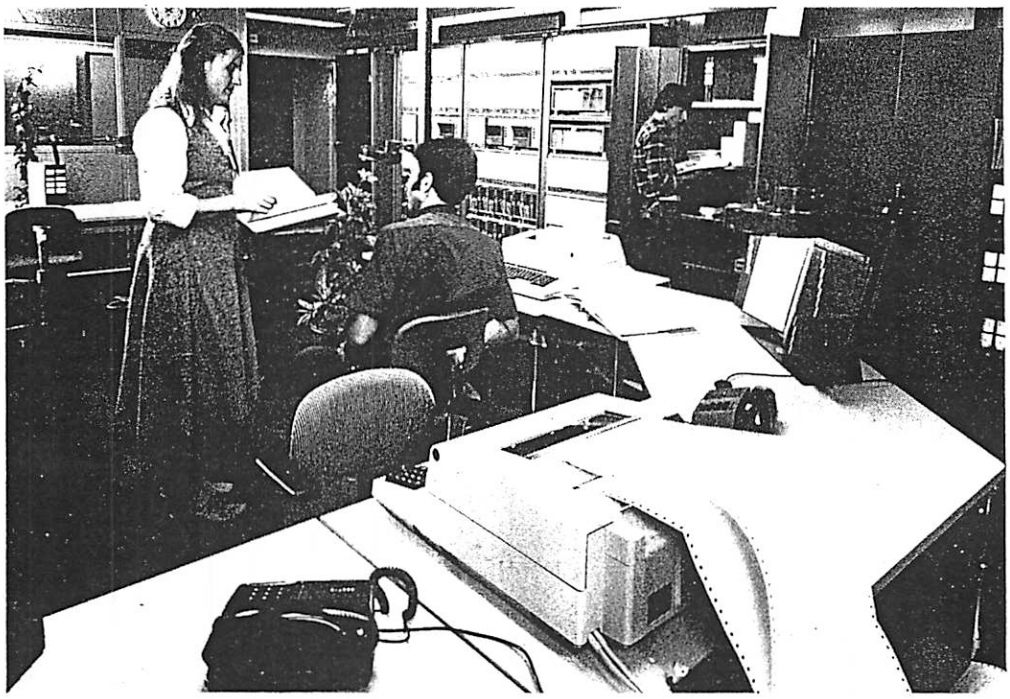
	450 MHz	900 MHz
DENMARK	●	●
FINLAND	●	●
NORWAY	●	●
SWEDEN	●	●
THE NETHERLANDS	●	
SPAIN	●	
AUSTRIA	●	
MALAYSIA	●	
SAUDI-ARABIA	●	
ICELAND	●	
SWITZERLAND		●
THE REPUBLIC OF CHINA	●	
LUXEMBOURG	●	
BELGIUM	●	
TUNISIA	●	
THAILAND	●	

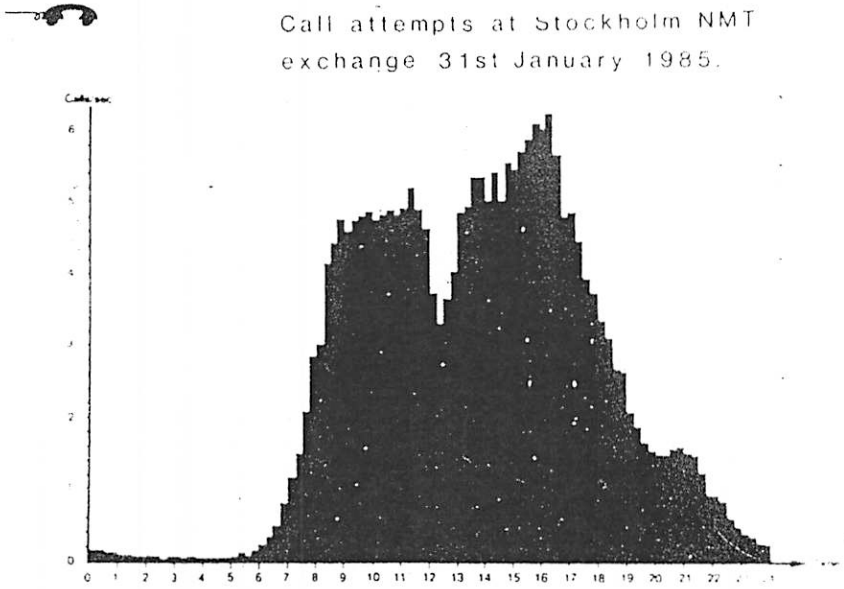
SUPPLIERS OF NMT NETWORK EQUIPMENT

- MOTOROLA
- ERICSSON
- PHILIPS
- TELENOKIA
- RADIOSYSTEM
- MAGNETIC
- MOBIRA
- MITSUBISHI
- ITT

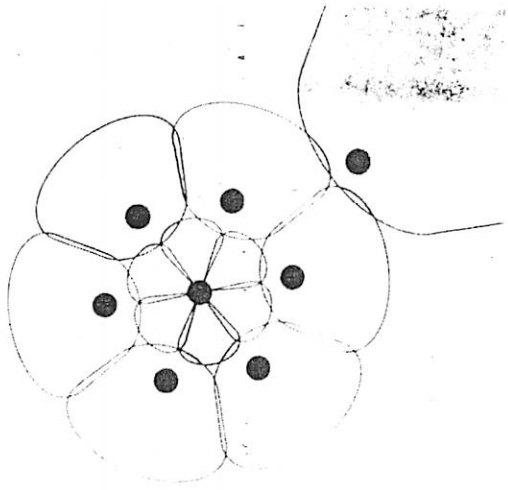
NMT STATUS MARCH 1, 1985

COUNTRY	NUMBER OF EXCHANGES	NUMBER OF CELLS	NUMBER OF CHANNELS	NUMBER OF SUBSCRIBERS
DENMARK	1	66	797	33110
FINLAND	1	102	636	20000
NORWAY	3	325	1585	42181
SWEDEN	2	228	1519	51819
IN TOTAL	7	721	4537	147110

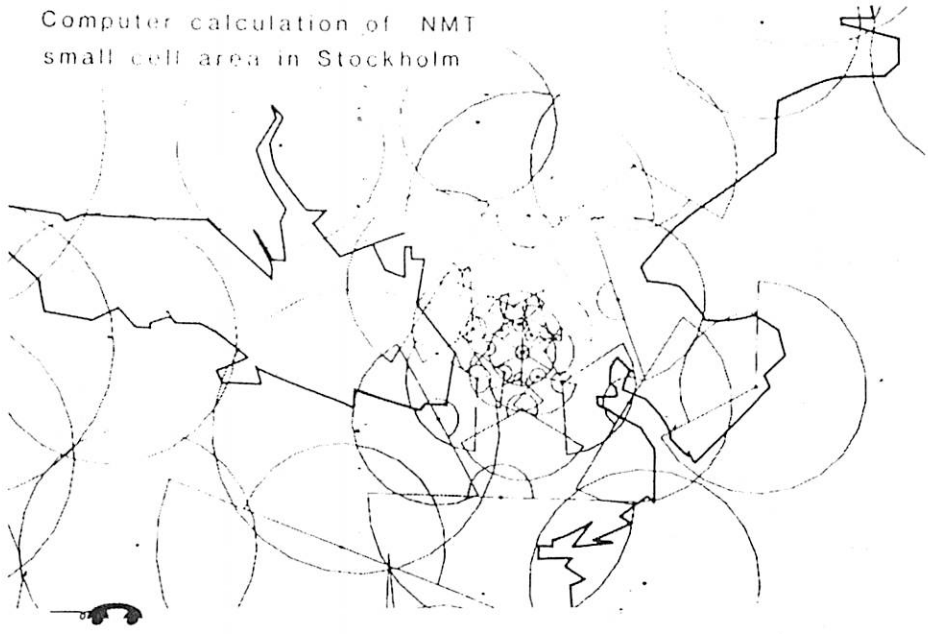


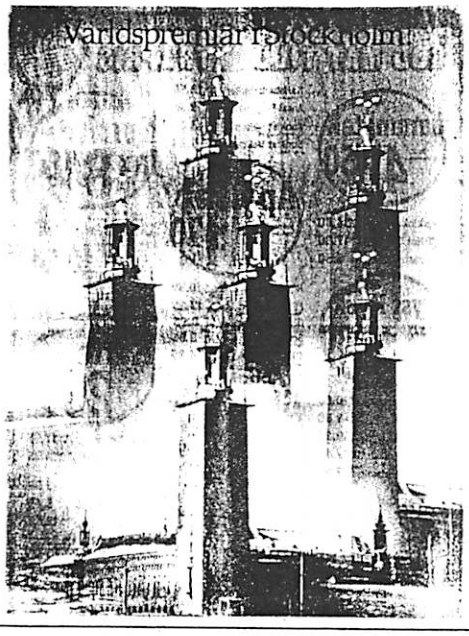


Basic structure of NMT small cell system in Stockholm area



Computer calculation of NMT small cell area in Stockholm





NMT förökar sig genom celldelning.
Fritt fram för fler mobiltelefoner.