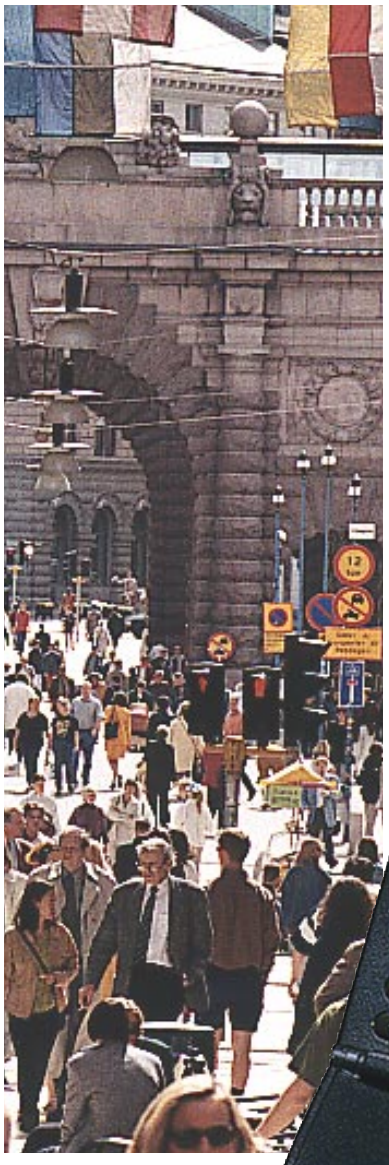
Health and Safety in Mobile Telephony



ERICSSON

An important area, in which we support continued independent research

At Ericsson, we regard the issue of product safety as being very important. Our products must be safe to use, while disturbing as little as possible the environments in which they operate.

We have developed and manufactured radio equipment for close to 70 years. In the last decade particularly, we have focused attention on whether radio waves can affect human health and/or the functions of electrical equipment and if so, to what extent. We have actively contributed to the support of this research.

By means of measurements and laboratory testing, we continuously ensure that our radio products meet national and international standards and limits for electromagnetic exposure and compatibility.

As far as mobile telephony is concerned, we have concluded that the compiled results of many years of international research do not show that the electromagnetic fields generated by radio base stations and mobile telephones cause any risk to health. This conclusion was also reached in April 1996 by the World Health Organisation's expert group, the International Commission on Non-Ionising Radiation Protection, in the document "Health issues related to the use of hand-held radio telephones and base transmitters".

Ericsson perceives the importance of supporting continued research in this critical area in order to further increase our understanding of our products' safety, and to get scientific answers to questions that may arise in the future. Since this issue is of the utmost importance to the industry and the public alike, we feel that it should be handled by independent national and international organisations that pursue and co-ordinate objective research into the possible effects of mobile telephony on human health and safety.

Stockholm, 1 July 1997

Lars Ramqvist
CEO

Ericsson's Policy

1. Ericsson will ensure that the company's current and future products comply with the existing recommendations, regulations and standards for human health and safety in exposure to electro-magnetic fields.

2. Ericsson will support the research that is being carried out in this area by independent national and international research organisations.

Radio Communication

Can the frequent use of mobile telephones cause brain damage? Is it dangerous to be near a base station antenna? Can mobile telephones interfere with medical equipment?

These are just a few examples of the questions that have arisen during recent years as an effect of the rapid expansion of radio communication, and in particular, mobile telephony. The area is obviously of great importance to Ericsson, which is currently a world leader in mobile radio communication.

This document is intended to give a brief description of the issue at hand, that is, what type of radiation is emitted by mobile telephones, and to describe how Ericsson is working in this field with research, testing and standardization of products. In addition, a couple of topical issues regarding health and safety are discussed in greater detail.

Radio communication has come to the modern world to stay. Development in the technology is rapid, and in the past few years, this technology has reached the public in the form of the mobile telephone, which has become a commonplace item.

Mobile Telephony

A mobile telephony system is made up of a network of radio base stations, each of which covers a certain geographical area (called a cell) and which together provide coverage for a larger area. The base stations, which continuously send and receive signals, are linked by cable or radio links to the fixed network via mobile exchanges that direct traffic and keep track of where in the network each activated mobile telephone is located.

When a subscriber turns on his/her mobile telephone, it immediately begins to send signals to establish radio contact with the closest base station. When contact is established, the mobile telephone goes into idle mode, in which it will only transmit

A mobile telephone network consists of several radio base stations that have a limited range and communicate on different frequency bands. Each base station controls several voice channels and can thus serve a number of users

information when necessary or at regular intervals. If the subscriber then wants to make a call, two-way radio communication is established between the antennas of the telephone and the base station, and the call is directed to an unoccupied radio channel with a specific frequency. Speech, or any other sort of message to be sent, is transmitted by modulating the transmitted radio wave (the carrier) according to a certain method.

Good sound quality depends in part on the radio signals having sufficient strength to convey the subscribers call, and in part on no other strong radio signals being present at either the same or adjacent frequencies. In other words, the mobile telephones and the radio base stations must use the proper output power.

Radio waves' tendency to lose intensity as distance from the antenna increases is useful in the mobile network. At a certain distance from a cell, the same frequency is re-used in a new cell without disturbing radio traffic in the first cell. This re-use is also necessary because a mobile network is only allocated a limited frequency spectrum.

In order to serve more subscribers, networks of higher density are being developed. Higher density also allows transmission power to be kept low.

Radio Waves and Frequencies

The radio waves used in mobile telephony are, like visible light and X-rays, electromagnetic waves that propagate at a speed of 300 000 km/sec. These waves consist of both an electric and a magnetic component which vary periodically in time. The number of oscillations performed by the radio waves each second is called frequency and is expressed in hertz (Hz), as in kilohertz (kHz = thousand Hz), Megahertz (MHz = million Hz) and Gigahertz (GHz =

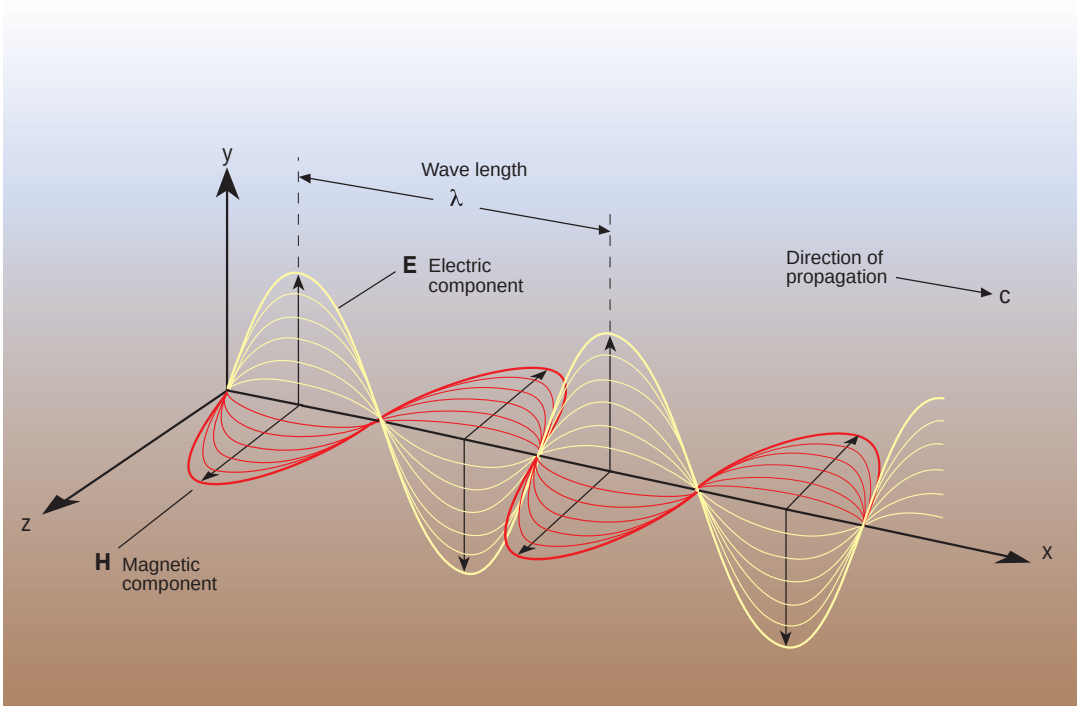
Fact Box

Electromagnetic waves with frequencies above those of radio waves have properties that differentiate them from radio waves. For example, light can be perceived by the eye, and electromagnetic radiation with very high frequencies—over a million times higher than a mobile telephone's radio waves—can ionize materia and break down molecules.

Gamma rays and X-rays are different types of ionizing radiation that can cause biological damage. When gamma rays are produced by radioactive material, they are known as radioactive radiation; however, radioactive radiation should not be confused with radio waves.

What is a radio wave?

Like visible light, radio waves are electromagnetic fields that propagate at a speed of 300,000 km / sec. Radio waves, which are transmitted and received by antennas, can be modulated so that they convey information in the form of voice, data or images.



The electromagnetic wave and its fields

Are radio waves different from other types of electro-magnetic fields?

Yes. Radio waves lack, for example, the capacity of X-rays and gamma rays to ionise materia and break down molecules.

billion Hz). The higher the frequency, the shorter the length of the wave. A wavelength is the distance between two wave crests.

As the electromagnetic spectrum in the diagram below shows, different types of electromagnetic waves have different frequencies. They also have different properties and uses. Radio waves, which can be used for various types of communication, are found in the lower part of the spectrum. In mobile telephony, radio waves within the frequency range of 450 – 2200 MHz are used, which is also part of the microwave frequencies.

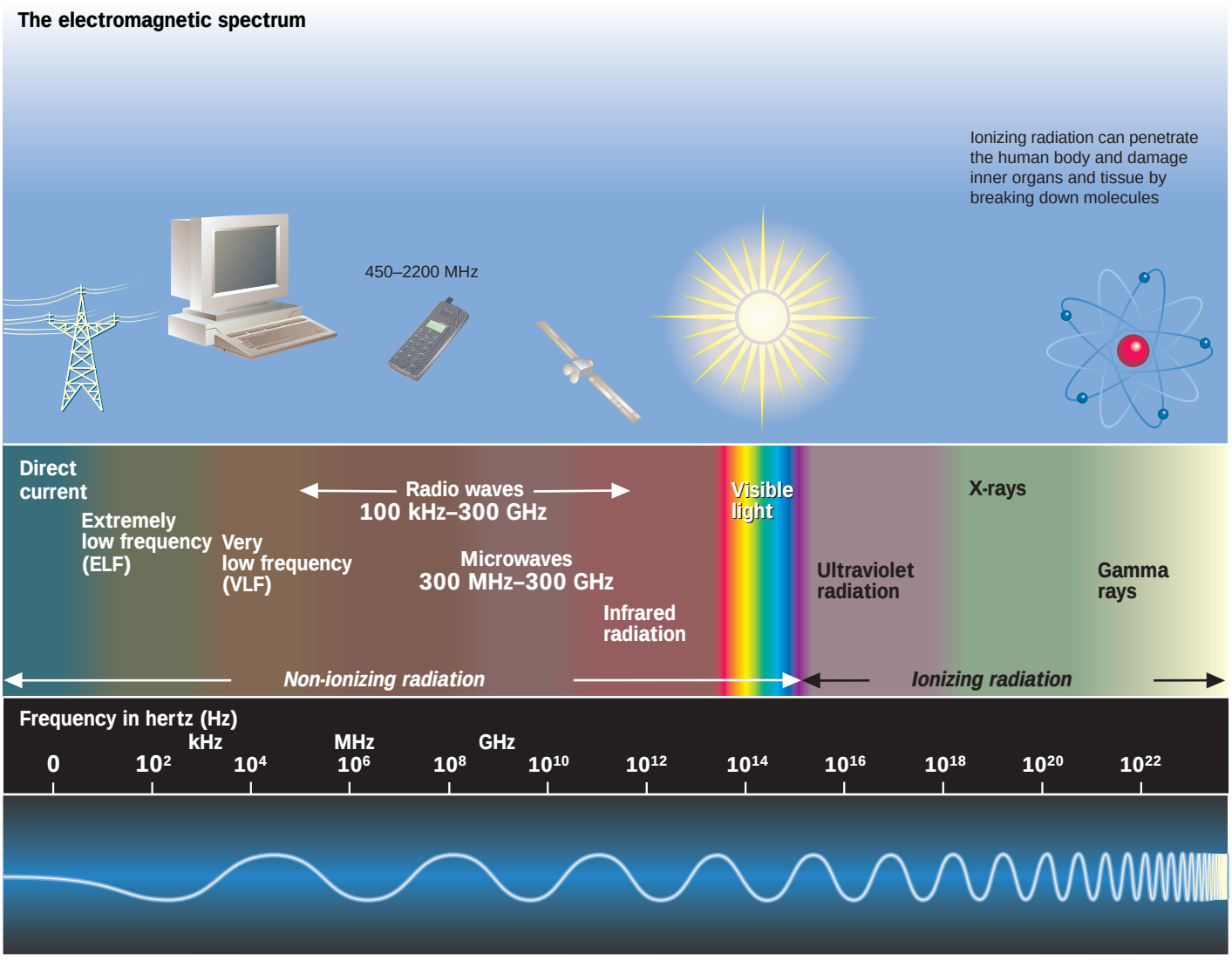
Radio Signal Intensity

The power density or intensity of radio signals emitted by a mobile telephone or a base station wanes quickly the greater the distance to the antenna. They decrease in power density by the square of the distance; thus, if the distance is doubled, the radio signal's intensity diminishes to one-fourth the original strength.

Furthermore, the radio signal's intensity is directly proportional to the transmitter's output power. Today's lightweight, energy-saving mobile telephones have a maximum output power of about one watt, which is roughly the power of a small flashlight. Besides, the telephones only use as much power as is necessary to retain good radio contact with the base station, which means that the average output power is considerably lower than the maximum level in many cases.

The output power of the base stations varies, depending on their type and location, from less than one watt for small units in indoor environments and

The electromagnetic spectrum



on the walls of buildings, up to a few hundred watts for antennas on high masts. The intensity of the radio signal also depends on the design of the antenna. To increase their range, most antennas have a directional effect, which means that the radio signals will be stronger in certain directions.

Continuous and Pulsed Signals

The early mobile telephony systems, such as NMT and TACS in Europe and AMPS in the USA, use analog technology. In these systems, several people located near each other can use their mobile telephones simultaneously because the telephones transmit on different frequencies. The radio signal from an analog telephone is continuous, that is, the telephone transmits an uninterrupted signal to convey the call.

In newer digital mobile telephone systems, for example GSM, several people share one and the same frequency in which each of them is allocated recurrent time slots (in GSM, eight calls can occupy the same frequency). The digital information, which is compressed into short periods, is sent at different times in the form of pulses to and from the various telephones.

Digital systems have several advantages compared with analog systems, for example, higher user capacity, better immunity to interference, lower power consumption and increased privacy.

Health and Safety

It is well known that radio waves can be absorbed by biological and other matter that contains water, and transformed into heat. To protect people from the heating effects of radio waves, exposure limits have been established. In Ericsson's case, this means seeing to it that radio equipment complies with the existing limits and recommendations.

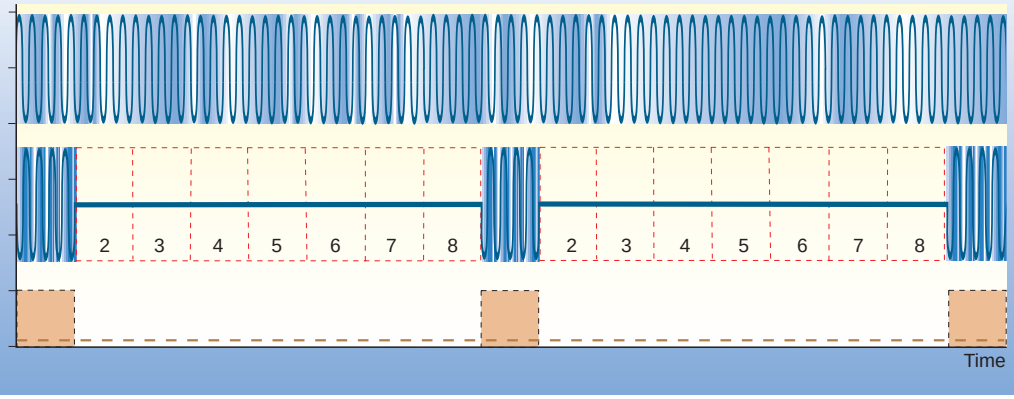
As far as safety is concerned, it is also a well-known fact that electric devices generate electromagnetic fields, while the functions in a piece of electrical equipment can be affected by electromagnetic fields generated by other equipment.

Thus, it is Ericsson's task to ensure that radio equipment meets the requirements for electromagnetic compatibility that are in force, and to prevent—in the best way possible—sensitive electronic equipment from being disturbed by radio equipment.

Mobile telephone system	Where primarily used	Type	Frequency band (MHz)	Handset output power (W) (maximum)
NMT	Scandinavia	Analog	900	1
ETACS	UK, Asia	Analog	900	0.6
AMPS	America, Asia, Austr.	Analog	800	0.6
D-AMPS	America, Asia	Digital	800/1900	0.2
GSM	Europe, Asia, Austr.	Digital	900	0.25
PDC	Japan	Digital	800/1500	0.2
GSM1800	Europe, Asia	Digital	1800	0.125
GSM1900	North America	Digital	1900	0.125
DECT	Europe, Asia	Digital	1900	0.01

A table showing the most common mobile telephone systems

Analog signal – digital signal



At the top, we see an analog signal, continuous and uninterrupted, with one call for each carrier frequency. Below this, we see a digital signal (GSM) with information compressed into pulses, over which eight people share a carrier frequency by exploiting time slots. At the lowest level, we see the maximum power of the pulses as compared with the average power

Health Issues

Are the safety limits in today's exposure standards reassuring?

Yes. They have been set with wide margins to provide protection from all known adverse effects on health.

Is there any evidence that mobile telephones can cause cancer?

No. There is no scientifically demonstrated connection between mobile telephony and cancer.

Standards and Limits

There are a number of national and international regulations, standards and recommendations dealing with electromagnetic exposure in the radio frequency range. The limits are generally very similar and are usually based on recommendations from the World Health Organization (WHO) and the International Radiation Protection Association (IRPA).

The limits have been set with a wide margin in order to protect people from any known negative health effects of both short- and long-term exposure to electromagnetic fields. The safety margin is sometimes as high as 50, that is, the limits are set at 50 times lower than the level at which one knows that heating-related effects can begin to occur.

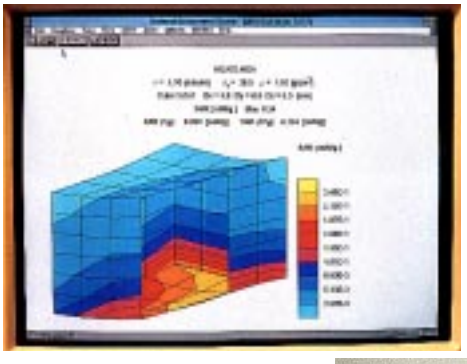
When the distance to the radio transmitter is greater than a few wavelengths (which is roughly one meter for the radio waves used in mobile telephony), safety limits expressed as field strength (V/m and A/m) or power density (W/m^2) are normally used. This applies in most cases to exposure from radio base stations. By measuring or calculating the field strength or intensity for the place in question, it can be established that the limits have not been exceeded.

On the other hand, when a radio transmitter is close to a person—for example, if he or she is using a mobile telephone—and the exposure is local, the highest power absorption per unit mass in a small part of the body must be established and compared with the basic limits given in the standards. Expressed in W/kg, this parameter, known as the Specific Absorption Rate (SAR), is a key concept.

Mobile Telephones

The main focus of questions relating to the potential health risks of mobile telephony radio waves has been the mobile telephone itself. The international press has published articles warning of the risk of brain damage, hypersensitivity, eye damage, etc., if people use mobile telephones.

One reason for these speculations is the mobile telephone antenna's proximity to the user's head during calls; there is anxiety regarding the possible damage that heating might cause. However, all the evidence indicates that these fears are groundless. The power level of a mobile telephone is so low that it has not been practically possible to register any rise in temperature in the body. Moreover, scientific analyses have shown that a long mobile conversation cannot raise the temperature inside the user's head



Ericsson checks that its mobile phones conform to the exposure standards by doing computer-controlled measurements on a model of a human head. The measurement results are shown on a computer screen, on which the highest power absorption per mass unit is shown in yellow

by more than 0.1 degrees Celsius. This effect can be considered entirely negligible compared with the normal temperature variations in the human body.

Occasionally, suspicions arise that radio waves—or certain radio waves such as the pulsed transmission from digital mobile telephones—can generate effects other than just heating, but there is no scientific evidence of such non-thermal effects.

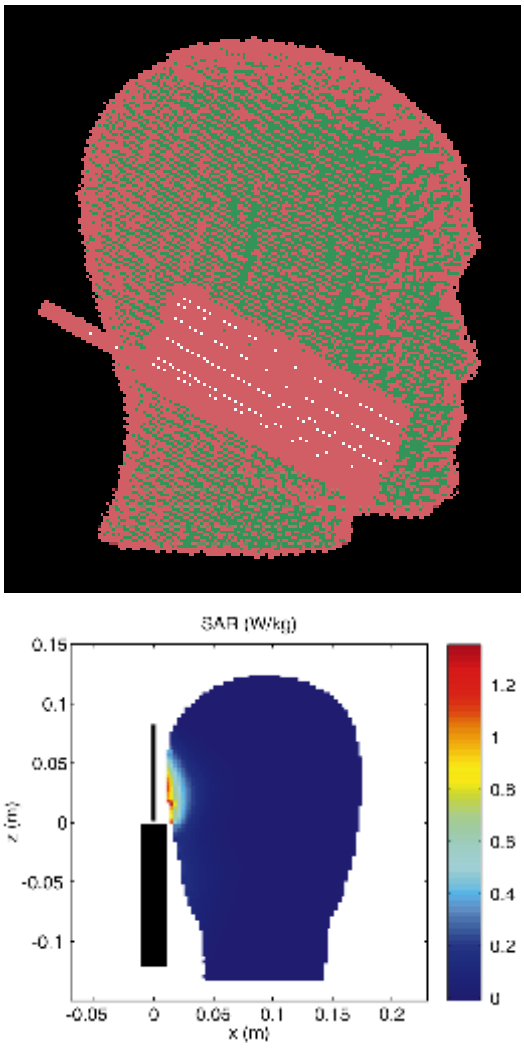
A leading organization in the field, the International Commission on Non-Ionizing Radiation Protection (ICNIRP) published a document in April 1996 that included SAR limits for exposure to radio waves from mobile telephones. The document states that there is no scientific evidence to support the theory that mobile telephones can cause health problems when exposure is within the set limits. ICNIRP mentions in particular that there is no known link between the use of mobile telephones and cancer.

Since 1995 at its SAR laboratory in Lund, Sweden, Ericsson has been performing dosimetric measurements to ensure that its various telephone models comply with the recommended SAR limits. The measurement equipment was developed by Professor Niels Kuster and his colleagues at the Swiss Federal Institute of Technology in Zürich, and the measurement methods conform to current standards.

SAR measurements are conducted by placing a mobile telephone that is transmitting close to a lifelike model of a human head which is filled with a fluid which has the same electrical characteristics as body tissue. A robot steers a probe that measures the electromagnetic field inside the head and, based on the readings, the maximum SAR values are determined by a computer. The measurements are taken at the highest possible transmitter power—the 'worst-case scenario' for a mobile telephone—which normally regulates the output power as demanded by conditions, and only uses the highest output power when signaling conditions are poor.

SAR limits for mobile telephones

Recommendation	SAR W/kg	Average mass (g)	Average time (min.)
ICNIRP 1996	2.0	10	6
CENELEC 1995	2.0	10	6
IEEE/ANSI 1992	1.6	1	30



This is an example of a computer estimate of SAR for hand-held mobile telephones. The upper picture shows the telephone's position, while the picture beneath it shows the calculated SAR distribution

The measurement system is fully automated and easy to use, and it takes barely an hour to run a complete test on a mobile telephone. This instrument is also a very important tool in the development of new mobile telephones. Therefore this type of measurement is carried out at an early stage in the design process.

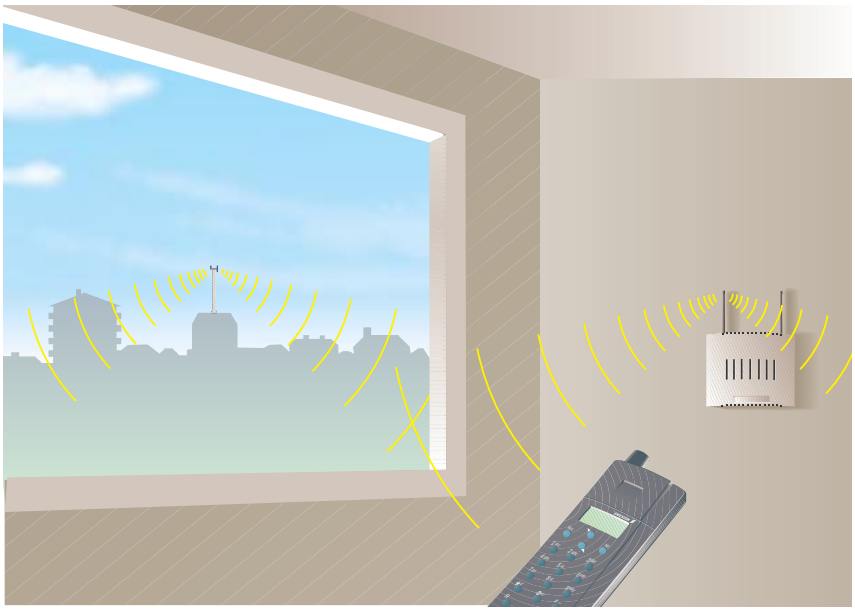
Besides laboratory measurements, Ericsson also uses advanced methods for electromagnetic calculations to estimate the exposure levels for mobile telephones. The figure above shows an example of the results of this type of calculation. The measurements and computations show that Ericsson's mobile telephones comply with the SAR limits.

Radio Base Stations

The mobile telephony network (as described in the Mobile Telephony section of this paper) is made up of units called cells. In each cell, there is a radio base

? Should we avoid being in the vicinity of radio base stations?

! Base station antennas are placed in such a way, or have such a low output power, that exposure levels are lower than the safety limits.



Radio base stations with a wide range that are mounted on masts transmit a few hundred watts at the most, whereas indoor base stations have no more power than a mobile telephone, i.e., around 1 watt.

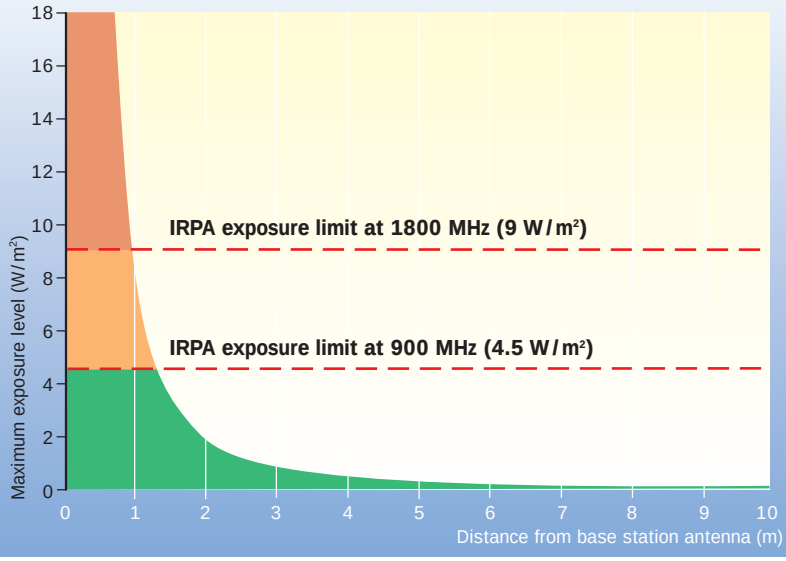
station that uses a number of radio channels to provide coverage and user capacity. In general, a mast-mounted antenna covers a small sector vertically and 60–120 degrees horizontally.

To handle more subscribers, the system is made more dense by expanding the network with smaller cells and more dense re-use of frequencies. This results in the need for more radio base stations and antennas placed closer and closer to users—on building facades, in shopping centers, in office buildings, at airports, etc. However, it should be noted here that when base stations come closer to the users the output power is reduced. Base stations in office buildings have an output power that is no higher than that of a hand-held mobile telephone.

The table below gives IRPA's international exposure limits for the general public at the frequencies 900 and 1800 MHz. For installation engineers, or others working under controlled conditions close to antennas, the exposure limits are five times higher. The limits here apply to exposure times longer than six minutes. For shorter periods higher exposure levels are permitted. For shorter distances to the antenna, the SAR limits apply, as they do for mobile telephones.

Frequency	IRPA limit (W/m²)
900	4.5
1800	9.0

Estimated maximum exposure level from a 100-watt (EIRP) base station and the exposure limits recommended by IRPA



In practice, exposure is less than these limits already at a distance of only a few centimeters from base stations with low output power (mounted indoors and close to people), and at only a few meters from base stations with high output power (mounted on masts, roofs, etc.). The intensity of the radio waves (power density) rapidly decreases as the distance from the antenna increases (see the figure at the left, bottom). The horizontal lines on the graph mark the recommended safety limits.

Installation Guidelines

On the basis of these limits and the results of measurements and calculations, Ericsson has issued recommendations to customers (mobile telephony operators) and installation engineers regarding how radio base station antennas should be positioned and mounted to ensure that neither the general public nor the installation engineers are overexposed.

There are low-level electromagnetic fields in the vicinity of the actual base station's transmitter unit, in areas only accessible to authorized personnel. Measurements carried out by Ericsson and by independent authorities and measurement laboratories have verified that the exposure levels are well below the specified safety limits.

Interference with Electronic Equipment

Can electronic equipment, such as pacemakers and hearing aids, suffer interference due to the radio waves from mobile telephones? And if so, what should be done to eliminate the risks?

This is the other major question that we address, however, in contrast to the health aspects, the safety aspects are purely technical in nature, since there are already solutions that provide adequate interference protection. Nevertheless, the topic does require comprehensive standardization and the development of new aids.

Electromagnetic interference (EMI) is a general concern for electronic equipment. Every electrical device generates around itself an electromagnetic field with a certain range. This also applies to mobile telephones and base stations, which are made to generate electromagnetic waves in accordance with certain specifications.

Electromagnetic fields, whether intentionally or unintentionnally generated, can affect electronic devices in the near vicinity. Both the risk of EMI occurring and the level of it are dependent as much on distance, the transmitter's power, the frequency of the waves, and the type of modulation from the radio source, as they are on the electronic device's interference immunity.

There are standards and recommendations that define interference immunity for electronic devices as well as the maximum strength of the electromagnetic fields they may generate. These are called electromagnetic compatibility (EMC) requirements.

Although Ericsson's mobile telephones and radio base stations meet these requirements there may be a risk of interference. For example, certain electrical devices can sometimes be affected—even though they meet the EMC requirements—by the electromagnetic field of a nearby mobile telephone. Moreover, for certain types of devices, there are no applicable EMC requirements in the first place.

The general answer regarding how to eliminate or minimize the risk of EMI is that EMC requirements must be tightened, and that cooperation between manufacturers of different types of electronic devices and the mobile telephone industry must be pursued. Furthermore, users of mobile telephones should respect the special rules that apply at hospitals, on planes etc., where it is difficult to wholly protect sensitive electronic devices, such as medical or navigational equipment, from interference.

Two devices have been discussed in particular in relation to electromagnetic interference: pacemakers and hearing aids.

Pacemakers

A pacemaker uses electrical impulses to help a weakened heart maintain a more even pace. In most cases, the pacemaker senses the heart's status, and only takes action if abnormal activity is detected. It has been shown that strong electromagnetic fields can affect the function of a pacemaker.

The fields around radio base stations in the mobile network are too weak to affect pacemakers; however, a number of international studies (some of which were initiated by the mobile telephone industry) have shown that certain types of pacemaker can be interfered with by a mobile telephone placed with its antenna directly over the area in which the pacemaker resides in the person's body. These disturbances had no permanent effect on the pacemaker, and disappeared completely when the mobile telephone was removed to a distance of a few cm. It has also been observed that pacemakers are more sensitive to signals from digital than from analog telephones.

These findings are the result of scientifically-conducted studies. There are no reports of actual cases of pacemaker disturbance and the probability of it occurring is deemed to be very low.

Over the long term, the potential for problems with pacemaker interference will be solved by increasing the immunity of pacemakers, and through new, more stringent EMC requirements for pacemakers. Already today, there are pacemaker models that contain EMI filters, which makes them entirely immune to electromagnetic interference from mobile telephones.

The short-term solution is to inform people about the risk of interference. Ericsson includes information of this kind in all its mobile telephone user's manuals, and we recommend that people dependent on pacemakers always maintain a distance of at least 15 cm between an activated mobile telephone and the pacemaker (for example, by not carrying the mobile telephone in a breast pocket).

Ericsson will continue to support research regarding potential interference with pacemakers, and will participate in activities aimed at finding new solutions together with pacemaker manufacturers.

Can a mobile telephone interfere with a pacemaker?

Yes, there is a small risk of interference, but only some types of pacemaker are susceptible, and only if the mobile telephone is placed right next to them.

With the help of Ericsson's portable handsfree solutions, a person wearing a hearing aid can use a digital mobile telephone without placing it at his or her ear, thus avoiding the risk of disturbance in the hearing aid

Hearing Aids

The users of hearing aids often experience disturbances due to EMI from various types of electrical devices such as fluorescent lights, computer screens, microwave ovens and burglar alarms in shops. Unfortunately, it has also been shown that hearing aids can be disturbed by digital mobile telephones. The rapid pulsation of radio signals from digital mobile telephones can give rise to a buzzing, humming or crackling sound inside the hearing aid in the immediate vicinity of a mobile telephone.

The extent of this potential interference problem has been investigated by Ericsson, by manufacturers of hearing aids and by independent research organizations. The results show that all types of digital mobile telephones can interfere with hearing aids.

The level of interference depends primarily on the electromagnetic immunity of the hearing aid, but also on the type of mobile telephone, its output power and the distance to the hearing aid. Small hearing aids placed inside the ear generally have a higher level of immunity than do larger devices that sit behind the ear.

Research results show that there is a relatively small risk that a hearing aid user will experience interference from someone else using a digital mobile telephone nearby; but many of today's hearing aids will be disturbed if the wearer uses a digital mobile telephone at full power, holding it at the ear with the hearing aid.

In Europe, the USA and Australia, a number of joint projects are being carried out between the manufacturers of hearing aids, the mobile telephone industry, and government authorities to arrive at both short-term and long-term solutions. The goal is, of course, that everyone, even those who use hearing aids, should be able to use and have the benefit of the new digital mobile telephones.

The most important long-term solution is to increase the immunity of hearing aids, but it is also important to develop suitable accessories to mobile telephones. The hearing aid industry is working actively towards improving hearing aids, and within a ten-year period, most of today's interference-sensitive hearing aids will have been replaced. New international EMC requirements for hearing aids are being developed, which will lead to increased compatibility between digital mobile telephones and hearing aids.

The short-term solution is to use some kind of additional equipment that makes it possible to use the telephone without having to hold it against the ear, or to use an analog mobile telephone. Ericsson supplies two different types of portable, handsfree accessories, both of which consist of an earphone-and-microphone set. However, one of the models contains a magnetic loop that allows it to be used with a telecoil-equipped hearing aid.

? Can a person with a hearing aid use a mobile telephone?

! Yes, but there are reservations. If the telephone is digital, the hearing aid must have high interference immunity; otherwise handsfree accessories such as earphones and microphones can be used.

Ericsson's Activities in the Area of Health and Safety

In 1993, Ericsson formed an "Electromagnetic Health and Safety Group" that includes representatives from all the affected business units within the corporation. The group's mission is to monitor what is going on in the area of Health and Safety, to initiate relevant activities within the company, to act as the steering group for these activities, and to make decisions regarding the financing of independent research.

Ericsson has placed the main part of this responsibility for activities with its research and development department for radio communication (RCUR for short). A team is carrying out a project to increase general knowledge within the field, and to develop measurement and calculation methods. A number of tools have already been developed.

Ericsson has its own internal research for the measurement and calculation of both electromagnetic exposure levels and electromagnetic interference, and also cooperates with other leading telecommunications corporations in a number of international projects.

To ascertain whether mobile telephones comply with the SAR limits, Ericsson has today three testing laboratories at its development units in Lund in Sweden and in Raleigh, North Carolina, USA, as well as a corporate laboratory at the RCUR research unit.

Since Ericsson is first and foremost a telecommunications technology company, it does not carry out any medical research itself, but does help finance research carried out by independent national and international organizations. The purpose of this research is to investigate all possible links between mobile communications and potential effects on human health or health-related interference effects.

Despite the comprehensive research that has been carried out during the past 30 years, there are still areas in which more knowledge is needed. Examples of the organizations that run and coordinate research with Ericsson's support are:

- Wireless Technology Research (WTR) in the USA
- Forschungsgemeinschaft Funk (FGF) in Germany
- The University of Oklahoma EMC Center in the USA
- The WHO's international EMF project.

Still other research programs will be started in Australia, Europe and Japan. Ericsson will contribute to the financing of these programmes.

Ericsson provides expertise in a number of national and international standardization groups, primarily in working groups whose task it is to develop standardized measurement methods and equipment for radio-frequency electromagnetic exposure and interference.

Does Ericsson carry out its own research in health and safety?

Ericsson has a number of its own research projects, but also cooperates with other telecom companies and financially supports research carried out by independent national and international organizations.

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Production: Ericsson Radio Systems AB
Graphic design: Hellmans
Photo: Anders Anjou, Kurt Johansson, Lars Åström
Printing and reproduction: Norstedts Tryckeri AB
This brochure is printed on TCF
(Totally Chlorine Free) paper.

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