MMF
Mobile Manufacturers Forum

Mobile Phone Base Stations
EMF / Health Fact Pack

Contents

1 Introduction

There has been a substantial growth in the use of mobile communication services over the last few years and this growth is expected to continue for the foreseeable future with the introduction of the 3rd Generation (3G) mobile technologies.

With this growth comes the inevitable increase in the number of base station sites, accompanied by public concern for possible impacts of these communication systems.

Therefore this document seeks to address such concerns by providing background information on the operation of mobile communication systems as well as providing answers to some of the most commonly asked questions with respect to health and safety.

2 What is a cellular system?

Mobile communication networks are divided into geographic areas called cells, each served by a base station (Figure 1). Mobile phones are the user's link to the network. The system is planned to ensure that mobile phones maintain the link with the network as users move from one cell to another.

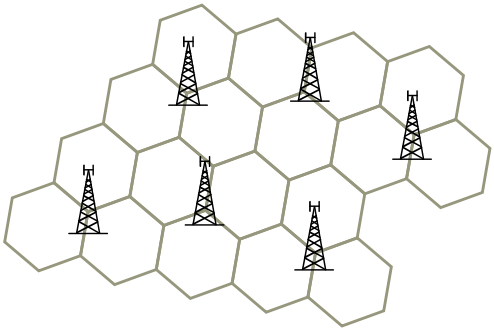


Figure 1: Theoretical modeling of a network

To communicate with each other, mobile phones and base stations exchange radio signals. The level of these signals is carefully optimized for the network to perform satisfactorily. They are also closely regulated to prevent interference with other radio systems used, for example, by emergency services, taxis as well as radio and television broadcasters.

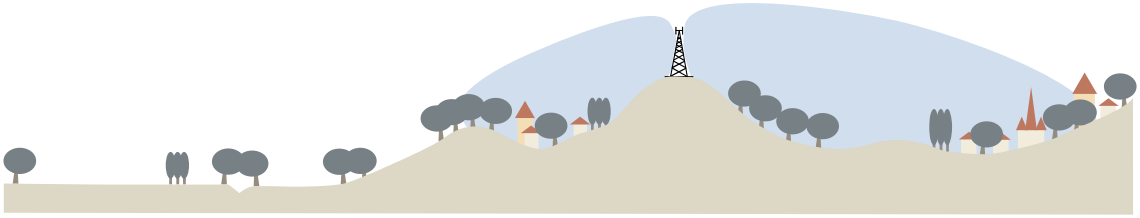


Figure 2: Example of a base station's coverage area

3 How a cellular system works

Mobile phones

When a mobile phone is switched on, it responds to specific control signals from nearby base stations. When it has found the nearest base station in the network to which it subscribes, it initiates a connection. The phone will then remain dormant, just occasionally updating with the network, until the user wishes to make a call or a call is received.

Mobile phones use automatic power control as a means of reducing the transmitted power to the minimum possible whilst maintaining good call quality. For example, while using a phone the average power output can vary between the minimum level of about 0.001 watt up to the maximum level which is less than 1 watt. This feature is designed to prolong battery life and possible talk time.

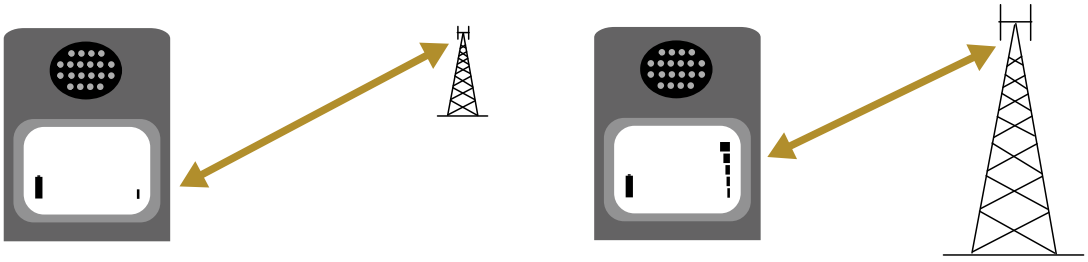


Figure 3: Signal strength is impacted by a number of factors but proximity to a base station is one of the most important.

Another aspect of a mobile network is that as the user is moving while talking, the network needs to be able to pass the call from one base station to another. This process is called a 'handover' – literally where the network hands over the call from one base station to another, and it is undertaken seamlessly and without the caller being aware of the change.

Base station sites

Transmitted power levels from base stations vary considerably depending on the required area or 'cell' that they are providing coverage for.

Typically transmitted power from an outdoor base station may range from a few watts to about 100 watts; while the output power of indoor base stations is even lower. For comparison purposes, 100 watts is equivalent to a standard light globe used in our homes.

A base station is comprised of several different components – including an equipment shelter, a tower or mast which provides the necessary height to give better coverage, and the transceivers and antennas which sit atop the tower or mast – or in some cases are attached to the top of buildings, where the building itself provides sufficient height. The antennas are typically about 15-30 cm in width and up to a few metres in length, depending on the frequency of operation.

These antennas emit Radio Frequency (RF) electromagnetic energy (also called radio waves) in beams that are typically very narrow in the vertical direction (height), but quite broad in the horizontal direction (width). Because of this, the RF energy at ground level directly below the antenna is very low.

To help assure that public exposures remain within established limits, antennas typically are elevated, and where necessary fences, or other means to restrict access are used together with appropriate signage to ensure that only authorized personnel can access the area immediately around a base station. The consequence of these measures is that in areas around base stations that are accessible to the public, the RF levels are typically many times below international safety limits.

4 Directivity of antenna

This is particularly relevant as there is a common misconception that emissions are stronger directly under antennas which partly explains some of the concern about those placed on schools or on residential buildings.

Whatever the equipment, the radio wave intensity decreases rapidly as it travels away from the antenna. In free space, the intensity decreases to a quarter when the distance is doubled. In reality, the intensity reduces much more quickly than that due to the loss of signal strength (also known as 'attenuation') that is caused by having to pass through obstacles such as trees and buildings.

Some people have asked why base station equipment is not always placed in industrial areas or areas remote from habitation. There are several reasons: firstly if the equipment is placed too far from the users it not only gives poor communication quality but also causes the phones to increase their output power to sustain the connection, thus decreasing battery life and talk time. Secondly, there are practical limitations to the geographic area that a base station can effectively serve, especially where there are high numbers of users. In this instance, the base stations need to be closer together to provide increased capacity rather than coverage, and as a result of their proximity to one another, each base station needs to operate at very low power levels to avoid interfering with others nearby. Therefore a properly designed network will optimize coverage and capacity and therefore operate at only the lowest power levels necessary to provide good communications.

5 Health concerns

RF fields are non-ionizing and do not disrupt the molecular structure of biological material. The globally recognized, independent 'International Commission on Non-Ionizing Radiation Protection' (ICNIRP) has released guidelines that provide levels of RF exposure that are regarded as safe for all members of the community.

All established health effects of RF exposure at the frequencies used for mobile communications relate to heating. So called 'non-thermal' effects have been, and are continued to be, evaluated. To date, the view of health experts is that the literature on non-thermal effects is inconsistent and its relevance to human health too uncertain for this body of information to be used as a basis for setting limits on human exposure to RF fields.

The depth to which radio waves penetrate exposed tissues is dependent on the frequency used. When radio wave energy is absorbed into our bodies, a heating effect may occur depending on the intensity of exposure. The level of heating that will occur from exposure to radio waves within the exposure guidelines is extremely low, and the body's normal thermoregulatory processes effectively dissipate any heat away that might be generated.

No confirmed study to date has shown adverse health effects at exposure levels below ICNIRP guideline levels.

6 Studies and safety guidelines

The biological effects of radio frequency electromagnetic fields have been studied for more than 50 years with over €200 million spent on research in the last decade alone.

The ICNIRP guidelines have been widely adopted internationally and turned into national safety standards. The guidelines apply to mobile phones as well as base station sites and incorporate wide safety margins to protect against all established health effects of RF exposure. There are no known adverse health effects at exposure levels below these guideline levels.

There are over 1300 peer-reviewed publications in the research database relating to the biological effects of RF fields. Included in these 1300 papers are more than 350 independent, peer reviewed studies conducted at frequencies used by mobile communications. Over half of these have looked for associations between cancer and radio waves.

Information on the various studies undertaken in this field are available from the World Health Organization (WHO) website: http://www.who.int/peh-emf/research/database/en/

The WHO in 2004 said:

> *"In the area of biological effects and medical applications of non-ionizing radiation approximately 25,000 articles have been published over the past 30 years. Despite the feeling of some people that more research needs to be done, scientific knowledge in this area is now more extensive than for most chemicals. Based on a recent in-depth review of the scientific literature, the WHO concluded that current evidence does not confirm the existence of any health consequences from exposure to low level electromagnetic fields."*

Exposure guidelines have been developed by ICNIRP and are based on a careful analysis of the scientific literature (taking into account both thermal and non-thermal effects) and provide protection against all identified hazards of RF exposure with large safety margins.

The views of the industry concerning the health effects of RF exposure from mobile phones and base stations are based upon the conclusions of many expert review panels established by official national and international entities. These panels have reviewed the scientific literature over the past 10 years and have consistently concluded that there is no credible or convincing evidence that RF exposure from mobile phones or base stations operating within ICNIRP exposure limits causes any adverse human health effects.

Demonstrating compliance with the standards

Even though today's mobile phones only emit, on average, a maximum of a few hundred milli-watts, they are held in close proximity to the body and, therefore, expose the user to local levels of EMF exposure that are relatively higher than those from base stations.

The concept of Specific Absorption Rate (SAR) was introduced to quantify the amount of energy being absorbed by the body, and to demonstrate compliance with national and international safety standards.

The SAR of a phone is determined by operating the device near a model of the head or body. The model is filled with a liquid that exhibits the electrical properties of body tissues. A SAR probe is operated inside the model and a 3 dimensional measurement takes place to determine the highest SAR and verify that this is below the limit.

With respect to base station sites, the simplest RF propagation model is the 'free-space' model, whereby the intensity decreases to one quarter when the distance is doubled. As mentioned previously though, in reality, it drops much faster than that due to loss of signal strength caused by absorption in trees, buildings and the earth itself.

To measure the RF levels for compliance purposes, one takes the highest transmitted power and the maximum antenna focus, and uses both of these to calculate the RF energy levels at any given distance from an antenna. Generally, due to the height of antenna masts, the antenna focus and other factors the RF emissions from base station sites are lower than the ICNIRP guidelines. In areas accessible to the public, measurements and calculations have found that the exposure levels to be far below international guidelines, typically by a factor of 500 or more.

7 Site design considerations

During the last decade the design of mobile communications equipment has matured rapidly, with a general trend to smaller equipment offering equal or greater functionality.

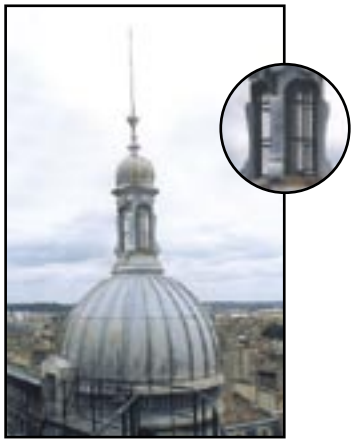
The antennas of base stations have however tended to remain visible, as radio engineers can achieve optimum performance when antennas are mounted on high ground (or the top of buildings) away from physical obstruction (other buildings, trees etc).

Creative antenna and mast tower design is capable of significantly reducing the visual impact of mobile communications infrastructure equipment. Examples of some of these creative solutions are as follows:

Base station integrated into lightpole

Base station blended into building facade

Base station blended
with historical building



Base station blended
into building facade

8 Site planning applications

It is appreciated that non-engineers having to consider applications for antenna sites frequently have to contend with a confusing array of technical information.

To assist these individuals in evaluating an application, the MMF has created a site declaration template that seeks to provide the main technical information relating to an installation in a consistent manner.

This template asks the person requesting the site to provide technical information on the RF emission levels as well as clear guidance on the compliance distance that applies and any exclusionary measures that are proposed.

The site declaration template can be downloaded from the MMF web-site http://www.mmfai.org

9 Community consultation

Despite the ever increasing use of mobile communications, the placing of communications infrastructure equipment within communities or in a visible rural location has tended to generate strong responses.

Predominately concerns relate to the landscape being spoiled, nearby property values being negatively affected and speculation that operating the equipment will lead to illness.

In some areas public feelings have been further heightened by real or perceived lack of consultation and factual information.

When considering the placement of communications infrastructure, it is suggested that;

- Community representatives are invited to view plans and are provided with independent factual information relating to health concerns.
- In areas of visual sensitivity then adoption of visually appealing solutions should be considered. It is important that the public is aware of such installations in order to avoid concerns that the equipment is being 'hidden'.
- in regions where best practice codes are in place then implementation of the requirements should be done in an open and transparent manner.

Sensibly designed equipment deployed after open consultation is more likely to meet the demands of the public, operators and local authorities and minimize unnecessary delays and concerns.

10 Further sources of information

1 **ICNIRP Guidelines on limiting exposure to time-varying electric, magnetic and electromagnetic fields (up to 300 GHz).** http://www.icnirp.de/documents/emfgdl.pdf

2 **NRPB-R321. Exposure to radio waves near mobile phone base stations.** http://www.nrpb.org/publications/archive/reports/2000/nrpb_r321.htm

3 **NRPB reports on EMF issues.** http://www.nrpb.org/radiation_topics/emf/index.htm

4 **Independent Expert Group on Mobile Phones (Stewart Enquiry).** http://www.iegmp.org.uk

5 **World Health Organisation International EMF Project**. http://www.who.int/peh-emf

6 **Report of the Health Council of the Netherlands.** http://www.gr.nl

7 **Australian Radiation Protection and Nuclear Safety Agency.** http://www.arpansa.gov.au/

8 **Council of the European Union Recommendation of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz) (1999/519/EC):** http://europa.eu.int/eur-lex/pri/en/oj/dat/1999/l_199/l_19919990730en00590070.pdf

9 **Professor John Moulder – Mobile Telephony and Human Health FAQ** http://www.mcw.edu/gcrc/cop/cell-phone-health-FAQ/toc.html

10 **The Wireless Information Resource Centre (WIRC) of Canada** (http://www.wirc.org)

11 Glossary

Definitions

Often one of the biggest barriers to understanding is the terminology used by the media, scientists and engineers. The following are useful to know:

2G	**2G**, the **Second Generation** of mobile communications systems, is the technology currently used in the operation of mobile phones.
3G	**3G**, or **Third Generation**, is the generic term used for the next generation of mobile communications systems. The new systems will enhance the services available today and offer multimedia and internet access and the ability to view video footage.
Aerial; Antenna	A device from which radio waves are transmitted and received. There are different designs in operation. A metallic rod or wire for sending and receiving radio waves or microwaves.
Analogue	First mobile phone technology which was phased out in favour of **Second Generation** digital technology.
ANSI	**A**merican **N**ational **S**tandards **I**nstitute.

Bluetooth	Based on a low-cost, short-range radio link, Bluetooth technology can connect many types of digital devices without a single cable in sight, giving more freedom to roam.
Cabin	A structure which protects **Transmitters** and receivers from damage. They can be in the form of large **Cabins** or smaller cabinets.
Cell	A geographic area of coverage that a **Radio Base Stations** covers.
Electromagnetic Waves; Fields; Electric Field	**Electromagnetic waves** are emitted by many natural and man-made sources and play a very important part in our lives. **Electromagnetic waves** are used to transmit and receive signals from mobiles phones and their base stations. The type of **electromagnetic waves** mobile phones use is called radio frequency (**RF**) waves/**fields**. A field of force surrounding a charged body or associated with a fluctuating magnetic field, with which charged particles interact.
EMC	Electromagnetic compatibility.
EMF	Electromagnetic **fields**.
ETSI	European Telecommunications Standards Institute.
Far Field	The area extending from an **antenna** where the **electric fields** and the magnetic **fields** are in phase with each other and are related by the characteristic impedance of free space.
FCC	Federal Communications Commission (USA).
Feeder cable	The co-axial cable which connects an **antenna** to a base station **transmitter** or receiver.
Field Strength	The amplitude of the electric or magnetic **fields**. Related to the **Power density** through the impedance of free space.
Frequency	**Frequency** is the number of times per second at which an electromagnetic wave oscillates. It determines the wave's properties and usage. Frequencies are measured in hertz (Hz). 1 Hz is one oscillation per second, 1 kHz a thousand, 1 MHz is a million and 1GHz is a thousand million. Frequencies between 30 kHz and 300 GHz are widely used for telecommunication, including broadcast radio and television, and comprise the radio **frequency** band. Mobile telephone systems currently operate at 900MHz and 1800MHz.

GSM	**GSM** (Global System for Mobile communications) is a world standard digital communications technology.
IARC	International Agency for Research on Cancer (IARC).
ICNIRP	The International Commission on Non-**Ionizing** Radiation Protection (**ICNIRP**) is an independent scientific body which has produced an international set of guidelines for public exposure to radio **frequency** waves. These guidelines were recommended in the Stewart Report and adopted by the Government, replacing the National Radiological Protection Board (**NRPB**) guidelines.
IEC	International Electrotechnical Commission.
IEEE	Institute of Electrical and Electronics Engineers.
Intentional Radiators	**Intentional radiators** are designed to radiate **EMF** and the levels they emit are strictly controlled by **EMC** and **EMF** guidelines.
Ionizing	A process in which an atom or molecule loses or gains electrons, acquiring an electric charge or changing an existing charge.
Macrocell	A **macrocell** provides the largest area of coverage within a mobile network. The **antennas** for **macrocells** can be mounted on ground-based **masts**, rooftops or other existing structures. They must be positioned at a height that is not obstructed by terrain or buildings. **Macrocells** provide radio coverage over varying distances depending on the **frequency** used, the number of calls made and the physical terrain. **Macrocell** base stations have a typical power output in tens of watts.
Mast	A ground-based structure that supports **antennas** at a height where they can satisfactorily send and receive radio waves. A typical **mast** is 15m high, and of steel lattice or tubular steel construction. New slimmer versions of **masts** are now available which can be painted to blend in with their surroundings, disguised as trees or used in conjunction with street lighting and CCTV cameras. **Masts** themselves play no part in the transmission of the radio waves.

Maximum Ground Level Emission	**Maximum Ground Level Emission** or the beam of highest intensity usually occurs between 50m and 200m from an antenna. The ground level emission within this area is the highest circling a base station. It is usually many thousands of times lower than international public exposure guidelines. Emission levels reduce rapidly as the distance increases from the **antenna**. The highest emissions levels are directly in front of the **antenna**.
Microcell	**Microcells** provide additional coverage and capacity where there are high numbers of users within urban and suburban **macrocells**. The **antennas** for **microcells** are mounted at street level, typically on the external walls of existing structures, lamp-posts and other street furniture. **Microcell antennas** are smaller than **macrocell antennas** and when mounted on existing structures can often be disguised as building features. **Microcells** provide radio coverage over distances, typically between 300m and 1000m and have lower output powers compared to **macrocells**, usually a few watts.
NCRP	National Council on Radiation Protection and Measurements.
Near Field	The **near field** is the region close to an **antenna**, where the electric and magnetic **fields** are not related to each other solely by the characteristic impedance of free space.
NRPB	The National Radiological Protection Board (**NRPB**) has two main functions: to advance knowledge about the protection of mankind from radiation hazards and to provide information and advice to persons in the UK with responsibilities relating to protection from radiation hazards. The **NRPB** has produced a set of national guidelines for public exposure to Radio **Frequency** waves. These have the same scientific foundation as the **ICNIRP** guidelines.
Picocell	A **picocell** provides more localised coverage than a **microcell**. These are normally found inside buildings where coverage is poor or where there are a high number of users such as airport terminals, train stations or shopping centres.
Power Density	The energy flowing from an **antenna** through a unit area normal to the direction of propagation in a unit time. This is measured in watts per square metre.
Radio Base Station	A **radio base station** is a **macrocell, microcell** or **picocell** site and consists of **transmitters** and receivers in a **cabin** or cabinet connected to **antennas** by **feeder cable**.
RF	Radio **Frequency**.

SAR	**SAR** (Specific Absorption Rate) is a measure of the amount of RF power absorbed in any part of the human body due to the use of equipment such as mobile phones or by human exposure close to other transmitting sources.
Second Generation	See **2G.**
Sectored Antenna	**Antenna** which transmits or receives higher signal levels in a horizontal direction. The **base station** is split into several sectors (typically 3 or 6) to provide 360 degree coverage.
Stub Mast	A roof-mounted **mast** structure which supports multiple **antennas** at a height where it can satisfactorily send and receive radio waves. A **stub mast** is typically 4m – 6m high and of steel lattice construction. **Stub masts** themselves play no part in the transmission of radio waves.
TETRA	**TE**rrestrial **T**runked **RA**dio, typically used by utilities and emergency services.
Third Generation	See **3G.**
Total Band Exposure Quotient	The sum of the **frequency** exposure quotients of all the bands at a single location.
Transmitter	Electronic equipment that generates radio **frequency** electromagnetic energy and is connected to an **antenna** via a **feeder cable**.
UMTS	Universal Mobile Telecommunication System (**UMTS**) is part of the international vision of a global family of third generation mobile communication systems. Some countries refer to this as 3G.
Unintentional Radiators	**Unintentional radiators** are not designed to radiate **EMF**. Any **EMF** they do emit are controlled by **EMC** guidelines.
Wavelength	**Wavelength** is the distance in metres between any two 'similar' points on a radio wave. This portion of the wave is referred to as one complete cycle. The lower the **frequency** of a wave the longer the **wavelength**.
WLAN	Wireless local area network (**WLAN**) is a low power radio technology which provides special zones for accessing a local area network over a short range, for instance at airports or hotels.
WMAN	Wireless metropolitan area network (WMAN) is providing wireless connection for broadband or multimedia users over a medium range, for instance covering small urban areas.

Mobile Manufacturers Forum

Diamant Building
80 Boulevard A. Reyers
B-1030 Brussels, Belgium
Telephone +32 2 706 8567 • **Fax** +32 2 706 8569
Internet www.mmfai.org