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GUIDANCE TO SAFETY AND HEALTH ASPECTS OF BASE STATIONS AND MOBILE PHONES

Prepared by

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Abbreviations

2G	Second Generation Mobile Communication
3G	Third Generation Wireless Technology
4G	Fourth Generation Mobile Communication
AC	Alternating Current
ACMA	Australian Communication and Media Authority
ADSL	Asynchronous Digital Subscriber Line
AFSSE	French Agency for Environmental Health Safety
AGNIR	Advisory Group on Non-Ionizing Radiation
AM	Amplitude Modulation
AMPS	Amplitude Modulation Pulse Synchronize
ANSI	American National Standards Institute
AP	Access Point
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency
B-field	The magnetic fields component of an electromagnetic field
BMI	Baseband Magnetic Interference
BWA	Broadband Wireless Access
CDMA	Code Division Multiple Access
CMA	Communication and Multimedia Act
CMCA	Malaysian Communications and Multimedia Commission Act 1998 / Act 589
DSL	Digital Subscriber Line
DS or DSSS	Direct Sequence Spread Spectrum
EA	Environmental Assessment
EC	European Commission
ECG	Electrocardiogram
E-Field	The electric field component of an electromagnetic field
EHS	Electromagnetic Hypersensitivity
EIRP	Effective Isotropically Radiated Power
ELF	Extremely Low Frequency
EM	Electromagnetic
EMC	Electromagnetic Compatibility

EMF	Electromagnetic Field
EMI	Electromagnetic Interference
ERP	Effective Radiated Power
ETACS	Extended Total Access Communication System
FAEHS	French Agency for Environmental Health Safety
FCC	Federal Communications Commission
FDA	Food and Drug Administration
FH or FHSS	Frequency Hopping Spread Spectrum
GHz	Gigahertz, one billion Hertz (1,000,000,000 Hertz)
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communication
HCN	Health Council of Netherlands
H-Field	The magnetic field component of an electromagnetic field
HPA	Health Protection Agency (formerly known as National Radiological Protection Board)
HSDPA	High-speed Downlink Packet Access
HSPDA	High Speed Packet Data Access
HSUPA	High-speed Uplink Packet Access
Hz	Hertz, unit of measurement for frequency (cycles per second)
I	Electric current
IAC	International Advisory Committee
IARC	International Agency for the Research on Cancer
ICNIRP	International Commission on Non-Ionizing Radiation Protection
IEC	International Electrotechnical Commission
IEE	Institute of Electrical Engineers
IEEE	Institute of Electrical and Electronics Engineers, Inc.
IEGMP	Indepedent Expert Group on Mobile Phones
ILO	International Labour Office
IP	Internet Protocol
IRPA	International Radiation Protection Association
ISM	Industrial Scientific and Medical
ITU	International Telecommunication Union

kHz	kiloHertz, one thousand Hertz (1000 Hertz)
MAC	Medium Access Control
MAN	Metropolitan Area Network
MCMC	Malaysian Communications and Multimedia Commission
MHLG	Ministry of Housing and Local Government (Kementerian Perumahan dan Kerajaan Tempatan)
MHz	Megahertz, one million Hertz (1,000,000 Hertz)
MIMO	Multi-input Multi-output Antenna System
Nuclear-Malaysia	Malaysian Nuclear Agency (formerly known as Malaysian Institute for Nuclear Technology and Research)
MoH	Ministry of Health Malaysia
MSC	Mobile Switching Centre
MTSFB	Malaysian Technical Standards Forum Berhad
NCRP	National Council on Radiation Protection and Measurements
NIR	Non-Ionizing Radiation
NMT	Nordic Mobile Telephone
NRPB	National Radiological Protection Board
OFDM	Orthogonal Frequency Division Multiplexing
OSHA	Occupational Safety & Health Act
PCS	Personal Communication System
PDC	Personal Digital Communication
PHY	Physical Layer
PSTN	Pulse Synchronization Transmission Network
QoS	Quality of Service
RF	Radio Frequency
RFI	Radio Frequency Interference
RFID	Radio Frequency Identification Device
rms	root mean square
SAR	Specific Absorption Rate
SIRIM QAS	SIRIM QAS International Sdn. Bhd., registered Certification Agency for Communication Equipment in Malaysia
TDMA	Time Division Multiple Access
UHF	Ultra High Frequency

UMMC	University Malaya Medical Centre
UMTS	Universal Mobile Telecommunications System
UNEP	United Nations Environment Programme
UV	Ultraviolet
UWB	Ultra-Wideband
VHF	Very High Frequency
VoIP	Voice over IP
WCDMA	Wide Band Code Division Multiple Access
WECA	Wireless Ethernet Compatibility Association
WHO	World Health Organization
WiBro	Wireless Broadband
WIEWG	Wireless Industries Emission Work Group
WiFi	Wireless Fidelity
WiMAX	World Interoperability for Microwave Access
WLAN	Wireless Local Area Network

INTRODUCTION

The intention of this document is to provide a guidance view on effects of human exposure to electromagnetic radiation, practices in other countries, interference in medical equipment and other related issues. This document is not meant to be prescriptive in anyway.

This guidance document has been prepared based on reports and guidelines from numerous studies and researches from various sources around the world. Some of the sources and well known documents referred in this document were published by the World Health Organization (WHO), International Commission on Non-Ionizing Radiation Protection (ICNIRP), the Independent Expert Group on Mobile Phones (IEGMP), the Health Council of the Netherlands (HCN), National Radiological Protection Board (NRPB) now known as the Health Protection Agency (HPA), the National Council on Radiation Protection and Measurements (NCRP) and the French Agency for Environmental Health Safety (AFSSE). All these documents and guidelines generally specify the human exposure limits to electromagnetic radiation up to 300 GHz and are applicable to both general public exposure and occupational exposure to electromagnetic fields (EMF) within the range of up to 300 GHz. These documents and guidelines exclude intentional exposure of patients who are undergoing medical treatment or in cases of medical diagnosis.

Product performance standards and measurement techniques will not be addressed in this document.

CHAPTER 1: BACKGROUND

1.1 Overview

Wireless communication has long played an important role. The rise in usage of mobile phones and its technologies has increased rapidly during the late 1990's. Worldwide, the number of mobile phone users reached 500 million in the year 2001, 700 million in the year 2003, and the estimated number of users today is expected to exceed the 1.5 billion mark. With the quick introduction of mobile telecommunications devices and technologies, especially among the general public, there has been a focus on the health problems associated with RF exposure from the base stations and mobile phones. In addition, concerns persist that chronic exposure to pulsed and amplitude modulated RF fields may cause specific health effects.

There have been numerous studies on the health effects of chronic exposure to the RF fields from base stations and mobile phones. The first extensive review on the effects of base stations and mobile phones and health was conducted in the year of 2000 by the Independent Expert Group on Mobile Phones (IEGMP), also known as the Stewart Report. This report focused on the radiation exposure from base stations and the use of mobile phones based on epidemiological and experimental studies on health effects. Subsequently the NRPB (currently known as HPA) published a report in 2004 that provides further advice to address public concerns about mobile phone technology.

In February 2005, the French Agency for Environmental Health Safety (AFSSE) published a document updating the scientific knowledge, in the specific field of non-ionizing radiation (NIR) used by mobile telephony system, titled "Report to the AFSSE on mobile telephony and health".

In Malaysia, the frequency bands at which the mobile phones operate are in the range from 450 MHz to 2200 MHz. These include 3 generations of mobile technologies. The first generation is NMT450 operating from 452 MHz to 466 MHz and ETACS from 888.5 MHz to 945 MHz. The second generation is GSM900 which operates from 880 MHz to 960 MHz and GSM1800 which operates from 1710 MHz to 1880 MHz. The third generation utilizes frequency from 1920 MHz to 2200 MHz. The estimated current total number of mobile phone subscribers in Malaysia is approximately 21.5 million as in the middle of year 2006, with the majority utilizing the second generation mobile technology.

In Malaysia, public concerns on the health effects over the widespread use of mobile phones started in the 1990's. This had prompted government to seriously look into the issue. In 1996, the Ministry of Health Malaysia was directed by the Cabinet to study the possible health effects of EMF. An inter agency committee was set-up for that purpose. This committee concluded that there was no conclusive evidence to indicate that EMF exposures at levels normally encountered can cause adverse health effects.

EMF exposure levels to all populations of the world will continue to increase with advancing technology. Therefore, even a small health consequence from EMF exposures could pose a major public health impact. Thus, continuous research and review of related documents are needed to ensure that they do not become outdated.

1.2 Radio frequency (RF) exposure

The RF part of the electromagnetic spectrum includes electromagnetic waves produced by broadcasting masts (television and radio transmitters) as well as telecommunication base stations. In mobile phone technology, there are two sources of RF exposure; the base station antennas and the mobile phones. Figure 1 illustrates how the mobile phone system works.

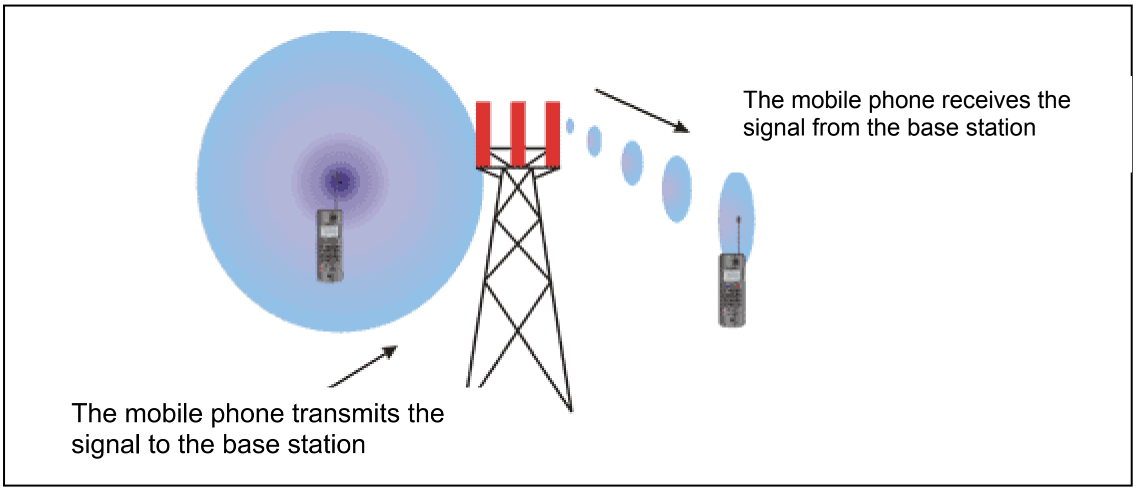


Figure 1: Basics on how mobile phone system works.

1.2.1 Base Stations

Base stations are responsible for receiving and transmitting phone signals to mobile phones. The phone call from a mobile phone is transmitted to the base station which connects to the rest of the other network operators. This can either be connected to a regular fixed-line phone system or to other mobile networks. Generally, base stations are located on towers, building structures (rooftops, sides, indoor, etc) and billboards.

Base stations are planned and located in a specific pattern geographically in order to achieve the most efficient coverage for a particular area. This pattern is normally referred to as a 'grid' and takes into consideration the surrounding terrain and structures.

1.2.2 Mobile phones

A mobile phone is a low-powered RF transmitter, radiating RF power in the range of 0.2 watts to 0.6 watts. Similar to the base station, the RF field strength falls off rapidly with increasing distance from the mobile phone. Exposure from the mobile phone to the head is more intense due to the shorter distance. However, it is only for intermittent periods and tends to be of concern to the user as the exposure is towards the side of the head for hand-held use, or towards the parts of the body closest to the mobile phones. The RF exposure will be discussed in Chapter 3.

As mobile phones and their base stations are two-way radios, they communicate by producing RF energy. As such, they expose people nearby them with RF energy. However, because both antenna of phone and the base stations emit low power RF (short range), its exposure levels are generally very low.

CHAPTER 2: BASIC CONCEPT OF EMF

2.1 What is Electromagnetic Fields (EMF)?

EMF is often used to indicate the presence of electromagnetic radiation, which consists of waves of electric and magnetic energy moving together through space at the speed of light. Electromagnetic (EM) waves can be characterized by their wavelength, frequency or energy. These three parameters are interrelated. The frequency of electromagnetic waves is the number of oscillations which passes a fixed point per unit time. It is measured in units of Hertz (1 Hz = 1 cycle per second). The wavelength is the distance travelled by the wave in one oscillation (or cycle). The middle of the amplitude modulation (AM) broadcast band, for example, has a frequency of 1 MHz and a wavelength of about 300 meters. EM waves can travel through space while carrying energy at the speed of light. The higher the frequency, the shorter the wavelength.

EM waves extend from the lowest frequency to frequencies beyond radio waves, light waves, X-rays and gamma rays. This broad energy range is known as the electromagnetic spectrum (refer Figure 2). Most cellular or mobile phones operate at a variety of frequencies between about 450 MHz to 2200 MHz.

In general, power lines, electrical wiring and electrical equipment produce EMF. There are many other sources of EMF which includes mobile phones and base stations.

It is established that energy from radio waves can lead to the heating of the body, but radio waves do not have sufficient energy to damage cell structures. Thus, the RF energy from the base stations and the mobile phones is considered as "non-ionizing". Non-ionizing radiation (NIR) is a general term for certain parts of the electromagnetic spectrum with energies that are too weak to break atomic bonds. They include extremely low frequency (ELF) fields, radiofrequency and microwave (RF/MW) fields, infrared radiation, visible light and ultraviolet (UV) radiation. As non-ionizing radiation cannot break chemical bonds, there is no similarity between the biological effects of non-ionizing radiation and ionizing radiation (such as x-rays).

At the extremely high frequencies of electromagnetic spectrum (such as x-rays and gamma rays), electromagnetic particles (photons) have sufficient energy to cause ionization (create positive and negative electrically charged atoms or parts of molecules) by breaking the atomic bonds that hold molecules in cells together. This is how x-rays damage the genetic material of cells, potentially leading to cancer or birth defects.

Even at high intensity, NIR cannot cause ionization in a biological system. However NIR have been shown to produce other biological effects; for instance, heating, altering chemical reactions or inducing electrical currents in tissues and cells. However, exposures normally encountered by the public do not result in these effects.

2.2 Quantities and units

Frequency and field strength are used to measure radio signals. Radio receivers tune in to signals according to their frequency and sufficient field strength must be available in order for them to be received. Field strength can further be specified as either electric field strength or magnetic field strength. In addition, current density, SAR and power density are used to relate the effects of RF exposure.

2.2.1 Electric field strength (E)

Electric fields are produced by voltage and increase in strength as the voltage increases. Electric fields are often present even when the electric appliance is switched off, as long as it remains connected to the source of electric power. It is expressed in volt per meter ($V\ m^{-1}$). Electric fields can be shielded or weakened by buildings, trees and other objects that conduct electricity.

2.2.2 Magnetic field strength (H)

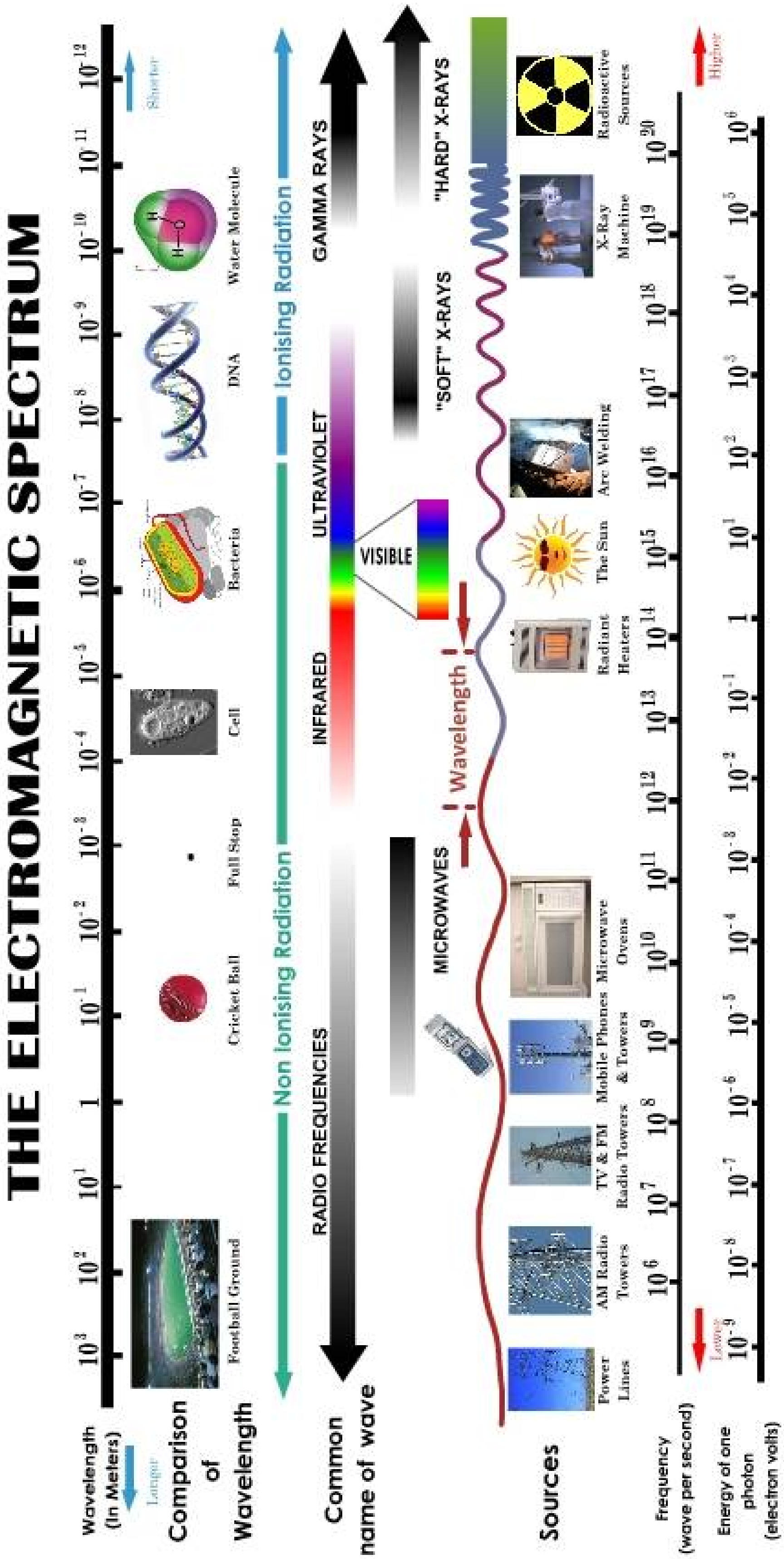
The magnetic fields resulted from the flow of current through wires or electrical appliances and it increases in strength as the current increases. Most electrical appliances have to be switched on, i.e. current must be flowing, for a magnetic field to be produced.

Alternating magnetic fields produced by alternating current (AC) electricity can induce the flow of weak electric currents in the body. The magnetic field strength is measured in ampere per meter ($A\ m^{-1}$). The unit for magnetic flux density (B) is expressed as Tesla (T) or Gauss (G) (1 T = 10,000 G). Since most environmental EMF exposures involve magnetic fields that are only a fraction of a tesla, microtesla (μT) or milligauss (mG) are commonly used.

2.2.3 Current density

Current density is a vector of which the integral over a given surface is equal to the current flowing through the surface; the mean density in a linear conductor is equal to the current divided by the cross-sectional area of the conductor. It is expressed in ampere per square meter ($A\ m^{-2}$).

Figure 2:



Electromagnetic Spectrum

2.2.4 Specific Absorption Rate (SAR)

For the purpose of radiation protection, dosimetric quantities are needed to estimate the absorbed energy and its distribution inside the body. SAR is a dosimetric quantity that is widely adopted to quantify the radiation from mobile phones. SAR values are a measure of the maximum absorption of energy per unit of tissue mass of a person exposed to RF radiation over a given period of time; or in simple terms, the power absorbed per unit mass. The unit for SAR is watts per kilogram (W kg^{-1}). This measurement is made over 10 g of tissue.

SAR is used to measure the amount of RF energy absorbed into the head during the use of mobile phone. In terms of SAR rating, higher the SAR rating or value, more energy is being absorbed by the tissues of the head. Therefore, mobile phones with a lower SAR value are considered "safer" than those with a higher SAR value.

Many governments and governmental agencies around the world have established the maximum allowable SAR values for mobile phones. Most of the governments and authorities require that the SAR value of all mobile phones should be made available. The SAR values for most mobile phones are available at *"http://www.fcc.gov/cgb/sar/"* or *"www.mmfai.org/public/sar.cfm".* See Annex B for details on SAR value.

2.2.5 Power density (S)

Power is measured in watts (W), milliwatts (mW) or microwatts (μW). The intensity of power (also referred to as "power density") of an electromagnetic wave is the power passing through 1 m^2 of wave propagation. Power density is normally used to measure RF radiation and it is measured in units of watts per square meter (W m^{-2}).

When considering human exposure to radio waves from base stations it is the norm to consider the power density rather than the field strength because this is more closely related to the quantities in which restrictions on exposure are specified.

2.3 Basic restrictions and reference levels

In order to assess health effects of electromagnetic fields, differentiation should be made between basic restrictions and reference levels. Basic restrictions for limiting exposure were developed based on thorough reviews various internationally published scientific literatures. The physical quantities used to specify these restrictions are "current density" (mA m^{-2}), "specific absorption rate" (W kg^{-1}) and "power density" (W m^{-2}) depending on the frequency of the field. However, basic restrictions are often impractical to measure. Therefore, reference levels which utilize quantities that are more practical to measure, are provided as an alternative means of showing compliance with the basic restrictions. Table 1 shows the relationship between basic restrictions and reference levels.

Table 1. Relationship between basic restrictions and reference levels

Frequency range	Basic restrictions	Corresponding reference levels
Up to 1 Hz	- Current density for head and trunk	- H - B
1 Hz to 100 kHz	- Current density for head and trunk	- E - H - B
100 kHz to 10 MHz	- Current density for head and trunk - Whole-body average SAR - Localized SAR (head and trunk) - Localized SAR (limbs)	- E - H - B
10 MHz to 10 GHz	- Whole-body average SAR - Localized SAR (head and trunk) - Localized SAR (limbs)	- E - H - B - Equivalent plane wave power density
10 GHz to 300 GHz	- Power density	- Equivalent plane wave power density

2.3.1 Basic restrictions

Basic restrictions are restriction on human exposure to time-varying electric, magnetic and electromagnetic fields which are based directly on established health effects and biological considerations. These restrictions must not be exceeded in order to minimise adverse health effects due to EMF exposure. Different scientific bases were used in the development of basic exposure restrictions for various frequency ranges:

- Basic restrictions between 1 Hz to 10 MHz are provided on current density to prevent effects on nervous system functions. Details of basic restriction limits for general public and workers for this frequency range are given in Table 2.

- Basic restrictions between 100 kHz to 10 GHz are provided on SAR to prevent whole-body heat stress and excessive localized tissue heating. In the 100 kHz to 10 MHz range, basic restrictions are provided on both current density and SAR. Details of basic restriction limits for general public and workers for this frequency range are given in Table 2.

- Basic restrictions between 10 GHz to 300 GHz are provided on power density to prevent excessive heating in tissue at or near the surface of the body. Details of basic restriction limits for general public and workers for this frequency range are given in Table 3.

Table 2. Basic restrictions for time-varying electric, magnetic, and electromagnetic fields for frequencies up to 10 GHz and SAR values

Exposure characteristics	Frequency Range	Current Density (head & trunk) (mA m^{-2}) (rms)	Whole body average SAR (W kg^{-1})	Localized SAR (head & trunk) (W kg^{-1})	Localized SAR (limbs) (W kg^{-1})
General public	Up to 1 Hz	8	-	-	-
	1Hz - 4Hz	$8/f$	-	-	-
	4Hz - 1kHz	2	-	-	-
	1kHz - 100 kHz	$f/500$	-	-	-
	100kHz - 10MHz	$f/500$	0.08	2	4
	10 MHz - 10 GHz	-	0.08	2	4
Occupational	Up to 1 Hz	40	-	-	-
	1Hz - 4Hz	$40/f$	-	-	-
	4Hz - 1kHz	10	-	-	-
	1kHz - 100 kHz	$f/100$	-	-	-
	100 kHz - 10MHz	$f/100$	0.4	10	20
	10 MHz - 10 GHz	-	0.4	10	20

NOTES:

1. f is the frequency measured in hertz.

2. Because of electrical inhomogeneity of the body, current densities should be averaged over a cross-section of 1 cm^2 perpendicular to the current direction.

3. For frequency up to 100 kHz, peak current density values can be obtained by multiplying the rms value by √2(~1.414). For pulses of duration t_p the equivalent frequency to apply in the basic restrictions should be calculated as $f=1/(2t_p)$.

4. For frequencies up to 100 kHz and for pulsed magnetic fields, the maximum current density associated with the pulses can be calculated from the rise/fall times and the maximum rate of change of magnetic flux density. The induced current density can then be compared with the appropriate basic restriction.

5. All SAR values are to be averaged over any 6-min period.

6. Localized SAR averaging mass is any 10 g of contiguous tissue; the maximum SAR so obtained should be the value used for estimation of exposure.

7. For pulses of duration t_p the equivalent frequency to apply in the basic restrictions should be calculated as $f=1/(2t_p)$. Additionally, for pulsed exposures in the frequency range 0.3 to 10 GHz and for localized exposure of the head, in order to limit or avoid auditory effects caused by thermoelastic expansion, an additional basic restriction is recommended. This is that the SAR should not exceed 10 mJ kg^{-1} for workers and 2 mJ kg^{-1} for the general public, averaged over 10 g tissue.

Table 3. Basic restrictions for power density for frequencies between 10 and 300 GHz

Exposure characteristics	Power density ($W\ m^{-2}$)
Occupational exposure	50
General public	10

NOTES:

1. Power densities are to be averaged over any 20 cm^2 of exposed area and any $68/f^{1.05}$-min period (where f is in GHz) to compensate for progressively shorter penetration depth as the frequency increases.

2. Spatial maximum power densities, averaged over 1 cm^2, should not exceed 20 times the values above.

2.3.2 Specific Absorption Rate (SAR)

Specific Absorption Rate (SAR) is a basic quantity for RF fields between about 1 MHz to 10 GHz. It is a measure of energy absorption from RF fields in tissues. A whole-body SAR value of 4 watts per kilogram (4 W kg^{-1}) has been identified as the threshold exposure value at which harmful biological effects may occur. This limit has been concurrently agreed by the ICNIRP, NCRP and IEEE as the threshold for SAR. As for localized SAR, the absorption of energy in the head should not exceed 2 W kg^{-1} (watts per kilogram) when averaged over any 10 gram of contiguous tissue and over any 6 minute period, as advised by ICNIRP.

All SAR values are to be averaged over a 6 minute period. For example, a 3 minute call during which the SAR was 1 W kg^{-1} followed by no use of the phone for the next 3 minutes, the 6 minute averaged SAR would be 0.5 W kg^{-1}. This figure should be the value to be compared with the 2 W kg^{-1} ICNIRP basic restrictions.

2.3.3 Reference levels

Reference levels are provided for practical exposure-assessment purposes to determine if basic restrictions are expected to be exceeded. If these levels are exceeded, adverse health effects may occur in exposed individuals. Certain reference levels are derived from relevant basic restrictions using measurements and/or computational techniques and certain reference levels address perception and adverse indirect effects of exposure to EMF. They are given for the condition of maximum coupling of the field to the exposed individual, thereby providing maximum protection.

The quantities for reference levels are “electric field strength (E)”, “magnetic field strength (H)”, “magnetic flux density (B)” and “power density (S)”. Quantities that address perception and other indirect effects are “contact current” (I_C) and, for pulsed fields, “specific energy absorption”.

In any particular exposure situation, measured or calculated values of any of these quantities can be compared with the appropriate reference levels. Compliance to the reference levels will ensure compliance to the relevant basic restrictions. If the measured value exceeds the reference level, it does not necessarily follow that the basic restriction will be exceeded.

Some quantities such as magnetic flux density (B) and power density (S) serve both as basic restrictions and reference levels at certain frequencies. Tables 4 and 5 summarize the reference levels for occupational exposure and exposure of the general public respectively, and the reference levels are illustrated in Figures 3 and 4.

Table 4. Reference levels for occupational exposure to time-varying electric and magnetic fields (unperturbed rms values)

Frequency range	E-field strength ($V\ m^{-1}$)	H-field strength ($A\ m^{-1}$)	B-field (μT)	Equivalent plane wave power density S_{eq} ($W\ m^{-2}$)
Up to 1 Hz	—	1.63×10^5	2×10^5	—
1 - 8 Hz	20,000	$1.63 \times 10^5/f^2$	$2 \times 10^5/f^2$	—
8 - 25 Hz	20,000	$2 \times 10^4/f$	$2.5 \times 10^4/f$	—
0.025 - 0.82 kHz	$500/f$	$20/f$	$25/f$	—
0.82 - 65 kHz	610	24.4	30.7	—
0.065 - 1 MHz	610	$1.6/f$	$2.0/f$	—
1 - 10 MHz	$610/f$	$1.6/f$	$2.0/f$	—
10 - 400 MHz	61	0.16	0.2	10
400 - 2,000 MHz	$3f^{1/2}$	$0.008f^{1/2}$	$0.01f^{1/2}$	$f/40$
2 - 300 GHz	137	0.36	0.45	50

NOTES:

1. *f* as indicated in the frequency range column.

2. Provided that basic restrictions are met and adverse indirect effects can be excluded, field strength values can be exceeded.

3. For frequencies between 100 kHz and 10 GHz, S_{eq}, E^2, H^2, and B^2 are to be averaged over any 6-min period.

4. For peak values at frequencies up to 100 kHz see Table 2, note 3.

5. For peak values at frequencies exceeding 100 kHz see Figure 3 and 4. Between 100 kHz and 10 MHz, peak values for the field strengths are obtained by interpolation from the 1.5-fold peak at 100 kHz to the 32-fold peak at 10 MHz. For frequencies exceeding 10 MHz it is suggested that the peak equivalent plane wave power density, as averaged over the pulse width, does not exceed 1,000 times the S_{eq} restrictions, or that the field strength does not exceed 32 times the field strength exposure levels given in the table.

6. For frequencies exceeding 10 GHz, S_{eq}, E^2, H^2, and B^2 are to be averaged over any $68/f^{1.05}$-min period (*f* in GHz).

7. No E-field value is provided for frequencies < 1 Hz, which are effectively static electric fields. Electric shock from low impedance sources is prevented by established electrical safety procedures for such equipment.

Table 5. Reference levels for general public exposure to time-varying electric and magnetic fields (unperturbed rms values)

Frequency range	E-field strength ($V m^{-1}$)	H-field strength ($A m^{-1}$)	B-field (μT)	Equivalent plane wave power density S_{eq} ($W m^{-2}$)
up to 1 Hz	—	3.2×10^4	4×10^4	—
1–8 Hz	10,000	$3.2 \times 10^4/f^2$	$4 \times 10^4/f^2$	—
8–25 Hz	10,000	4,000/*f*	5,000/*f*	—
0.025–0.8 kHz	250/*f*	4/*f*	5/*f*	—
0.8–3 kHz	250/*f*	5	6.25	—
3–150 kHz	87	5	6.25	—
0.15–1 MHz	87	0.73/*f*	0.92/*f*	—
1–10 MHz	$87/f^{1/2}$	0.73/*f*	0.92/*f*	—
10–400 MHz	28	0.073	0.092	2
400–2,000 MHz	$1.375f^{1/2}$	$0.0037f^{1/2}$	$0.0046f^{1/2}$	*f*/200
2–300 GHz	61	0.16	0.20	10

NOTES:

1. *f* as indicated in the frequency range column.
2. Provided that basic restrictions are met and adverse indirect effects can be excluded, field strength values can be exceeded.
3. For frequencies between 100 kHz and 10 GHz, S_{eq}, E^2, H^2, and B^2 are to averaged over any 6-min period.
4. For peak values at frequencies up to 100 kHz see Table 2, note 3.
5. For peak values at frequencies exceeding 100 kHz see Figure 3 and 4. Between 100 kHz and 10 MHz, peak values for the field strengths are obtained by interpolation from the 1.5-fold peak at 100 kHz to the 32-fold peak at 10 MHz. For frequencies exceeding 10 MHz it is suggested that the peak equivalent plane wave power density, as averaged over the pulse width does not exceed 1,000 times the S_{eq} restrictions, or that the field strength does not exceed 32 times the field strength exposure levels given in the table.
6. For frequencies exceeding 10 GHz, S_{eq}, E^2, H^2, and B^2 are to be averaged over any $68/f^{1.05}$-min period (*f* in GHz).
7. No E-field value is provided for frequencies < 1 Hz, which are effectively static electric fields. Perception of surface electric charges will not occur at field strengths less than 25 $kV m^{-1}$. Spark discharges causing stress or annoyance should be avoided.

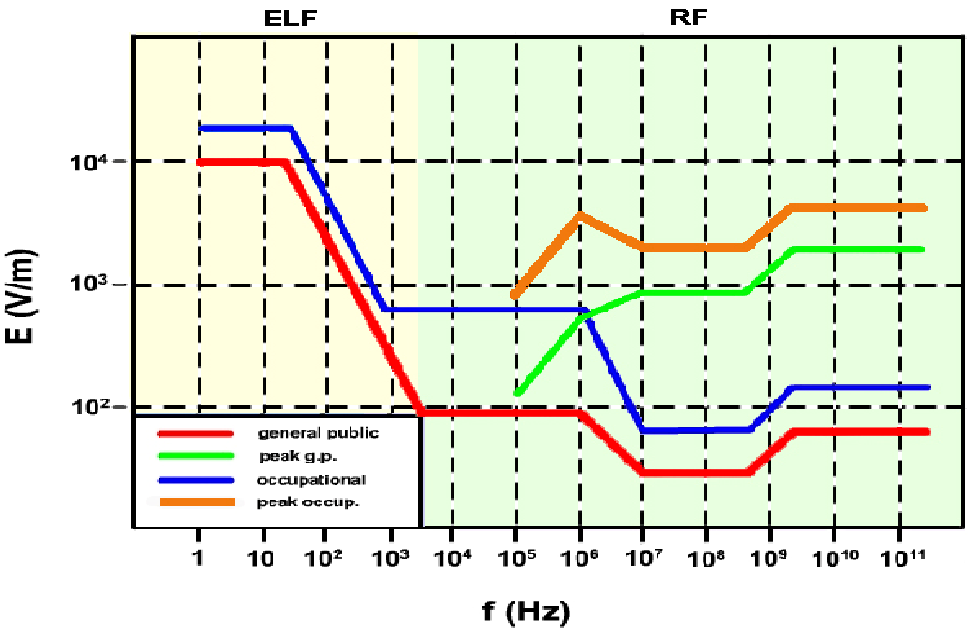


Figure 3: Reference levels for exposure to time varying electric fields (compare Tables 4 and 5).

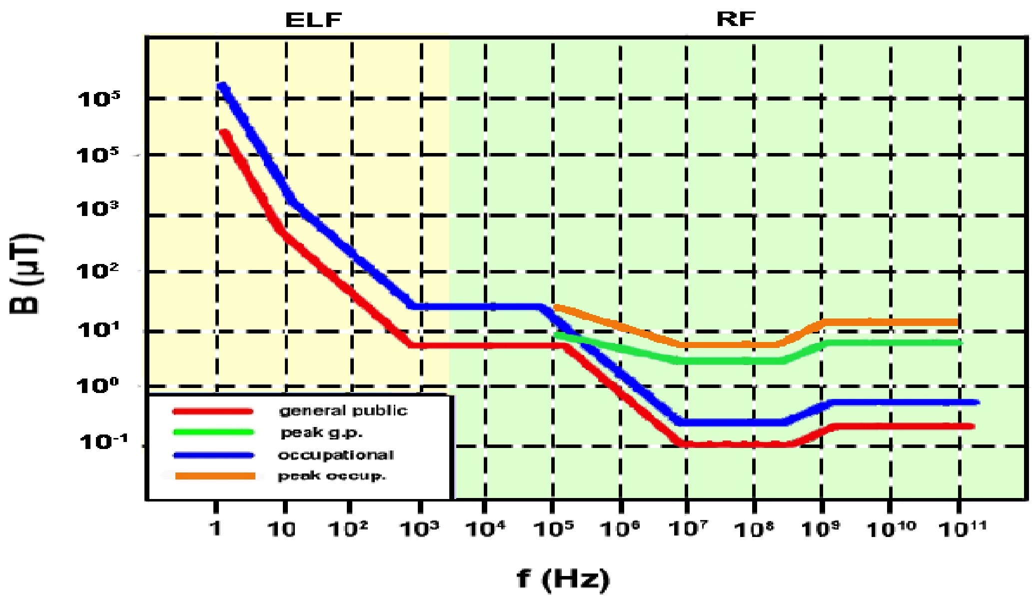


Figure 4: Reference levels for exposure to time varying magnetic fields (compare Tables 4 and 5).

2.4 Exposure limits

Exposure limits is the limit on exposure to EMF, which are based directly on established health effects and also biological considerations. As mentioned earlier, ICNIRP has developed guidelines for exposure limits to EMF up to 300 GHz. The ICNIRP guidelines are based on an analysis of all relevant scientific literature, including both thermal and non thermal studies. They are based on comprehensive reviews of published peer-reviewed literature. Its aim is to establish guidelines that will provide protection against known adverse health effects. The guidelines include a substantial safety margin for limiting exposure. The advice on exposure guidelines is based on an assessment of the possible thermal effects of EMF on human health. It is derived from epidemiological studies of exposed human populations, experimental investigations, results from volunteer studies and dosimetric information.

A person's exposure to RF energy can be measured in several ways. To evaluate exposure from base station transmitters, the relevant basic restriction in the ICNIRP guidelines is whole-body averaged SAR. ICNIRP specifies that this value should not exceed 0.4 W kg^{-1} for workers and 0.08 W kg^{-1} for the general public.

As for exposure from mobile phones, the relevant ICNIRP basic restriction in the ICNIRP guidelines is localized SAR. ICNIRP specifies that head and trunk localized SAR should not exceed 2 W kg^{-1}.

However, since SAR is not very easy to measure practically, a reference level (refer section 2.3.3) in terms of the power density is used to determine the exposure received. The limits depend on the frequency of the RF field. For both occupational and public exposure, see Table 4 and Table 5 respectively.

An important point to be considered in exposure limit guideline is that a guideline limit is not a precise delineation between safety and hazard. There is no one particular level where exposures become hazardous to health. However, the potential harm to human health gradually increases with higher exposure levels. Exposure limit guidelines indicate that, below a given threshold, EMF exposure is safe according to scientific knowledge. However, assumption should not be made that, above the given limit, exposure is harmful. This is because a safety factor is introduced to set the exposure limits. ICNIRP uses a reduction factor of 10 to derive occupational limits for workers and a factor of about 50 to arrive at exposure limit for the public.

Most international and national guidelines specify two different sets of exposure limits; one for occupational and another for the general public (non-occupational) exposures. The exposure limit for the general public is set lower than the limit for occupational exposure. This is because the occupationally exposed population consists of adults who are generally exposed under known conditions and are trained to be aware of potential risk and to take appropriate precautions. By contrast, the general public comprises individuals of all ages and of varying health status, and may include particularly susceptible groups or individuals. It also takes into account the fact that in many cases, members of the public are unaware of their exposure to EMF. Moreover, individual members of the general public cannot reasonably be expected to take precautions to minimize or avoid exposure. In addition, workers are typically exposed only during working hours (usually 8 hours per day) while the general public can be exposed for up to 24 hours per day. Those are the underlying considerations that lead to more stringent exposure restrictions for the general public than the workers.

2.4.1 Occupational exposure

An occupational exposure refers to all exposure to EMF experienced by individuals in the course of performing their work. Occupational exposure involves adult population who are generally exposed to EMF under known conditions during the normal course of employment. Employers in this population are expected to train workers to be aware of the potential health and safety risks associated during employment and to take appropriate precautions from excessive exposure to EMF.

The Australian Standard (Maximum Exposure Levels to Radiofrequency Fields – 3 kHz to 300 GHz) on RF exposure specify on occupationally exposed women who are pregnant. It states that in order to reduce the risk of accidental exposure above occupational limits, a pregnant woman should not be exposed to levels of RF above the limits of general public exposure.

2.4.2 Public exposure

A public exposure refers to all exposure to EMF experienced by members of the general public, excluding occupational exposure and exposure during medical procedures. Public exposure involves the general public in all age groups and in various health conditions, including groups or individuals who may be susceptible to EMF exposures such as children or younger adults. Usually, members of the public are not aware of their exposure to EMF and cannot be expected to take precautions in order to minimize or to avoid exposure. It is due to this factor that extra stringent exposure restrictions were developed for the general public.

ICNIRP has recommended that exposure guidelines for members of the public should be more restrictive than for workers. This allows for a greater sensitivity to adverse health effects in the general population than for the working population. Increased sensitivity may occur in infants and children, individuals being treated with medication and those in the later years of life. ICNIRP recommends a reduction factor of five in the basic restrictions for members of the public compared with workers.

Table 6 shows the summary of the ICNIRP exposure guidelines at frequencies of 900 MHz and 1800 MHz at which most mobile phone systems in Malaysia operate (Refer to Tables 4 and 5 for details on exposure limits).

The reference level is 4.5 W m^{-2} for the 900 MHz frequency band, and 9 W m^{-2} for 1800 MHz. The different reference levels arise because the body tends to interact more strongly with radio waves at 900 MHz than at 1800 MHz meaning that a lower reference level has to be set.

Table 6: Summary of the ICNIRP exposure guidelines

	Mobile phone base station frequency			
Frequency	450 MHz	900 MHz	1800 MHz	2000 MHz
Unit	Power density (W m^{-2})	Power density (W m^{-2})	Power density (W m^{-2})	Power density (W m^{-2})
Public exposure limits	2.25	4.5	9	10
Occupational exposure limits	11.25	22.5	45	50

It should be noted that ongoing research on exposure limits and health risk assessments are being carried out by ICNIRP. Therefore, any future findings and recommendation from ICNIRP and WHO EMF project group should be continuously reviewed.

2.5 Multiple frequency exposure

When considering exposure in the context of ICNIRP guidelines, it is important to recognise that the guidelines are intended to limit total exposure to radio waves from all sources and not just that part of exposure arising from a particular frequency. Multiple frequency exposures are the simultaneous occurrence to fields of different frequencies, and the possibility that these exposures will be cumulative in their effects must be considered. The formulae in section 2.5.1 and 2.5.2 apply to multiple frequency exposure situations.

2.5.1 Basic restrictions

For thermal effects, relevant above 100 kHz, SAR and power density values should be added according to:

$$\sum_{i = 100\ \text{kHz}}^{10\ \text{GHz}} \frac{SAR_i}{SAR_L} + \sum_{i > 10\ \text{GHz}}^{300\ \text{GHz}} \frac{S_i}{S_L} \leq 1 \qquad (1)$$

where,

SAR_i is the SAR caused by exposure at frequency *i*;

SAR_L is the SAR limit given in Table 2;

S_i is the power density at frequency *i*, and

S_L is the power density limit given in Table 3;

2.5.2 Reference levels

For thermal consideration, relevant above 100 kHz, the following two requirements should be applied to the field levels:

$$\sum_{i=100\text{ kHz}}^{1\text{ MHz}} \left[\frac{E_i}{c}\right]^2 + \sum_{i>1\text{ MHz}}^{300\text{ GHz}} \left[\frac{E_i}{E_{L,i}}\right]^2 \leq 1 \qquad (2)$$

and

$$\sum_{j=100\text{ kHz}}^{1\text{ MHz}} \left[\frac{H_j}{d}\right]^2 + \sum_{j>1\text{ MHz}}^{300\text{ GHz}} \left[\frac{H_j}{H_{L,j}}\right]^2 \leq 1 \qquad (3)$$

where,

E_i is the electric field strength at frequency *i*;

$E_{L,i}$ is the electric field reference level from Tables 4 and 5;

H_j is the magnetic field strength at frequency *j*;

$H_{L,j}$ is the magnetic field reference level from Tables 4 and 5;

c is $610/f$ V m^{-1} (*f* in MHz) for occupational exposure and $87/f^{1/2}$ V m^{-1} for general public exposure; and

d is $1.6/f$ A m^{-1}(*f* in MHz) for occupational exposure and $0.73/f$ for general public exposure.

The summation formula assume worst-case conditions among the fields from the multiple sources. As a result, typical exposure situations may in practice require less restrictive exposure levels than indicated by the above formula for the reference levels.

Chapter 3: Mobile Phone and Base Station Technology

3.1 Technical background

3.1.1 Mobile phone

Across the world, mobile phones and the mobile network operate differently in terms of frequency and transmission power. However, all mobile phones communicate using electromagnetic waves over the air through base stations. See Figure 1.

The mobile phones have a low power transceiver that is designed to transmit voice and data up to a few kilometers to where the base station is located. The mobile phone constantly listens for the nearest base station with the strongest signal. Upon detection of a signal, the mobile phone's radio frequency signals are transmitted to the nearest base station and incoming signals are sent from the base station to the phone at a slightly different frequency. This cycle is then repeated as the phone 'roams' around the network and new base stations appear in the mobile phones range.

Base stations have radio transmitters which broadcast their presence and relay communications to and from the mobile phones. The base stations are connected to the telephone network by a high-capacity link which provides the backbone to the operator's mobile network and this in turn, to the wider public telephone network as well as the networks of other mobile phone operators. The dialogue between each mobile phone and the base station is a stream of digitized signals.

The power transmitted from a mobile phone during a call is dependant on the received coverage level from the base station. In cellular technology, all transmitting devices, be it mobile phones or base stations, are designed to transmit the lowest amount of power as required to sustain a call. This is in order to minimize the possibility of interference to the system if excessive power is used. Therefore, good coverage is necessary so that emission from the mobile phone is reduced. This is turn saves on the mobile phone battery power, due to the lower output power used.

The technology that achieves this communication between the mobile phone and base station depends on the system which the mobile phone operator has adopted. Some current technologies include Code Division Multiple Access (CDMA), Global System for Mobile Communication (GSM) and Universal Mobile Telecommunication System (UMTS) for digital communications. Each network operator has a unique assigned radiofrequency from defined standard frequencies allocated to each technology.

Worldwide, the mobile phone system is often referred to as 'cellular' telephone technology because the regions being covered are broken up into 'cells', and each of these cells has their own localized service provided by a base station antenna. Currently, both the GSM and CDMA systems, and most recently WCDMA and CDMA 2000 are used in mobile networks worldwide.

Examples of different frequencies for mobile phone systems in some countries are listed below:

- **Canada:** Analog and digital mobile phones operate around 800-900 MHz, and there is a 2000 MHz digital system (similar or identical to PCS service in the US).

- **Australia:** The analog AMPS phones operate around 800 MHz. The GSM phones operate around 900 and 1800 MHz. WCDMA operates around 2000 MHz.

- **Europe**: The analog systems operate at about 450 MHz and 900 MHz. The GSM phones operate around 900 and 1800 MHz. WCDMA operates around 2000 MHz.

- **USA**: The analog AMPS phones operate around 800 MHz. The GSM phones operate around 1900 MHz. CDMA 2000 and PCS operates around 2000 MHz.

3.1.2 Base stations

Technology limits the mobile coverage area for base stations because the radio signals are only able to travel within a distance before they become weak and cannot be received by mobile phones. Higher transmission power and greater base stations antenna height allow radio signals to travel further. However, connection to the base station is limited by the lower power of mobile phones.

Base stations are also limited in terms of capacity, meaning that there are a limited number of mobile phone calls they can handle at any one particular moment. The determining factor in terms of capacity and the number of phone calls a base station can handle depends largely on the number of transceiver installed on a base station.

As mentioned in mobile phone technology (section 3.1.1), communication between base stations with mobile phones within a defined area is known as 'cells'. Cells are typically described in the form of regular hexagons making up a 'honeycomb' structure. In actual situations, their shapes are irregular (see Figure 5). Most cells for GSM base stations are generally 1-5 km in radius in rural areas and limited to a few hundred metres in radius in urban areas, depending on the capacity needed.

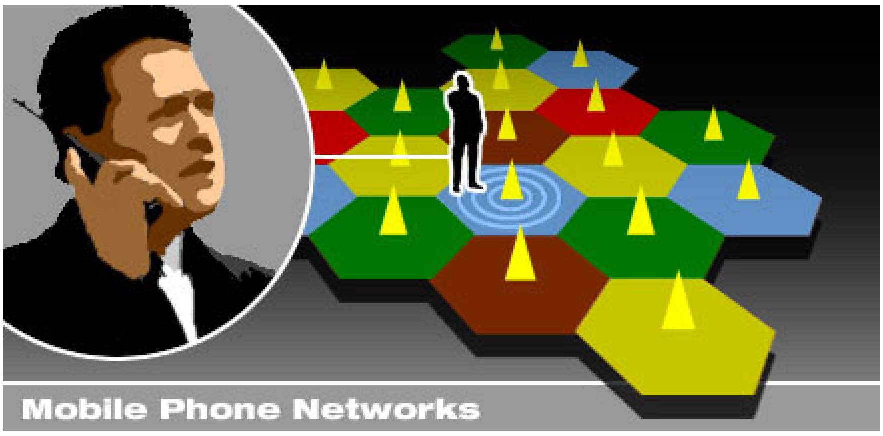


Figure 5: Cells of mobile phone base station

When a person using a mobile phone travels, the radio communications signals are passed from one base station to another, therefore allowing continuous communication. These signals never have to travel more than a few kilometres before connected to other base stations that are nearest to the person. Base stations link mobile phones to the rest of the mobile and fixed networks. Without sufficient base stations in the right locations, mobile phones will not work, thus network signals will be 'weak' or 'unavailable'.

Base stations and their coverage, depending on Effective Isotropically Radiated Power (EIRP) of the antenna are known as either macrocells, microcells or picocells.

As a reference Table 7 below summarizes the type of base station locations.

Table 7: Typical base stations locations

Site Type	Location 1	Location 2	Location 3
Outdoor - Macro Cells	**Rooftop -** Mini Structure Boom Pole Wall Mounted (Tall Buildings)	**Land -** Guyed Mast Cellular Tower Broadcast/ Transmission Tower Monopole	**Others -** Billboard Water Tank Signboard Minaret
		Stand Alone Mast	
		Aesthetic Monopole	
Outdoor - Micro Cells	**Street Level -** Lamp Post Traffic Light Wall Mounted (2/3 storey building)		
In-Building – Pico Cells	**Corridor/ Hall/ Room-** Wall Mounted Ceiling Mounted Leaky feeder/cable	**Parking Area -** Wall Mounted Ceiling Mounted Leaky feeder/cable	**Tunnel -** Wall Mounted Ceiling Mounted Leaky feeder/cable

The main structure for base station networks are macrocells. Macrocells have base stations antennas mounted on structures which are higher than the buildings and with power outputs of a few hundred watts which enable communication of up to approximately 10 km.

Microcell base stations have antennas mounted much closer together than macrocell and are closer to street level, thus giving extra capacity to the network where the demand for phone use is high. These cells are typically located at shopping centres, airports and railway stations. Microcell base stations emit less power than those for macrocells and their communication range is limited to a few hundred meters.

Picocells are base stations with the lowest emission of power (less than one watt) and are used to provide coverage inside buildings or enclosed structures.

Base stations employ the use of antennas to provide radiofrequency coverage which is critical for mobile phones to access the network to make and receive calls. Two main types of antenna systems are usually used: Omnidirectional and sectorized antennas. Each of these two types has specific characteristics and are employed depending on the coverage requirements.

Omnidirectional antennas, or Omni, provide an all-round 360 degree coverage for a particular base station. They are normally used where the surrounding area is open, sparsely populated and also where traffic usage is not high. The advantage of omnidirectional antennas is that they provide equal coverage all around the base station. The disadvantages are that it cannot cater for high capacity and the range of coverage may be limited.

Sectorized antennas, or sectors, are used where the coverage area is specific, such as a certain localized area. They are used at urban areas where high capacity is required. It is common to have 3 to 6 sectors per base station and in doing so, all areas surrounding a base station site is covered. The range from sectorized antennas is also better due to its higher the antenna gain, which improves in-building coverage as well.

Proper coverage and sufficient capacity is usually planned for areas where mobile phone usage is required. This, in turn, requires proper locating of the base stations, so as to allow efficient use of the network resources and also to satisfy the needs of the mobile phone users. Good coverage will reduce the output power from a mobile phone, which in turn lower emission levels while in use. Users in areas where coverage is poor, due to distant base stations, will have their mobile phones transmitting at higher powers to maintain a call. However, these limits would still be within safe limits.

RF exposure from the base station antennas is continuous and very low, which irradiates the whole body and exposes an entire community within the reach of these antennas. These base stations transmit power levels from a few watts to several hundred watts, depending on the size of the region or "cell" that they are designed to service. The RF field strength falls off rapidly with increasing distance from the base stations.

3.1.2.1 Effective Isotropically Radiated Power (EIRP)

This is defined as the product of the power applied to an antenna, and its gain in a given direction relative to that of a zero gain isotropic antenna.

The power of a mobile phone base station is most often described by its EIRP which is either given in watts (W) or dBm. EIRP is a measure of the power in the main beam of the base station antennas. This measure of power or EIRP is the power output by a transmission system from signal through amplification to transmission gain from a directional antenna's surface and shape. The amount of power is equivalent to that supplied to the antenna multiplied by the gain provided by a directional antenna.

EIRP takes into account the losses along the feeder cables and connectors and adds the gain of the antenna at a base station site.

EIRP is used to calculate the coverage area of a particular base station site. It limit and coordinate coverage from other base stations to minimize overlaps. EIRP is normally limited in order to minimize interference to other base stations on similar frequencies.

3.1.2.2 Antenna gain

Antenna gain is a measure of how directional an antenna is, and it is measured in decibels (dB). Depending on the antenna gain, a 20-50 W base station transmitter could produce an EIRP of anywhere from about 50 W to over 1000 W.

To further explain the concept of 'EIRP' and 'antenna gain', we can use the analogy of 2 light bulbs of different wattages. Compare a regular 100 W light bulb to a 25 W spot light. In terms of power, the spot light has less total power than the regular light bulb, but it is much brighter when you are in its beam and much weaker when you are outside its beam. Therefore, a mobile phone base antenna is like the spot light, and the EIRP is equivalent to the effective power in the spot light's main beam.

3.2 Mobile network

Mobile phones connect to base stations (cell sites) and the base stations are connected to the mobile switching centre (MSC), which can be likened to be as the heart and brain of the mobile phone network. The MSC controls all aspects of the communication and connectivity of the mobile phones (subscribers' terminals) to the mobile phone network. From there onwards the MSC is interconnected to other networks for extended communications with other than its own subscribers.

Signals from base stations are transmitted to the MSC, either by cables or microwave links between an antenna (e.g. dish) at the base station and another at a terminal connected to the MSC.

Mobile phone networks and their signals are typically limited beyond the line of sight, reaching into buildings and around corners as a result of various processes including diffraction and reflection, allowing radiation to bend round corners to a few degrees.

3.3 Typical exposure

People have been subjected to RF radiation for a very long time. This radiation comes from many RF sources present in the environment. However, its level is so low that it is almost negligible when compared with the exposure limits set by ICNIRP Guidelines. Typical radiation levels in open spaces on the ground usually vary between 0.01 W m^{-2} and 0.02 W m^{-2} and inside buildings it is 10 to 100 times lower due to significant attenuation of its intensity by the building materials.

In spite of generally known lower levels of radiation in public accessible areas, there are locations in certain workplaces where the radiation can be quite significant and some may even approach the ICNIRP limits. There are legitimate concerns in such situations, especially when the resulting exposure received by individuals may reach or exceed the guideline limits. By ICNIRP guideline, radiofrequency and microwave exposures should be averaged over time for any cumulative effects. The ICNIRP guidelines specify a time-averaging period of six minutes and short-term exposures above the limits are acceptable.

Table 8 below demonstrates the most common sources of RF exposures. All values shown are maximum levels of public exposure and a typical exposure is likely to be much lower.

Table 8: Typical exposures of RF and microwave on the ground around some sources

Exposure source	Power density (W m^{-2})			
	WHO EMF Document	Canada	Australia (FS 6 ARPANSA)	Malaysia
TV and radio transmitters	0.1	NA	0.0000004 – 0.0006 (TV) 0.0000024 – 0.0003 (FM Radio)	0.00001 – 0.98 (TV) 0.00001 – 0.3 (FM Radio)
Mobile Base stations – Rooftop **Tower**	0.1	Below 0.003 0.00001 – 0.005	0.00018 – 0.0007	0.000093 0.000013
Microwave ovens	0.5	Below 0.05	NA	Below 0.0003 at 1 metre
Radar	0.2	NA	NA	0.021 – 0.046

** NA – non-available*

Using a large number of antennas to provide mobile telecommunication service in a densely populated area does not necessarily equate with greater RF exposure. Transmitted power levels are usually kept at minimum output, just enough to maintain good communications.

3.4 Base station planning and siting

As mentioned previously, base stations are ideally placed in a grid pattern to enhance coverage. These ideal locations are planned and designed using complex radio propagation prediction software. The placement of the base station sites take into consideration the surrounding population, building and terrain types and expected capacity required. Once predictions are done and the design criteria set, engineers are sent out to locate the most suitable sites. Normally building rooftops and towers are preferred. The placement of one site has an effect on its surrounding neighboring sites, as moving a site may require the other sites to be shifted as well. Therefore, it is critical to be able to obtain the initial planned location.

In order for RF signals to reach mobile phone users, the antennas need to be placed at locations that are clear of obstructions. This is because the RF signals need clear space to propagate. RF signals can also reflect and refract off surfaces. As such, antennas are not normally placed facing building walls or hills directly. The industry in Malaysia have identified and agreed on basic guidelines for the placement of antennas for such purposes.

Besides placement of antennas for coverage purposes, they also require proper location for safety purposes. Placement of antennas which transmit RF signals directly into general public areas (within 10 m) should not be practiced except for in-building systems where the output power is very low.

The siting of all mobile telecommunication base station antennas must be elevated and located clear of physical obstructions to ensure a wide coverage and to reduce the incidence of dead spots. The RF signals from these base station antennas is beamed horizontally at the horizon with a slightly downward tilt which causes the maximum exposure to occur at distances of about 100 meters. The power output from an antenna will vary depending on the number of people using the facility at a given time.

A typical base station antenna will operate at about 60 W. Dead spots, which are due to shadows caused by physical obstructions such as tall buildings, are covered by micro cells that have an antenna power output of about 1 W.

The microwave dish antennas are used to provide line of sight communications with other antenna installations and operate in the 5 GHz to 40 GHz range at about 1 W to 8 W. These microwave links are highly directional and apart from the side lobes, they would not normally affect ground level exposures. Side lobes from these antennas directed downwards and at a distance of 20 m will give exposure levels of about 0.064 W m^{-2}.

3.4.1 Guideline for siting base station antennas

Siting of base station antennas should be designed so that the public cannot access areas that exceed exposure limit for public exposure. Generally, the public exposure limit will not be exceeded at more than six meters from an antenna.

Generally in most countries, the above guideline will be met when antennas are placed on their own towers. However, when problems exist they are generally confined to:

- Antennas placed on rooftops of buildings, especially where multiple base station antennas for different carriers are mounted on the same rooftops;

- Antennas placed on structures that require access by workers (either for uncommon paintings, maintenance or roofing).

3.4.2 Specific antenna installation guidelines

For roof-mounted antennas (see Figure 6), the general guidelines are:

- To elevate the transmitting antennas above the height of people who needs to be on the roof.

- To keep the transmitting antennas away from areas where people are most likely to be, such as roof access points or telephone service points.

For roof-mounted sectorized antennas, the general guidelines are:

- To place the antennas near the periphery and point them away from the building.

- To consider the trade off between large microwave dish antennas (lower transmitted power) and small microwave dish antennas (lower visual impact but higher transmitted power).

Special precautions must be taken to keep higher-power antennas away from accessible areas and when designing "co-location" sites, where multiple antennas owned by different companies are on the same structure.

It is important to keep antennas at a site as far apart as possible.

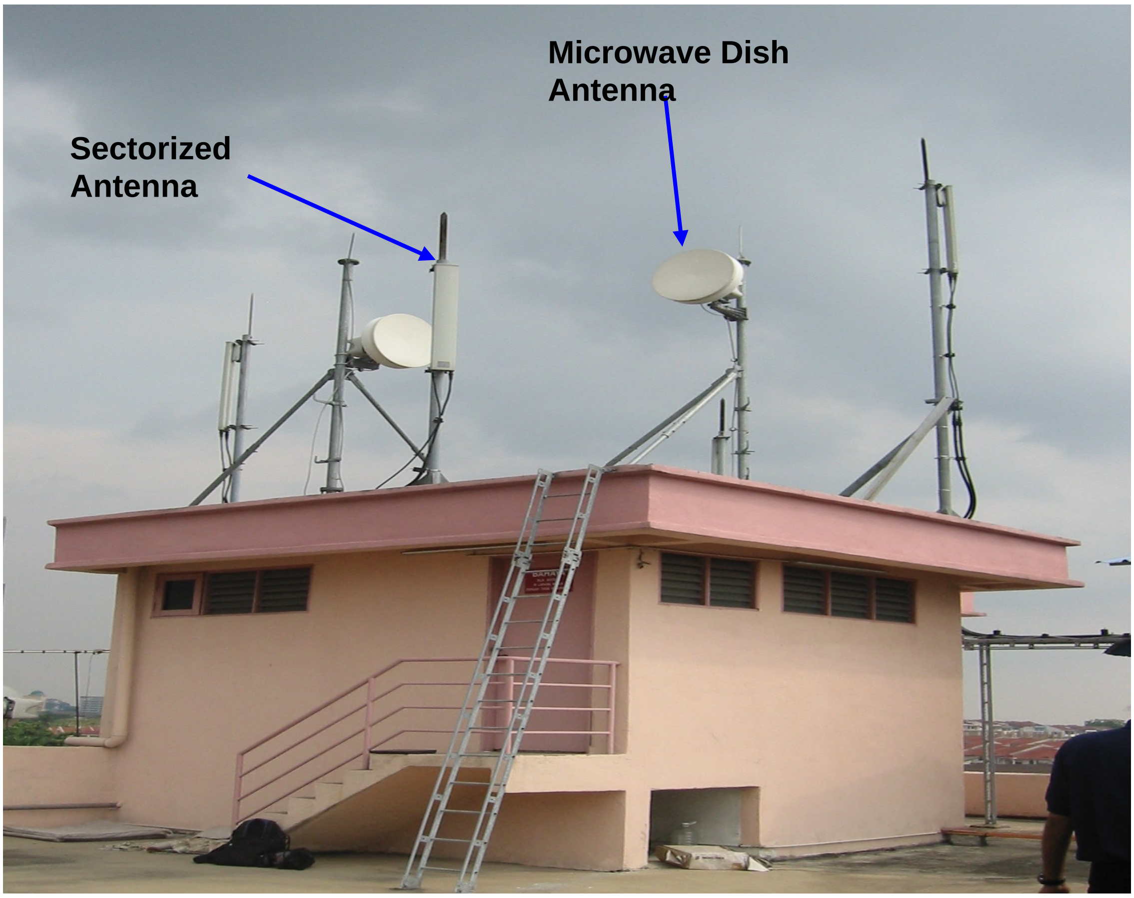


Figure 6: Two different types of antennas

3.5 Current/latest technology

There are numerous mobile phone technologies in use and researched worldwide. For the purpose of this document, only the more common technology and potential usage of new technology will be discussed. Discussion in this section will not go into technical aspects as many of these new technologies are still undergoing tests and reviews.

It is important for such technology changes to be reviewed frequently as new and improved technologies evolved and commercial utilization of such technologies changes over time.

3.5.1 Second Generation Mobile Communication (2G)

3.5.1.1 Global System for Mobile Communications (GSM)

GSM is a digital cellular phone technology which is based on Time Division Multiple Access (TDMA). This system originated in Europe but is used worldwide by over 2 billion people. The ubiquity of the GSM standard makes international roaming very common between mobile phone operators, enabling subscribers to use their phones in many parts of the world.

3.5.1.2 General Packet Radio Service (GPRS)

Most users of GSM mobile phones are able to use a mobile data service known as GPRS. It is sometimes described as ‘2.5G’ technology, meaning technology between the 2G and 3G for mobile phone. GPRS provides moderate data transfer speed via unused TDMA time slot in the GSM network.

GPRS is an enhancement of the GSM mobile communications system that supports data packets. GPRS enables continuous flow of internet protocol (IP) data packets over the system for applications such as Web browsing and data file transfer.

3.5.1.3 Enhance Digital GSM Evolution (EDGE)

EDGE is a further enhancement of GPRS (also known as EGPRS). EDGE uses the same TDMA frame structure, logic channel and 200 kHz carrier bandwidth as today's GSM networks, which allows it to be overlaid onto an existing GSM network directly. EDGE was introduced as a GSM network enhancement since 2003.

EDGE is a digital mobile phone technology that allows increased data transmission rate and improved data transmission reliability and is generally classified as a 2.75G network technology. EDGE increases the data capacity of up to 3 times compared to GPRS.

EDGE is typically used for packet switched applications such as an Internet connection and Web browsing. High-speed data applications such as video services and other multimedia services is also supported using this increased data capacity.

3.5.1.4 Code Division Multiple Access (CDMA)

CDMA also known as IS-95, is a digital cellular technology that uses spread-spectrum techniques. In CDMA, every channel is allocated the entire spectrum all of the time. CDMA technology uses pseudo-random codes to identify call connections. The typical application of CDMA in digital cellular operates in the 800 MHz band and 1.9 GHz frequency band. See Annex A for details.

3.5.2 Third Generation Mobile Communication (3G)

3G which is based on digital technology offers increased voice capacity and provides higher data rates than 2G and 2.5G. As defined by the International Telecommunications Union (ITU), 3G technology has been or will be implemented as WCDMA, CDMA 2000 and HSDPA/HSUPA. 3G download speed for mobile internet connections is up to 384 kbps, for 2G it is 9.6 kbps and for 2.5 G it is up to 100 kbps. However, due to network congestion, actual data rates are usually slower.

3.5.2.1 Wideband Code Division Multiple Access (WCDMA)

WCDMA is a 3G mobile technology with much higher data speed than normal 2G mobile phones. It is one of two 3G standards that make use of a wider spectrum than CDMA. This allows transmission and reception of information to be faster and more efficient. WCDMA can support voice, images, data and video communications of up to 2 Mbps for wide area access.

3.5.2.2 Code Division Multiple Access 2000 (CDMA 2000)

CDMA 2000 is a family of 3G standards that offers increased voice capacity and higher data rates compared to the previous 2G standards. The CDMA 2000 family of standards include CDMA2000 1X and CDMA2000 1xEV-DO.

3.5.2.3 High Speed Packet Data Access (HSPDA)

HSPDA is an evolution of the WCDMA standard that enables high-speed wireless connectivity which is comparable to wired broadband.
HSPDA consist of High Speed Downlink Packet Access (HSDPA) and High Speed Uplink Packet Access (HSUPA). HSDPA refers to the speed at which

individuals can receive large data files, the “downlink” . HSUPA refers to the speed at which individuals can send large data files, the “uplink” .

HSPDA enables individuals to send and receive e-mail with large file attachments, play real-time interactive games, receive and send high-resolution pictures and video, download video and music content or stay wirelessly connected to their office computers. All these can be done from the same mobile device.

3.5.3 Broadband Wireless Access (BWA)

3.5.3.1 Wireless Local Area Network (WLAN)

The market for Wireless Local Area Network (WLAN) has been experiencing tremendous growth in recent years, as evidenced by the fast increasing popularity of WLAN hotspots deployed in residence, enterprise and public areas such as airports, campuses, conference venues, shopping malls and exhibitions. Meanwhile, WLAN services are evolving from best effort data services to real-time applications with a certain level of Quality of Service (QoS) provisioning. WLAN aims at developing a Medium Access Control (MAC) and Physical Layer (PHY) specifications for wireless connectivity for fixed, portable and moving stations within a local area.

WLAN technology developed under IEEE 802.11 standard to provide broadband wireless packet service to help handy sets like mobile phones, laptops and PDA get access to the internet within small coverage area up to 300 feet via an Access Point (AP), which commonly called a hot spot. The IEEE 802.11 standard defines three physical techniques for WLAN; diffused infrared (IR), frequency hopping spread spectrum (FH or FHSS) and direct sequence spread spectrum (DS or DSSS). While the infrared technique operates at the baseband, the other two radio-based techniques operate at the 2.4 GHz band.

IEEE 802.11 standard, encompasses a family of sub standards. The original 802.11 specification provides 1 or 2 Mbps transmission in the unlicensed 2.4 GHz band using either a FHSS technique or DSSS, also known as CDMA. Wi-Fi the 802.11b standard is rated at 11 Mbps in the 2.4 GHz band, but delivers approximately 7 Mbps in practice. The Wireless Ethernet Compatibility Association (WECA) endorsed the DSSS 802.11b version, branding it "Wi-Fi" for Wireless Fidelity. Wi-Fi and 802.11b have thus become synonymous. The 802.11a standard provides from 6 to 54 Mbps at 5 GHz, but is not backward compatible with 802.11b. While 802.11g standard provides up to 54 Mbps at 2.4 GHz as well as backward compatibility with the slower 11b. Both 802.11a and 802.11g use Orthogonal Frequency Division Multiplex (OFDM) modulation to achieve the higher data rates.

3.5.3.2 Wireless Interoperability for Microwave Access (WiMAX)

Wireless Interoperability for Microwave Access (WiMAX), is a last mile broadband wireless technology based on IEEE 802.16 fixed application standard optimized to deliver high speed multimedia services at higher data rates of up to 75 Mbps to the end user over a large coverage area with excellent QoS under line and non line-of-sight (LOS & NLOS) transmission condition over severely multipath propagation channel. WiMAX will operate in the 2 to 11 GHz frequency range, for both licensed and unlicensed spectrum. WiMAX has the potential to be a huge disruptive force in the telecom sector in the years ahead, displacing DSL and cable modem in some markets or to integrate perfectly into existing mobile networks.

Recently, a new technology, IEEE 802.16e standard and generally known as Mobile WiMAX is expected to be commercialized at the first half of 2007. It is developed based on next generation all IP-network to provide mobility to the end users in a Metropolitan Area Network (MAN) environment and introduces OFDM and multi-input multi-output antenna system (MIMO) due to their robustness in multipath environment. The technology is optimized to deliver high, bursty data rates to mobile subscribers and the advanced Medium Access Control (MAC) architecture can simultaneously support real-time multimedia and asynchronous applications such as Voice over IP (VoIP). Mobile WiMAX technology is uniquely positioned to extend broadband wireless beyond the limits of existing technologies. Both fixed and mobile applications of WiMAX are engineered to help deliver ubiquitous, high-throughput broadband wireless services at a low cost.

3.5.4 Short range devices

3.5.4.1 Bluetooth

Bluetooth, a wireless technology using short-range radio of 2400 MHz (ISM band), is widely used in today's mobile phone technology. Bluetooth makes it possible to transmit signals over short distances of up to 10 m between mobile phones and their peripherals, computers and other devices and thereby simplify communication and synchronization between devices.

It is a global standard that eliminates wires and cables between both stationary and mobile devices, facilitates both data and voice communication, offers the possibility of ad hoc networks and delivers the ultimate synchronicity between personal devices.

Bluetooth radio uses frequency-hopping scheme to make the link robust even in noisy radio environments. This technology provides a universal bridge to existing data networks, peripheral interfaces and a mechanism to form small private ad hoc groupings of connected devices away from fixed network infrastructures.

3.5.4.2 Radio Frequency Identification (RFID)

An automatic identification method, relying on storing and remotely retrieving data using devices is known as RFID tags. An RFID tag is a small object that can be attached to or incorporated into a product, animal or person. Tiny silicon chips and antennas are embedded into RFID tags to enable them to receive and respond to radio-frequency queries from an RFID transceiver. There are 2 types of RFID tags; passive and active. Passive tags require no internal power source, whereas active tags require a small power source. In Malaysia RFID operates in the frequency range of 919 MHz to 923 MHz.

RFID tags are widely used for item tracking, inventory management, security and safety. Examples of its usage are in libraries and bookstore for tracking books, patient identification, warehouse pallet tracking, public transport passes, credit cards, building access control, airline baggage tracking and apparel and pharmaceutical item tracking. This RFID tags are slowly replacing earlier magnetic stripe cards. Microwave RFID tags are also used in long range access control for vehicles, for electronic toll collection at toll booths.

3.6 Future technology

3.6.1 Fourth Generation Mobile Communication (4G)

4G technology is an improvement of 3G technology in terms of higher data rate and user capacity. In principle, 4G will allow high-quality smooth video transmission and will enable fast downloading of full-length songs or movies.

Some countries are planning to introduce 4G technology. However, the direction towards 4G technology standards is still being studied. There is a high probability that the mobile WiMAX technology will be the path towards 4G technology.

4G mobile data transmission rates are expected to be up to 100 Mbps which is about 50-100 times faster than the standard ADSL services. In terms of connection speeds, 4G will be about 1000 times faster than the present 2G mobile data rates and about 50 times faster than the 3G broadband mobile.

3.6.2 Ultra-Wideband (UWB) Technology

UWB technology is also known as non-sinusoidal communication technology, impulse radar, ground-penetrating radar, impulse radio or baseband pulse technology.

Similar to Bluetooth, UWB systems has short range coverage of up to 10 m and with data rate of up to 100 Mbps.

UWB systems transmit signals across a much wider frequency than conventional systems and are usually very difficult to detect. The amount of spectrum or bandwidth occupied by a UWB signal is at least 25% of the center frequency. The minimum bandwidth of UWB is 500 MHz. The most common technique for generating a UWB signal is to transmit pulses with durations of less than 1 nanosecond.

Early UWB systems were developed mainly as a military surveillance tool because they could "see through" trees, walls and beneath ground surfaces. Recently, UWB technology has been focused on consumer electronics communications.

Chapter 4: Health Effects

4.1 Interaction mechanism

The interaction mechanism of EMF with the human body is characterized by the frequency of the radiation. There are two known interaction mechanisms, namely, induction of electric current and production of heat. Fields at frequencies above 1 MHz primarily cause heating by moving ions and water molecules through the medium in which they exist.

There are three established basic coupling mechanisms through which time-varying electric and magnetic fields interact directly with living matter:

- coupling to low-frequency electric fields;
- coupling to low-frequency magnetic fields; and
- absorption of energy from electromagnetic fields.

4.1.1 Coupling to low-frequency electric fields

The interaction of time-varying electric fields with the human body results in the flow of electric charges (electric current), the polarization of bound charge (formation of electric dipoles) and the reorientation of electric dipoles already present in tissue. The relative magnitudes of these different effects depend on the electrical properties of the body, that is electrical conductivity (governing the flow of electric current) and permittivity (governing the magnitude of polarization effects). Electrical conductivity and permittivity vary with the type of body tissue and also depend on the frequency of the exposed field. Electric fields external to the body induce a surface charge on the body and this results in induced currents in the body. The distribution of this induces current depends on exposure conditions, size and shape of the body and on the body's position in the field.

4.1.2 Coupling to low-frequency magnetic fields

The physical interaction of time-varying magnetic fields with the human body results in induced electric fields and circulating electric currents. The magnitudes of the induced field and the current density are proportional to the radius of the loop, the electrical conductivity of the tissue and the rate of change and magnitude of the magnetic flux density. For a given magnitude and frequency of magnetic field, the strongest electric fields are induced where the loop dimensions are greatest. The exact path and magnitude of the resulting current induced in any part of the body will depend on the electrical conductivity of the tissue. The body is not electrically homogeneous; however induced current densities can be calculated using anatomically and electrically realistic models of the body and computational methods which have a high degree of anatomical resolution.

4.1.3 Absorption of energy from EMF

Exposure to low-frequency electric and magnetic fields normally results in negligible energy absorption and no measurable temperature rise in the body. However, exposure to EMF at frequencies above about 100 kHz can lead to significant absorption of energy and an increase in temperature. As regards to absorption of energy by the human body, EMF can be divided into four ranges:

- frequencies from about 100 kHz to less than about 20 MHz; where absorption in the trunk decreases rapidly with decreasing frequency and significant absorption of energy may occur in the neck and legs;
- frequencies in the range from about 20 MHz to 300 MHz; where relatively high absorption of energy can occur in the whole body and to even higher values if partial body (e.g. head) resonances are considered;
- frequencies in the range from about 300 MHz to 10 GHz; where significant local non-uniform absorption occurs; and
- frequencies above 10 GHz; where energy absorption occurs primarily at the body surface.

When EMF interact with the body, it may produce biological effects which may sometimes, but not always, lead to adverse health effects. It is important to understand the difference between these two effects.

4.2 Biological effects

Biological effect is defined as measurable responses to a stimulus or to a change in the environment but changes may not necessarily be harmful to our health. Examples of biological effects are responses that result from going from a dark room to a bright room and playing football. These may produce a diverse range of biological effects such as dilation of the pupil of the eyes and sweating which may not cause any health effects. A biological effect may or may not result in an adverse health effect.

Human or animal exposure to RF energy can result in biological effects and those effects that result in the heating of tissue are often referred to as thermal effects. Available experimental evidence indicates that the exposure of resting humans for approximately 30 min to EMF producing a whole-body SAR of between 1 and 4 W kg^{-1} results in a body temperature increase of less than 1°C. Animal data indicates a threshold for behavioral responses in the same SAR range. Exposure to more intense fields, producing SAR values in excess of 4 W kg^{-1}, can overwhelm the thermoregulatory capacity of the body and produce harmful levels of tissue heating.

Adverse biological effects can be caused by temperature rises in tissue that exceed 1°C. The overall scientific conclusion to date is that the biological effects associated with non-thermal exposures are not known to cause any adverse health effects.

4.3 Health effects

With the incorporation of new technologies in our daily lives, concerns have been centered on health from using a mobile phones and base stations. There are some epidemiological studies on EMF that associate an increase in certain types of tumors to long-time heavy users of mobile phones. However, based on WHO's International EMF Project, there is no definitive conclusion on the adverse health effects resulting from the usage of mobile phones and base stations.

All established health effects of RF exposure are clearly related to heating. While RF energy can interact with body tissues at levels too low to cause any significant heating, no study has shown adverse health effects at exposure levels below ICNIRP guideline limits.

Generally, the scientific community concluded that RF is incapable of producing other than heating effects due to its inability to cause breakage of chemical bonds due to its low energy. Despite this, there is still on-going debate in the scientific community with regards to mobile phone health effects.

4.3.1 Potential health effects

Potential health effects or possible health effects refers to the possibility of adverse effects which may not be detected at the beginning but may be detected only after a long duration. This is due to the prolonged latency period of many chronic diseases. There may be potential adverse health effects from the prolonged usage of mobile phones which are not fully known at this point in time. Therefore, precautionary approach is to be adopted for mobile phone usage until further research and data are available.

4.3.2 Adverse health effects

Adverse health effect causes detectable damage or impairment of the health of the exposed individual or to his or her offspring. Most of the authoritative research and scientific reviews completed within the past 4 years have concluded that there is no clear evidence of adverse health effects associated with RF fields.

However, some mobile phone users have complained of short term adverse effects which include headaches, dizziness and unpleasant heating or tingling in the head or behind the ear and this symptoms increases with greater mobile phone use.

Adverse effects to the eye by RF radiation have been observed in mobile phone users and should be treated with caution and concern. Concerns that RF radiation may have effects on cognitive functions such as memory, reaction times and sleep processes have been highlighted by the Royal Society of Canada and the IEGMP*.*

4.3.3 Thermal and non-thermal effects

In terms of mobile safety standards and biological effects, discussion is usually focused on RF radiation between non-thermal and thermal effects. Non-thermal effects are the result of a direct interaction between the RF radiation and the organism. Thermal effect is a direct result of heating. There are findings to demonstrate that non-thermal effects do exist and may occur at a significantly lower radiation level than what causes heating. This means that present safety standards may need to be changed so that they allow considerably lower levels of radiation intensities.

The distinction between thermal effects and non-thermal effects is on the basis of whether the effect is due simply to the heat developed in the tissue.

Non-thermal effects occur in an exposed material when the RF energy is deposited into the material results in an increase in temperature which is lesser than the normal temperature fluctuation of the material. This heat is carried away by the body's normal thermoregulatory process without the person noticing it. These non-thermal effects are not mediated by heat but are due to the direct action of the radiation on the molecules or tissue components.

Thermal effects from RF fields are those effects that results from a measurable temperature increase, which is beyond the body's normal thermoregulatory process. This kind of thermal effects may occur in the exposed biological material such as tissue, cell, etc. due to the heating of such material to RF fields. For thermal effect, the exposure limits are set to prevent whole-body heat stress or excessive localized tissue heating.

4.4 General health symptoms

Most reported general symptoms of RF exposure includes dizziness, fatigue, chronic headache, irregular heart beat, nausea, vertigo, loss of memory and decrease in concentration. These and other symptoms are reported to result from exposure to a range of EMFs, including RF fields which are encountered in our daily lives, not necessarily due to mobile phone usage. However, based on current scientific knowledge, there is no convincing evidence to relate those symptoms with EMF's exposure that is normally encountered, including from mobile phones and their base stations.

4.5 Long term effect – cancer

The main concern on long term effect of EMF exposure is the possibility of inducing cancer. ICNIRP in it's guideline (1998) states that there is no convincing evidence that typical exposure levels can lead to an increased cancer risk in exposed individuals. This is in line with WHO's latest statements in its fact sheet (Base Station and Wireless Technologies, 2006) which reported that studies over the past 15 years to examine a potential relationship between RF transmitters and cancer have not provided evidence that RF exposure from base station increases the risk of cancer. Likewise, long-term animal studies have not established an increased risk of cancer from exposure to RF fields, even at levels that are much higher than produced by base stations.

4.6 Other effects

Few studies have investigated health effects in individuals exposed to RF fields from base stations. However, it is difficult to draw a conclusion from these studies because of the difficulty in distinguishing possible health effects from the very low signals emitted by these base stations in the presence of higher strength RF signals in the environment. Most studies have focused on the RF exposures of mobile phone users. Human and animal studies examine brain wave patterns, cognition and behaviour after exposure to RF fields, such as those generated by mobile phones, have not identified adverse effects. RF exposures used in these studies were about 1000 times higher than those associated with general public exposure from base stations or wireless networks. No consistent evidence of altered sleep or cardiovascular function has been reported.

4.7 Electromagnetic Hypersensitivity (EHS)

WHO has produced a fact sheet on electromagnetic hypersensitivity in December 2005 (Fact Sheet No. 296). A majority of the people are not affected by EMF exposure. However, some individuals report mild symptoms and react by avoiding the fields as best as they can, while others are so severely affected that they cease work in EMF environment and change their entire lifestyle. This reputed sensitivity to EMF has been termed "electromagnetic hypersensitivity" (EHS). EHS is characterized by a variety of non-specific symptoms, which afflict individuals who are exposed to EMF. The symptoms most commonly experienced include dermatological symptoms (redness, tingling and burning sensations) as well as neurasthenic and vegetative symptoms (fatigue, tiredness, concentration difficulties, dizziness, nausea, heart palpitations and digestive disturbances). The severity can vary widely from individual to individual. WHO's opinion is that EHS has no clear diagnostic criteria and there is no scientific basis to link EHS symptoms to EMF exposure.

However, in Sweden, hypersensitivity to electromagnetic fields has been addressed as a national concern, and the Swedish authorities have accepted such sensitivity as a physical impairment. A scheme is in place to improve home and working conditions for people who consider themselves to be sufferers of EMF hypersensitivity.

4.8 EMF exposure in children

It has been suggested that children may be more vulnerable to adverse health effects to EMF exposure due to the following reasons:

- Their nervous system is still in the development stage
- There is greater absorption of energy in the tissues of their head
- Longer lifetime exposure

In line with this, IEGMP recommended, as a precautionary approach that the widespread use of mobile phones by children for non-essential calls should be discouraged. It is also recommended that the mobile phone industry should refrain from promoting the use of mobile phones targeting children.

However, there is insufficient evidence to substantiate the hypothesis that there is greater absorption of energy in the tissues of the child's head. Recent results have not indicated that there may be any effects which could be exacerbated by cumulative exposure. To date, all expert reviews have concluded that there is no adverse health effect from exposure to RF fields at levels below the international guidelines on exposure limits published by the International Commission on Non-Ionizing Radiation Protection (ICNIRP, 1998).

The ICNIRP guidelines were developed to limit human exposure to EMF under conditions of maximum absorption of these fields, which rarely occurs. These limits incorporate large safety factors to protect workers and even larger safety factors to protect the general public, including children.

ARPANSA's Fact Sheet No. 11 stated that "the balance of evidence does not indicate a risk to the health of people, including children, living in the vicinity of base stations where the exposure levels are only small fractions of ARPANSA Standard". This standard is similar to ICNIRP guidelines for the range of 400 MHz to 2.0 GHz.

The use of text messaging has considerable advantages compared to voice communication as the phone is in use for only a short time and is not placed near the head when transmitting the message. Therefore, the use of text messaging is recommended.

4.9 Scientific uncertainty

There is no conclusive evidence that exposure to EMF will cause adverse health effects and there is also no conclusive evidence that it will not cause adverse health effects. Available evidence is insufficient to establish a causal relationship between exposure and effects. There are also gaps in knowledge in this field. Hence research is ongoing worldwide.

4.10 Precautionary principle

Precautionary principle refers to actions that should be taken to prevent serious potential harm in view of scientific uncertainty. The precautionary approach describe the cautious process that scientists use when converting experimental data into advice on acceptable levels of public or occupational risk or where data cannot provide a reliable estimate. The WHO definition of precautionary principle with regards to EMF and public health is:

> "*A risk management policy applied in circumstances with a high degree of scientific uncertainty, reflecting the need to take action for a potentially serious risk without awaiting the results of scientific research*".

With regards to precautionary principle, WHO in its fact sheets on mobile phones and base station (Fact Sheet No. 193) stated that present scientific information does not indicate the need for any special precautions for use of mobile phones. If individuals are concerned, they might choose to limit their own or their children's RF exposure by limiting the length of calls, or using wired hands-free devices to keep mobile phones away from the head and body. WHO also recommends that additional precautionary measures to reduce exposure to RF fields should not undermine the scientific basis of the guidelines by incorporating arbitrary additional safety factors into the exposure limits.

4.11 Summary of findings

There is some scientific evidence to suggest that there may be biological effects occurring at exposures below these guidelines. However, this does not necessarily mean that these effects lead to disease or injury, but it is potentially important information.

Between 2000 to 2005, major reports concluded that exposure to low level RF fields may cause a variety of subtle biological effects on cells, animals or humans, particularly on brain activity during sleep. However, the possibility of exposure causing adverse health effects remains inconclusive. These reports also stressed that at very low exposure level, typical of base stations, are unlikely to cause any effects on biophysical grounds. Localised exposures from mobile phones may induce effects due to mild heating of superficial tissues close to the mobile phones.

In 2002, the HCN issued a report on the safety of mobile phones. On the general issue of mobile phone safety, the HCN concluded that mobile phones EMF do not constitute any health hazard based on available present scientific knowledge. In November 2005, the HCN issued a document “Electromagnetic Fields: Annual Updates 2005” which disagrees with the conclusion drawn by some studies which found links between living in the proximity of base stations and the occurrence of cancer.

In 2003, AGNIR has come out with a report based on detailed review of the sources and exposure from RF fields. The conclusion is that recent published research findings do not give cause for concern. It also states that exposure from base stations is unlikely to pose a risk to health.

In 2004, the Radiation and Nuclear Safety Authority of Finland, the Danish National Board of Health, the Norwegian Radiation Protection Authority, the Icelandic Radiation Protection Institute and the Swedish Radiation Protection Authority jointly issued a statement with regards to mobile phones and health. In summary, these authorities agreed that there is insufficient evidence to link any kind of adverse health effects to mobile telecommunication systems. These include neither from the base stations nor from the mobile phones which are below the basic restrictions and reference levels recommended by ICNIRP.

In 2004, ICNIRP concluded that the research performed to date, including studies of mobile phone users; give no consistent or convincing evidence of a causal relationship between RF field exposure and any adverse health effects.

In 2004, NRPB in its review of the scientific evidence for limiting exposure to EMF stated that, overall, the recent research does not give cause for concern and that the weight of evidence does not suggest that there are adverse health effects from exposure to RF fields below guideline values even though subtle biological effects are possible.

In 2004, the report from the Institute of Electrical Engineers Biological Effects Policy Advisory Groups concluded that the research published during the previous two years did not suggest that harmful effects exist from exposure to low level RF fields.

In May 2006, WHO’s Fact Sheet No. 304, concluded that studies have not provided evidence that RF exposure from the base station increases the risk of cancer. Likewise, long-term animal studies have not establish an increased risk of cancer from exposure to RF fields, even at levels that are much higher than produced by base stations and wireless networks.

Notwithstanding these conclusions, there exist certain knowledge gaps that justify more research in this field.

4.12 Conclusion on adverse health effects

The balance of evidence to date suggests that exposures to RF radiation below ICNIRP guidelines do not cause adverse health effects to the general population. The general consensus in all the reports and guidelines by most authorities on mobile phone health is that there is no clear evidence of adverse health effects associated with mobile phone and base stations. This consensus is in-line with WHO’s stand. However, due to the fact that mobile phones has only been in widespread use for a relatively short time, the possibility of causing health effects remained open. Hence, continued research is on going to fill the gaps.

Chapter 5: Interaction of Radiofrequency (RF) with Medical and Other Devices

5.1 Electromagnetic Interference (EMI)

EMI or Radio Frequency Interference (RFI), otherwise known as electromagnetic radiation emitted by mobile phones can interrupt or limit the effective operation and performance of medical and other electronic devices.

Based on reports of studies on interference of medical equipment by mobile phones, there is evidence to suggest that some form of interference may occur with some of the devices and these interferences also depends on the types, makes and models of mobile phones. However, some of these interferences may not be significant enough to cause any harm or damage to the medical devices. As a result of this, the precautionary approach should be observed in terms of using mobile phones in and around areas where medical devices are in use, such as hospitals.

Many medical devices today that are tested for susceptibility to RFI cannot meet the 3 V m^{-1} minimum immunity requirements of the current IEC Standard 601-1-2. Mobile phones emit field strengths stronger than the recommended 3 V m^{-1} at distances of up to 1 m, while higher power transceivers produce 3 V m^{-1} fields at distances of up to 2.6 m. Due to this reason, serious failures of life sustaining medical devices can happen. In USA, the FDA has recommended that immunity to RFI be designed for new medical devices.

5.2 Implanted medical devices

There is no strong evidence that mobile phones and base stations will interfere with medical devices as long as exposure levels are below IEC 601-1-2 standard.

However, wireless devices such as mobile phones may interfere with patient monitoring devices in different ways. All wireless devices operate on a specific band on the electromagnetic spectrum. These interferences can result when multiple devices operating on the same frequency and their signals collide. Some devices have stronger signals than others, so one device potentially could interfere with the other device.

Interference can also be caused by the output power of a wireless communication device. Device that produces powerful signals can interfere with other devices even if they are not on the same frequency range. Mobile phone-related interference was also detected in ECG tracings displayed on monitors when a phone was placed at less than 84 cm from the devices. In another test, when a mobile phone was held within 5 cm of the communication port on the back of a ventilator, the machine was experienced power off and restarted.

5.2.1 Cardiac pacemaker

There is a possibility that mobile phones themselves might interfere with pacemakers if they are placed directly over the pacemaker. This interference has been reported to occur with only some types of mobile phones and some types of pacemakers.

Research have shown that mobile phones may also interfere with implanted cardiac pacemakers if used within 20 cm of a pacemaker. People who are using pacemakers should avoid placing their mobile phones close to the location of their pacemaker or using the mobile phone on the side near the pacemaker.

5.2.2 Hearing aids

People with hearing aids may experience loud interfering noise when using a mobile phone or when one is used nearby. This interference is caused by the radio signals (RF) generated by the mobile phone. In some severe cases, it can make the device unusable.

Hearing aids with a T-switch or ‘telecoil’ may experience an additional form of interference referred to as ‘baseband magnetic interference’ (BMI), which originates from the mobile phone's electronics such as backlighting, display, keypad, battery and circuit board. BMI can add to any RFI experienced by the hearing aid user. The degree of interference to hearing devices is likely to be greater for GSM (2G) mobile phones as opposed to WCDMA (3G) mobile phones. GSM (2G) mobile phones do not have 3G capability but the reverse is not true.

5.2.3 Cochlea implant

Some features on mobile phones can produce RFI with cochlea implant. Interference can come from the transmission signal that sends the call, the antenna, the battery or even the screen’s backlight. The interference will not harm the implant wearer or cause damage to the implant but may cause noise that interferes with the ability to hear a conversation.

5.3 Medical equipment

5.3.1 Life support equipment

In hospitals worldwide, the recommendation is that mobile phones and two way radios should not be used in intensive care units, operating theatres, patient rooms or wherever critical care medical equipment is in used. Similarly, doctors are recommended to educate their patients who are using medical equipment at home to be aware of possible hazards from the use of wireless telecommunication devices due to RFI.

5.3.2 Other medical equipment

Interference of some degree to other equipment has also been documented. These equipment include ventilators, defibrillators, bedside monitoring equipment, infusion pumps and ECG monitors. It is recommended that the use of mobile phones be discouraged around such devices.

5.4 Other equipment

5.4.1 Interference with aircraft navigation system

The use of mobile phones on aircraft during flight is generally forbidden in most countries and by most aviation authorities. One reason given for this is that the mobile phone could interfere with the sensitive navigation and communication equipment on the aircraft, especially for voice communications between the aircraft and the ground.

If a mobile phone is activated in the aircraft, it can generate signals which can interfere with the aircraft navigational and communication systems. During take off and landing, the interference can result in serious consequences.

The United Kingdom Civil Aviation Authority carried out two tests on parked aircraft and found evidence that mobile phone calls produced interference levels which could disrupt aircraft systems.

Some of the faults that could be caused by the use of mobile phones include interference in pilots' headsets, malfunctioning of aircraft systems and false cockpit warnings.

5.4.2 Induced charge

This effect of RF radiation can also be very serious in cases where flammable chemicals are used or stored. It is caused by collection of RF energy by conductive structures capable of having potentials induced in them. Any appearance of discontinuity in such structures is capable of causing spark and if occurred in a place where flammable vapours are present, it may lead to fire and explosion.

Chapter 6: Practice in Other Countries and International Recommendations

6.1 Introduction

To protect the general population living around base stations and users of mobile phones, about 80 governments and regulatory bodies to-date have adopted mobile phone safety standards, which translate to limits on exposure levels recommended by ICNIRP. This is in line with WHO's recommendation. However, there are some countries that set the limits which are different with ICNIRP guidelines. A summary of the exposure limit set by some of the countries is shown in Annex C.

Generally, many countries have adopted and incorporated ICNIRP standards into base station licensing procedures and in some countries into their legislations. Current practice is for the service providers (Telcos) to obtain approval from the relevant authorities for the construction and operation of base stations. These authorities also recommend that service providers try to achieve sharing of infrastructures so as to decrease environmental, social and aesthetic impact.

6.1.1 Mobile phones

Public concern has been expressed regarding the possibility of adverse health effects related to RF emissions from mobile phones and base stations. Besides health effects, some research has shown that driving a vehicle while using a mobile phone can increase the risk of being involved in a road accident, both as a result of driving one-handed and the distractions posed by the mobile phone conversation. As this could have an adverse effect on road safety, the use of mobile phones without a hands-free set in vehicles is prohibited in some countries. Some studies have shown that the drivers' concentration is reduced considerably even when using mobile phones with hands-free set.

6.1.2 Base stations

Siting of mobile phone base stations require a detailed knowledge of the site, the antenna and the mounting structure. A number of countries have their own regulations for public exposure to RF energy from base stations. While most of these regulations follow similar framework and rationales recommended by ANSI/IEEE and ICNIRP, they may differ slightly.

6.2 Australia

6.2.1 Mobile phones

In Australia, ARPANSA recommended that if individuals are concerned about the safety of mobile phones usage, they should limit their own or their children's RF exposure by limiting the number and length of calls, or by using hands-free devices to keep mobile phones away from the head and body.

ARPANSA also recommends the use of hands-free devices when using mobile phones while driving. It also recommends that the motorists park their vehicle at a safe place to make or receive calls with mobile phones.

Mobile phones released into the Australia consumer market must include maximum SAR value in the product information manuals, or in separate manuals or brochures to be included into the box of new mobile phone set. Mobile phones manufactured in Australia must comply with the Australian Communication and Media Authority (ACMA) Radio-communication Standard 2003. The ACMA mandates the specific absorption rate (SAR) from the ARPANSA Standard. All mobile phones introduced to the Australian market must comply with the Australian Standard.

6.2.2 Base stations

In Australia, the siting Guidelines for base station antennas is described in the Australian Standard (AS 3516.2-1998) titled "Siting of Radio Communications Facilities: Part 2: Guidelines for Fixed, Mobile and Broadcasting Services Operating at Frequencies above 30 MHz" and "Maximum Exposure Levels to RF Fields – 3 kHz to 300 GHz.

6.2.3 Responsible agencies

ARPANSA, as part of the Health and Ageing Portfolio, is a Federal Government agency with the responsibility for protecting the health and safety of the people and the environment from the harmful effects of ionizing and non-ionizing radiation.

ARPANSA Standard sets limits for human exposure to RF fields in the frequency range 3 kHz to 300 GHz. ARPANSA Standard also includes requirements for protection of the general public and the management of risk in occupational exposures.

6.3 Canada

6.3.1 Base stations

In Canada, the Canadian standard with regards to base stations appears to be identical to the USA's FCC standard and Safety Code 6 - Limits of Human Exposure to Radiofrequency Electromagnetic Fields in the Frequency Range from 3 kHz to 300 GHz.

6.3.2 Responsible agencies

Health Canada's Radiation Protection Bureau has established safety guidelines for exposure to RF fields. These safety guidelines are outlined in the publication, "Limits of Exposure to Radiofrequency Fields at Frequencies from 10 kHz - 300 GHz", also known as Safety Code 6. Safety Code 6 sets safe exposure limits for individuals working on sources of RF fields (8 hours a day) and for the general public who could be exposed for 24 hours a day. The Code also outlines safety requirements for the installation and use of devices that emit RF fields. The exposure limits in this code are not applicable to medical treatment under the direction of a physician.

Safety Code 6 is a guideline rather than a law. However, it is referenced in the regulations written under the Canada Labour Code. This means that federal government departments, crown corporations and other organisations that come under the control of these regulations, must follow the safety procedures and installation guidelines given in Safety Code 6 (unless they are exempted by regulations). Industry Canada also requires operators of radio communication and broadcast facilities to follow Safety Code 6. In addition, Canadian provinces and territories have generally adopted the Safety Code 6 exposure recommendations.

6.4 France

In France, a number of steps to protect the public against exposure to EMF have been taken. Regulation No. 2001-670 of July 2001, transposing Directive 1999/5/EC established health protection as one of the essential requirements regarding telecommunications equipment. The specification to be met by operators wishing to set up and operate mobile phone networks were changed by an Order issued on 14 November 2001 to take account of the provisions on public health protection. This Order contained a reference to the exposure limits set out in the Recommendation of 12 July 1999 (1999/519/EC).

6.5 Netherlands

6.5.1 Mobile phones

In 2002 the HCN issued an advisory report "Mobile Phones: A Health-Based Analysis", which states that, based on the data concerning the development of the head and brain in children above two years of age, there is no reason to suggest significant differences in sensitivity between adults and children.

Studies conducted on the road indicate that driving behavior is adversely affected by mobile phone use. This is because holding the mobile phone in one hand or wedging it with the shoulder against the head can reduce the ability of the driver to react quickly to road situations. As a result, the government decided to allow only hands-free calling when driving a motor vehicle. It also recommends that people postpone lengthy calls and calls demanding close attention until when the vehicle has been brought to a stop at a suitable place.

6.6 New Zealand

6.6.1 Base stations

In New Zealand, the standard for siting of mobile phone base stations used is the 1999 New Zealand standard NZS 2772.1:1999 Radiofrequency fields - Part 1: Maximum exposure levels - 3 kHz to 300 GHz. With respect to public exposure to RF energy from mobile phone base stations the New Zealand standard appears also to be in agreement with the ICNIRP Guidelines.

6.7 United Kingdom

6.7.1 Mobile phones

Following recommendations from the International Expert Group on Mobile Phones (IEGMP), the UK government published a brochure recommending that children up to the age of about 16 should use mobile phones as little as possible. The IEGMP suspects that, since they are still developing, children are more sensitive to influences from EMF. The supporting argument provided is that children's brain tissue is more conductive than that of adults, since it has a higher water content and ion concentrations.

6.7.2 Responsible agencies

HPA follows WHO's recommendations concerning the need for more research into possible effects of exposure to EMF in children.

HPA has the responsibility for providing advice on limiting exposure of people to EMF. It also has the responsibility to provide advice on the implementation of exposure guidelines for EMF. HPA recommended the adoption of ICNIRP guidelines for limiting exposure to EMF.

HPA is committed to monitor the results of research that are related to effects of EMF on health and to revise its advice when appropriate. HPA recommends that the government should consider the possible need for precautionary measures.

6.8 United States

6.8.1 Base stations

In USA, antenna sites should be designed so that the public cannot access areas that exceed the 1999 ANSI/IEEE or FCC guidelines for public exposure. As a general rule, the guideline stipulates that uncontrolled public exposure condition should not be more than 8 m from the radiating surface of the antenna. If there are areas accessible to workers that exceed the 1999 ANSI/IEEE or FCC guidelines for uncontrolled (public) exposure, it is required for workers to know where the areas are, and what precautions need to be taken when entering these areas. For areas where the radiation levels is expected to exceed the 1999 ANSI/IEEE or FCC guidelines for occupational exposure, workers should be able to shut down the transmitters when entering these areas.

6.8.2 Responsible agencies

US FCC is required by the National Environmental Policy Act of 1969 to evaluate the effect of emissions from FCC-regulated transmitters on the quality of the human environment. At present, in the USA, there is no federally mandated RF exposure standard. The FCC's requirements dealing with RF exposure can be found in Part 1 of its rules at 47 Code of Federal Regulations (CFR) Section 1.1307(b). The exposure limits themselves are specified in 47 CFR Section 1.1310 in terms of frequency, field strength, power density and averaging time. Facilities and transmitters licensed and authorized by the FCC must either comply with these guidelines or else an applicant must file an Environmental Assessment (EA).

However, several non-government organizations, such as the American National Standards Institute (ANSI), the Institute of Electrical and Electronics Engineers, Inc. (IEEE) and NCRP have issued recommendations for controlling human exposure to RF electromagnetic fields.

Back in 1996, FCC required that all mobile phones sold in the USA shall meet minimum guidelines regarding safe human exposure to RF radiation emitted from these mobile phones. The FCC and the FDA share regulatory responsibilities for ensuring the safe use of mobile phones.

The limits for mobile phone exposure adopted by the FCC are the exposure levels recommended by IEEE and the NCRP.

6.9 Usage of mobile phones by children

Prof. William Stewart, Chair of UK's NRPB (currently known as HPA) issued a warning that children under 8 years old should not use mobile phones and those between 8 and 14 should use them only when absolutely necessary. Prof. Stewart issued the same warning in 2000, when he chaired an enquiry that resulted in the "Report of an Independent Expert Group on Mobile Phones",

In relation to the usage of mobile phones by children, WHO's findings, based on expert reviews on the health effects of exposure to RF fields, is that there is no adverse health consequences established from exposure to RF fields at levels below the ICNIRP guidelines on exposure limits published in 1998.

In 2000, WHO issued a fact sheet on "Mobile Phones and Their Base Stations" (Fact Sheet No. 193). In the section under "Precautionary Measures", which states:

> *"Present scientific evidence does not indicate the need for any special precautions for the use of mobile phones. If individuals are concerned, they might choose to limit their children's RF exposure by limiting the length of calls, or by using "hands-free" devices to keep mobile phones away from the head and body."*

In 2005, AFSSE advised parents to ensure minimum usage of mobile phones by their children based on the precautionary approach.

Due to a lack of proven scientific evidence, many national bodies have adopted a different approach in terms of advice on the usage of mobile phone by children, and these include FCC, FDA and HCN. These organizations see no basis to recommend the precautionary approach issued by AFSSE.

Guidelines were intentionally developed by ICNIRP to limit human exposure to EMF under conditions of maximum absorption of the fields which rarely occurs. These limits also incorporate large safety factors to protect workers and even larger safety factors to protect the general public, including children. Therefore, the limits in the ICNIRP guidelines are sufficient to safeguard public health, including children.

6.10 Other international and national organization's requirements and recommendations

Various recommendations from different organizations were reviewed. In summary these recommendations are basically similar.

6.10.1 ICNIRP

ICNIRP concluded that the results of published epidemiological studies do not form a basis for health hazard assessments to RF fields, neither can they be used for setting quantitative restrictions on human exposure. They do not provide a basis for hazard assessments in relation to the use of mobile phones and base stations. Data from laboratory studies relevant to cancer do not provide a basis for limiting exposure to the fields associated with the use of mobile phones and base stations. It also concluded that there is no substantive evidence that adverse health effects, including cancer, can occur in people exposed to levels at or below the recommended limits on whole body average SAR and localized SAR.

At the frequencies and power levels involved in the use of mobile phones there will be no concern about shocks and burns. For occupational situations ICNIRP recommends that the localized SAR in the head be limited to 10 W kg^{-1} averaged over any 10 g mass of tissue in the head (0.1 W absorbed in any 10 g mass of tissue in the head).

For the general public, ICNIRP recommends that the localized SAR in the head be limited to 2 W kg^{-1} averaged over any 10 g mass of tissue in the head (0.02 W absorbed in any 10 g mass of tissue in the head).

The use of mobile phones should be restricted to areas where interference effects are unlikely to occur (for example, well away from hospital intensive care units and similar locations). Manufacturers of electrical equipment are encouraged to design and manufacture equipment that is insensitive to RF interference.

See Annex D for details on ICNIRP.

6.10.2 WHO

In its fact sheet on mobile phones and base stations, WHO stated that present scientific information does not indicate the need for any special precautions for the usage of mobile phones. If individuals are concerned with the safety of mobile phone usage, they may choose to limit their own RF exposure by limiting the length of calls or using hands-free devices to keep mobile phones away from the head and body. WHO also states that motorists should be strongly discouraged from using mobile phones while driving.

See Annex E for details on WHO International EMF Project.

6.10.3 IEEE of the United States

IEEE issued a Position Statement on human exposure to RF emissions from cellular radio base stations antennas in May 1992. In the summary of the Statement, the IEEE stated that it recognizes public concern for safety of microwave exposure from cellular communications base stations. It also recognizes the importance of various standard guidelines established by national and international organizations to protect workers and the general population from harmful exposure to RF EMF. IEEE agrees with the conclusion of these national and international organizations that based on present knowledge, prolonged exposure at or below the levels recommended in the guidelines is considered safe for human health. Measurements near typical cellular base stations have shown that exposure levels normally encountered by the public are well below the limits recommended by the guidelines. Furthermore, public exposure near cellular base stations is not significantly different from the usual “RF background” levels in urban areas, which are produced by radio and television broadcast stations present in every modern community. The IEEE concluded that exposure from properly operating cellular base stations is safe for the general population.

The IEEE issued another Position Statement to provide clarification on matters pertaining to safety of portable and mobile phone usage. The Statement, entitled Human Exposure to Radiofrequency Fields from Portable and Mobile Telephones and Other Communication Devices, was issued in December 1992. In its conclusion the IEEE stated that data from engineering studies indicate that in most cases SARs associated with the use of hand-held commercial cellular transportable and mobile transreceivers and telephones do not exceed the maximum permissible levels specified in the existing RF safety standards and guidelines. Therefore, under conditions of normal use, it is concluded that cellular telephones are considered safe for the users and the public.

6.10.4 ARPANSA of Australia

ARPANSA is of the opinion that the weight of national and international scientific opinion is that there is no substantiated evidence that using a mobile phone causes harmful effects and may lead to adverse health outcomes.

All mobile phones used in Australia must comply with the Australian Communications and Media Authority (ACMA) Radiocommunications (Electromagnetic Radiation - Human Exposure) Standard 2003. The ACMA standard mandates the SAR limit from the ARPANSA standard. Mobile phone manufacturers have to include maximum SAR information in the product manuals, or in a separate brochure in the box, for a new mobile phone models released in Australia according to this standard. All mobile phone models sold in Australia are compulsory meet the requirements set by Australian Standard.

In all mobile phones, RF is emitted by both the handset and the antenna. The most effective way to minimize exposure is to increase the distance between the mobile phone and the user. In line with this, ARPANSA recommends the used of hands-free kit. Other things that can be done to minimize RF exposure from mobile phones that are recommended by ARPANSA include:

- not using a mobile phone when a normal phone is available,
- limiting the duration of the calls that are made from a mobile phone, and
- using a mobile phone in an open area, not inside a vehicle, so that the phone transmits at a lower level.

In 1997-1999 ARPANSA measured RF levels at 14 different localities near GSM mobile phone base stations around Australia. ARPANSA found that emissions from these base stations were usually many orders of the magnitude below the limit set for general public exposure. As such no recommendation was given by ARPANSA to minimize RF exposure from base station.

6.10.5 HPA of UK

HPA (formerly known as NRPB) is charged with matters related to public exposure to EMF in UK. NRPB, in its report in March 2004, concluded that there is no firm evidence of adverse health effects at levels of EMF to which people are normally exposed. It published advice on limiting exposure to EMF and recommended the adoption in UK of the ICNIRP guidelines. The advice is supported by a comprehensive scientific review covering the broad base of the scientific evidence in epidemiology, experimental biology and dosimetry. HPA Radiation Protection Division (RPD) made measurements of exposure levels at publicly accessible locations around base stations and in June 2000, published results from 118 locations from 17 different base station sites. Average exposures were found to be 0.002% of the ICNIRP public exposure guidelines and at no location was exposure found to exceed 0.2% of the guidelines.

6.10.6 Health Canada

Health Canada issued a guide to consumers on safety and safe use of mobile phones, which is posted in its website and was last updated on 19th December 2006. This Guide states that, there is currently no convincing evidence, from animal or human studies, that the energy from mobile phones is sufficient to cause serious health effects, such as cancer, epileptic seizures or sleep disorders. Some scientists have reported that mobile phone use may cause changes in brain activity, reaction times, or the time it takes to fall asleep. But these findings have not yet been confirmed.

Chapter 7: Situation in Malaysia

7.1 Mobile phone users

Mobile phones are amongst the most popular consumer items in many countries and a similar situation is also experienced in Malaysia. There is a rapid increase in the number of mobile phone users in the country over the last few years. It was reported that there were about 2.5 million mobile phone users in 2000 and the number had increased to 12.3 million in 2004 and 19.5 million by the end of 2005. The total number of mobile phone users in 2006 is approximately 21.5 million. With the popularity of mobile phone usage, it is expected that this number will continue to increase significantly.

7.2 Base stations

The rapid increase of mobile phone users in the country has resulted in a corresponding increase in the number of base stations which are required to meet the demand for a larger area of coverage, higher capacity and better quality of services. Records of the Malaysian Communication and Multimedia Commission (MCMC) indicate that the number of base stations in operation were about 8,400 at the end of 2003. This number increased to about 15,000 by early 2006. A recent government directive to have nationwide coverage of the mobile phone services within the next couple of years and with the introduction of new mobile technologies, it is expected that this number would continue to grow.

7.2.1 Current status of RF radiation exposure levels around base stations

The Malaysian Nuclear Agency (Nuclear Malaysia) carried out a study on radiation levels from base stations in the northern, central, southern and eastern regions of Peninsular Malaysia. The results of this study show that there was no significant difference in terms of radiation emitted by base stations in all the four regions. However, the total broadband radiations were found to be slightly enhanced in the central region. This was expected and was due to the higher number of RF and microwave sources present in the Klang Valley as compared to the other areas in the Peninsular. The results also confirmed that there was no significant difference in terms of radiation produced by base stations of the current three service providers. The average radiation levels on the ground in open spaces around base stations were below 0.000093 W m^{-2}, which corresponds to about 0.002% of the ICNIRP exposure limits for the general public. The total radiation contributed by all sources was expectedly higher than the mobile radiation but overall it was still below 0.3% of the ICNIRP limits for the general public.

Theoretically, transmitted RF radiation reduces inversely proportional to the square of the distance. However, the results showed that the RF radiation actually reduces inversely proportional to the distance and this is due to the interference and reflection of the surroundings and the presence of other radiation sources. It was clearly observed that towers being higher than the rooftop structures generally produced much lower radiation levels on the ground than those produced by the rooftop structures.

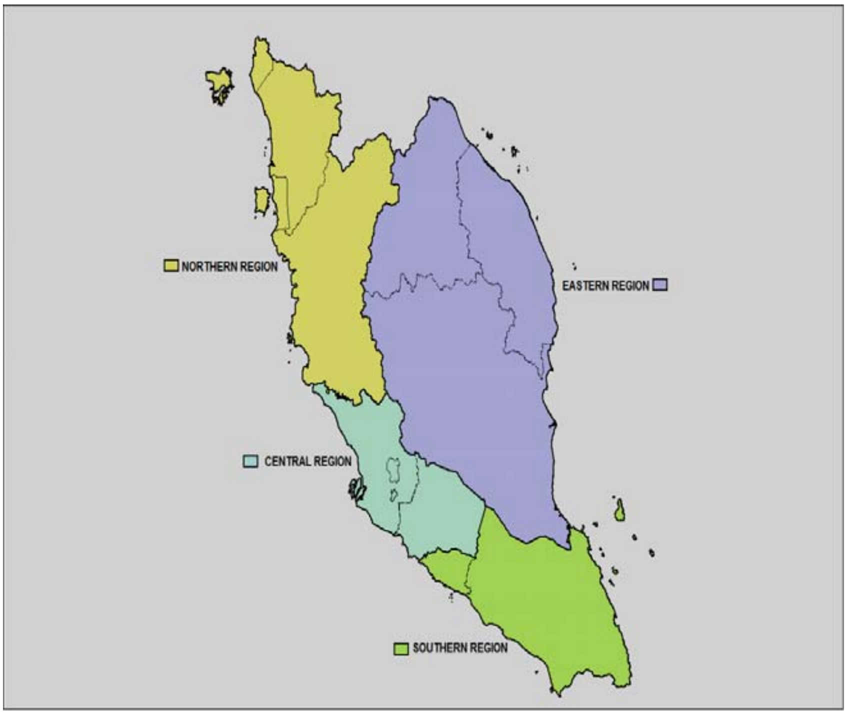


Figure 7: MCMC Regions

7.3 Related regulatory authorities

In Malaysia, with regards to matters pertaining to base stations and mobile phones, there are three regulatory authorities. They are:

- Ministry of Health Malaysia (MoH)
- Malaysian Communications and Multimedia Commission (MCMC); and
- Ministry of Housing and Local Government (MHLG)

7.3.1 Ministry of Health Malaysia (MoH)

The role of MoH is to protect the public from any health related aspects, including those related to EMF. In 1996, the Malaysian Cabinet directed MoH to study the possible adverse health effects of EMF. An Inter-agency Scientific Committee comprising of representatives from various relevant agencies was set up to prepare a cabinet report. The report concluded that there is no conclusive evidence that at EMF levels normally encountered by the general public will cause adverse health effects. However, there is also no conclusive evidence that it will not cause health effects. As such, further studies and research need to be carried out. MoH is continuously monitoring the ongoing scientific findings and research worldwide as well as practices in other countries that are related to health aspects of EMF.

7.3.2 Malaysian Communications and Multimedia Commission (MCMC)

MCMC is the regulator for the telecommunications and multimedia industry in Malaysia. The Commission was created in pursuant to the Malaysian Communications and Multimedia Commission Act 1998 / Act 589 (CMCA 98) and Communications and Multimedia Act 1998/Act 588(CMA 98).

For RF emission, MCMC looks into both aspects of base station and mobile phone. With regards to RF emission from base stations, MCMC looks into ways to improve the legislative framework by introducing appropriate measures to protect the public and workers from potential adverse effects of EMF. MCMC has been following closely on the recommendations by WHO so as to keep abreast with the latest legislative model as well as the practices in others countries.

To ensure that mobile phones are safe for use, MCMC requires that all new models of mobile phones undergo type approval before they are allowed to be marketed.

7.3.3 Ministry of Housing and Local Government (MHLG)

MHLG's contribution in this area is through its telecommunication tower and structure planning guideline which emphasizes siting criteria for base stations. One of the objectives of this guideline is to assist local authorities and city councils in their planning approval process. Under this guideline, the erection of base stations will need to obtain planning approval from the local authorities or city councils. Upon receiving such applications, local authorities or city councils will consult other technical agencies for advice before approval is granted.

7.4 Legislative Instruments

Currently, there is no specific legislations that govern the exposure levels from mobile phones and base stations. However, Malaysia uses ICNIRP guidelines as recommended by WHO for EMF exposure limits for the public and workers. In 1998, MCMC released guidelines on permissible radiation levels which are based on ICNIRP guidelines. Meanwhile, a standard on EMF exposure (which is based on ICNIRP guidelines) is being prepared by a technical committee coordinated by SIRIM Berhad.

7.4.1 Technical Regulation (Standards)

Communications and Multimedia (Technical Standards) Regulations 2000 / P.U. (A) 124, requires that communication equipment, including mobile phones be tested and certified. The certification is to ensure the safety and interoperability of the telecommunication equipment. The regulation also requires that all mobile phones sold are labeled. Currently, SIRIM QAS International Sdn. Bhd. is the sole registered Certification Agency for Communication Equipment in Malaysia registered under the CMA98.

7.4.2 Technical Code

MCMC is currently registering a technical code titled “Technical Standard on RF Emission Control of Cellular Radio Sites”. This technical code is developed by the Malaysian Technical Standards Forum Berhad (MTSFB) under its Wireless Industries Emission Work Group (WIEWG). The technical code which provides a guideline based on the ICNIRP, indicates the limits and the proper placement of antenna for cellular coverage. Identification of exclusion zones for public and workers are also listed in this document.

The service providers in Malaysia have agreed to adhere to the requirements stated in this technical code as part of the self-regulated framework required by CMA 98.

7.4.3 MHLG Guideline

MHLG has approved a planning guideline titled “Planning Guide for Telecommunication Towers” in August 2006. This document will be used by the local authorities for their planning approval process. This document is developed by the technical committee formed by the Federal Department of Town and Country Planning under the ministry. The guideline provides procedures on planning approval process, site specifications which emphasizes on types, size and design allowed for various types of telecommunication towers. It also emphasizes on safety aspects which need to be adhered to by the local authority when approving such applications. Under the new guideline, any proposal for telecommunication towers must obtain planning approval from the local authority.

The guideline consists of siting criteria for activities involving erection of base stations and emphasizes on the following:

- site suitability
- set back requirements
- social and environmental considerations (eg. safety, topography preservation etc.)
- aesthetical value (height control, size and type of structure)
- other planning aspects

- public notification according to the Town and Country Planning Act 1976 (Act 172)

However, the document does not cover specifications for exposure limits as this aspect will be referred to the MCMC and other technical agencies.

7.5 Other initiatives

7.5.1 Study conducted in Malaysia

A study had been carried out by Nuclear Malaysia on base stations with aims to assess the levels of emitted radiation, its distribution patterns and to analyze the health impact caused to members of the public living in areas close to them. The study covered 128 base stations that belong to the local service providers located in the four regions of Peninsular Malaysia. They were selected randomly to cover both rooftop structures and towers and they evenly distributed to cover the rural, suburb and urban areas in the regions.

7.5.2 Public education/ awareness program

A collaboration approach among relevant agencies in addressing public concerns on matters related to EMF, including mobile phones and base stations, will ensure harmonization, consistency and enhanced public awareness. MOH, together with other agencies such as MCMC, Nuclear Malaysia and University Malaya Medical Centre (UMMC) continuously organize seminars and talks to disseminate correct information to address the concerns of the general public and to allay their fears of the adverse health effects from EMF.

There are many misconceptions on the effects of RF emissions from base stations and mobile phones. These misconceptions have created anxiety and unfounded fear among the general public on the siting of base stations and the usage of mobile phones. In order to create awareness on the factual information of RF emissions, MCMC with the support of the experts in this field from UMMC, MoH, Nuclear Malaysia and SIRIM Berhad, has been conducting roadshows and seminars nationwide on the effects of RF emission.

A website has been developed by MCMC to address the public's concern on the effects of RF emission from base stations and mobile phones. This website provides information on upcoming event and seminars as well as information on RF emissions. The website address is "www.rfrad.gov.my".

A booklet titled "Radiation, Mobile Phones, Base Stations and Your Health" by Professor Ng Kwan Hoong from UMMC has been published to address the misconceptions of RF emissions.

As there are gaps in knowledge about the possible adverse health effects mentioned above, the Inter-agency Advisory Committee on Non-ionizing

Radiation which was established in 1996 will continue to monitor and review the latest scientific findings and subsequently to advise the government and the public.

The local universities and research institutes continuously carry out research and studies pertaining to the health effects of RF emissions.

See Annex F for details on Guide on How to Use Mobile Phone.

Chapter 8: Conclusions and Recommendations

Based on current scientific findings, especially by WHO, it is the opinion of MoH that the evidence to-date is not conclusive to indicate that RF emissions from base stations at levels normally encountered in this country will cause adverse health effects. Results of studies on RF emissions from base stations in Malaysia confirmed that the levels are well below the limits specified in ICNIRP guidelines (less than 0.002%).

As a precautionary approach and in the absence of conclusive evidence, guidelines and standards are more appropriate to implement in order to address concerns pertaining to health effects of RF emissions from mobile phones and base stations.

It is recommended that:

- MoH and other relevant government agencies continuously monitor the latest findings on health risks associated with the exposure to EMF, particularly from mobile phones and base stations. This is to ensure that the practices in this country remain current and harmonised with international recommendations and practices.
- MoH continues to maintain contact with WHO through its participation as a member of the International Advisory Committee (IAC) of WHO International EMF Project to ensure that Malaysia keeps abreast with the latest findings.
- MoH will keep the public informed of any further developments and take the necessary actions if needed.
- Local universities and research institutes carry out research and studies pertaining to health effects of RF emissions from mobile phones and base stations.

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Annex A

Terms and definitions related to mobile phone technology

2G - Second Generation
Refers to the second generation of mobile telephones using digital technology to transmit voice and data, which came into use in the 1990s.

3G - Third Generation
A new system giving high speed data links. These services operate at 2200 MHz (2.2 GHz). The third generation technology used in the UK is called UMTS.

Absorption
In an antenna, the process within a poorly conducting material in which RF energy is absorbed and converted to heat energy.

Base station
A base station consists of the antenna(s) emitting electromagnetic radiation in the radio frequency range, the supporting structure, the equipment cabinet and the cable structure.

Bluetooth
Wireless personal area network (PAN) standard that enables data connections between electronic devices such as desktop computers, wireless phones, electronic organizers and printers in the 2.4 GHz range at 720 kbps within a 30-foot range. Bluetooth depends on mobile devices equipped with a chip for sending and receiving information.

Broadband
A classification of the information capacity or bandwidth of a communication channel. Broadband is generally taken to mean bandwidth higher than 2 Mbps.

CDMA
Code Division Multiple Access. In a CDMA system, each voice circuit is labeled with a unique code and transmitted on a single channel simultaneously along with many other coded voice circuits. The receiver uses the same code to recover the signal from the noise. The only distinctions between the multiple voice circuits are the assigned codes. The channel is typically very wide with each voice circuit occupying the entire channel bandwidth. This system used 1.23 MHz wide channel sets. The full vocoder rate is 8.55 Kbits/sec, but voice activity detection and variable rate coding can cut the data rate to 1200 bits/sec. A very robust and secure channel can be established, even for an extremely low-power signal-theoretically, the signal can be weaker than the noise floor.

CMA 98
Communications and Multimedia Act 1998 / Act 588

CMCA 98
Malaysian Communications and Multimedia Commission Act 1998 / Act 589

Coverage
Denotes the area in which a mobile phone can make and receive calls. It is often described by networks in terms of the percentage of population that can use the service rather than actual geographic coverage.

dB (decibel)
A unit stating the logarithmic ratio between two amounts of power. Typically used in receiver and transmitter measurements.

DECT
Digital European Cordless Telephone. A digital cordless telephone standard that incorporates some of the features of the cellular telephone systems. DECT telephones use picocells, and calls can be handed off from one cell to the next.

Dipole Antenna
Any one of a class of antennas producing a pattern with a node or zero level at each end.

Directional antenna
A directional antenna is an antenna which transmits or receives maximum power in a particular direction.

Dish antenna
Antenna that transmit and receive a highly focused radio wave in one direction and are used for point to point communication links.

Electric field strength
The vector quantity that corresponds to the force exerted on a charged particle regardless of its motion in space. It is expressed in volts per meter ($V m^{-1}$).

ETACS
Extended Total Access Communication System. A cellular mobile telephone standard originally used in the UK. Operated on the 900 MHz frequency band.

Exposure
Arises when a person is subject to electric, magnetic or electromagnetic fields or conduct currents, different from those which originate from physiological activities of the human body or other physical effects.

Extremely Low Frequency (ELF)
A signal in the frequency in the range below 300 Hz.

Frequency allocation
A band of radio frequencies identified by an upper and lower frequency limit earmarked for use by one or more of the 38 terrestrial and space radio-

communications services defined by the International Telecommunication Union under specified conditions.

GSM
Global System for Mobiles - The most mature digital wireless standard is GSM, usually referred to as the 'European' digital standard. GSM is a TDMA standard, with 8 users per channel. The speech is taken in 20 ms windows, which are sampled (13-bit resolution at 8 ksps), processed and compressed. The vocoder rate of 13 kbits/s is used. A channel is 200 kHz wide, and contains data from eight users. Each user has a time slot of 0.577 ms, during which a burst of 156 bits is transmitted at a modulation frequency of approximately 270 kHz. GSM is transmitted on a 900 MHz carrier.

GSM900
A network which operates in the 900 MHz GSM band.

GSM1800
A network which operates in the 1800 MHz GSM band.

GSM1900
A network that operates in the 1900 MHz GSM band. Some networks in the USA, South America, Asia and Africa use this band.

High-Gain Antenna
An antenna whose radiation pattern is concentrated in a more or less narrow beam, i.e. a "directional antenna".

ICNIRP
International Commission on Non-Ionizing Radiation Protection

Ionizing radiation
Radiation that produces ionization in matter. Examples are alpha particles, gamma rays, x-rays and neutrons. When these radiations pass through the tissues of the body, they have sufficient energy to damage DNA.

Magnetic field strength
The vector quantity (H), which, together with the magnetic flux density, specifies a magnetic field at any point in space. It is expressed in amperes per meter ($A\ m^{-1}$).

Magnetic flux density
A measure of the magnetic effect induced in a medium by an external field. Unit tesla, symbol T.

Multiple Access
A method for accommodating more users in the same frequency band.

NCRP
National Council on Radiation Protection and Measurements

Network
In the wireless industry, a network refers to the infrastructure enabling the transmission of wireless signals. A network ties things together and enables resource sharing.

NMT450Nordic Mobile Telephone
A mobile technology operating in the 450 MHz specified by Nordic telecommunications administrations

Non-ionizing radiation
Any kind of electromagnetic radiation which cannot extract electrons from atoms or molecules in order to produce directly or indirectly ions or ionized molecules.

Omni-Directional Antenna
An antenna that radiates energy power more or less uniformly over an angle of 360 degrees in the horizontal plane around the antenna. Sometimes called a "low-gain" antenna. The familiar "whip" antennas are omni directional in their radiation patterns.

Power density
A measure of the radiated power reaching unit area of a surface. The accepted unit for this parameter is watts per square meter (W m^{-2}). However, the older measure milliwatts per square centimeter (mW cm^{-2}) is still encountered.

1 mW cm^{-2} is equivalent to 10 W m^{-2}.

RF
Radio Frequency. Also used generally to refer to the radio signal generated by the system transmitter, or to energy present from other sources that may be picked up by a wireless receiver.

RFI
Radio Frequency Interference. A non-desired radio signal which creates noise or dropouts in the wireless system or noise in a sound system. RFI can be generated by a wide variety of sources including electronic organs, computers, switching power supplies, broadcast radio signals and outside radio devices. Radio signal energy can enter a sound system component or alter the audio signals in cabling, producing annoying hiss, whining or intelligible audio signals. Proper shielding and balanced audio cabling are the best defense against RFI problems in a sound system. High quality receivers are the best defense against RFI in wireless microphone systems.

RFID
Radio Frequency Identification. RFID is an automatic identification method, relying on storing and remotely retrieving data using devices known as RFID tags.

Service provider
A company that provides mobile phone users with services and subscriptions to mobile phone networks.

SMS (Text messaging)
Short Message Service. Available on digital GSM networks allowing text messages of up to 160 characters to be sent and received via the network operator's message center to your mobile phone, or from the Internet, using a so-called "SMS gateway" website. If the phone is powered off or out of range, messages are stored in the network and are delivered at the next opportunity.

Spectrum
The range of electromagnetic radio frequencies used in the transmission of sound, data and television.

TDMA
Time Division Multiple Access. TDMA systems are able to transmit multiple voice circuits per channel. A TDMA channel is a single FDMA channel divided up in time into multiple time slots. Three users can take it in turn to share one radio channel. The channels can vary in bandwidth and depending on the type of system, the time slots can transmit all or part of a voice circuit. Each user's speech is stored, compressed and transmitted as a quick packet, using controlled time slots to distinguish them-hence the phrase 'time division'. Its uses 30 kHz channels and a vocoder rate of 8 kbits/sec. At the receiver, the packet is de-compressed.

UMTS
Universal Mobile Telecommunications System. UMTS referred to 3G mobile communication system standard for Europe.

Wi-Fi
Wireless Fidelity. Wi-Fi originally referred to the 802.11b specification for wireless LANs, but it is now used to describe any of the 802.11 wireless networking specifications.

WiMAX
Wireless Interoperability Microwave Access. WiMAX is a last mile broadband wireless technology based on IEEE 802.16 fixed application standard optimized to deliver high speed multimedia services at higher data rates up to 75 Mbps to the end user.

Annex B

Specific Absorption Rate (SAR) value

B1. SAR

Specific Absorption Rate averaged over the whole body or over parts of the body is defined as the rate at which energy is absorbed per unit mass of body tissue and is expressed in watts per kilogram (W kg^{-1}). Whole body SAR is a widely accepted measure for relating adverse thermal effects to RF exposure. Besides the whole body average SAR, local SAR values are necessary to evaluate and limit excessive energy deposition in small parts of the body resulting from special exposure conditions. Examples of such conditions includes a grounded individual exposed to RF in the low MHz range and individuals exposed in the near field of an antenna.

Limit for exposure in Europe, Australia and USA is as per table below.

Region/ Country	Reference to SAR measurement protocol	Reference to SAR limit	Limit
Europe	European Specification ES 59005 (1998)	ICNIRP Guidelines 1998 (ICNIRP 1998)	2.0 W kg^{-1} in 10 g of tissue
Australia	Australian Communications Authority (ACA) Standard (ACA RS 1999)	Australian Standard AS/NZS 2772.1	1.6 W kg^{-1} in 1 g of tissue
US	Federal Communications Commission (FCC) Guidelines (FCC 1997)	American Standard ANSI C95.1 (ANSI 1992)	1.6 W kg^{-1} in 1 g of tissue

In general, the peak SAR for a mobile phone is usually found near the jaw position because this is where the phone is in contact with the head. This test position is called *up* by current SAR standards and is referred to as the *touch* position. The localized exposure at the jaw is generally greater than the localized exposure to the brain or ear region. The SAR standard (EN 50361) calls for an additional test in which the phone is placed in a tilting position whereby the antenna is moved toward the head and the phone is moved away from the jaw. This new *tilt* position results in the shifting of the maximum SAR value from the jaw closer to the earphone.

The standard, IEEE C95.1-1991 gives recommendations to prevent harmful effects in human beings exposed to electromagnetic fields in the frequency range from 3 kHz to 300 GHz.

B2. Electromagnetic Power Flux Density

The rate of flow of electromagnetic energy (RFR) per unit area is used to measure the amount of radiation at a given point from a transmitting antenna. This quantity is expressed in units of watts per square meter ($W\ m^{-2}$) or milliwatts per square centimeter ($mW\ cm^{-2}$).

The maximum exposure level for members of the public exposed to RFR at 900 MHz is 0.45 $mW\ cm^{-2}$. This figure can be compared with the amount of heat radiated by the human body at room temperature of about 2 $mW\ cm^{-2}$. (Note this energy is radiated primarily in the infra red region not as RFR). Evaluation of mobile phones for compliance with the interim Standard are not required because of their low power output.

In September 2001 the European Committee for Electrical Standardisation (CENELEC) published a standard testing procedure for the measurement of SAR from mobile phones. Information on all phones marketed in the UK, using this standard testing procedure, is now available.

The CENELEC Board welcomes the provision of information on the SAR from phones by all manufacturers using a standard testing procedure. This is an important contribution to providing information to the public about the potential for exposure and informs consumer choice. It recommends that comparative information on the SAR from phones is readily available to the consumer at the point of sale on leaflets available in stores giving comparative information on different phones and with explanatory information. And as a menu option on the screen of the phone and as a label on the phone. Additionally, on a national web site, which lists the SAR values of different phone types.

The inclusion of comparative data on the SAR from phones in its promotional literature by at least one retailer is a welcome development. The public also need to be able to understand the merits and limitations of published SAR values.

Mobile phones presently marketed in the UK comply with both NRPB (HPA) and ICNIRP guidelines. A crucial issue in relation to the exposure of people using mobile phones is the SAR. This determines the amount of energy absorbed in the body of the user. In most circumstances of use this will be the head. The SAR depends upon the power output of the phone and its design. SAR measurements are now based on the standard published by CENELEC. Such a procedure benefits consumers and has been welcomed by industry.

The harmonized standard EN 50360 published in July 2001 is the Product Standard which manufacturers must now follow to demonstrate compliance of mobile phones with basic restrictions related to human exposure to electromagnetic fields in the range 300 MHz to 3 GHz. It is potentially more demanding than previous standards and refers to new test procedures and measurements to demonstrate compliance with Article 3.1A of the RTTE Directive. The test procedure specifies more detailed SAR measurements, and reinforces the importance of SAR measurements and the role they play in giving confidence regarding the health and safety of mobile phones.

B3. Measurement protocol

Restrictions on exposure to EMFs are designed to prevent adverse health effects and are based on their interactions with body tissues. They are termed basic restrictions as they are developed from experimental data relating to thresholds for direct and indirect health effects, which give rise to the fundamental limits on exposure. Generally, the basic restrictions are not readily measurable.

Reference levels are also given; these are conservatively derived levels relating to the electric field, magnetic field or current for comparison with measurements that can readily be made. Comparison of measurements with the reference levels can be used to assess whether compliance with the basic restrictions has been achieved. If the field to which a person is exposed exceeds the relevant reference level it does not necessarily follow that the basic restriction is exceeded. It is, however, then necessary to investigate compliance with the basic restriction using more detailed methods of exposure assessment. The reference levels may be used to indicate whether there is a need to take appropriate action to prevent shock and burn.

IEEE Standard 1528-2003 specifies protocols and test procedures for the measurement of the peak spatial-average SAR induced inside a simplified model of the head of users of certain handheld radio transceivers.

The following items are described in detail: measurement concepts, measurement techniques, instruments, calibration techniques, simulated-tissue (phantom) models, including homogeneous anatomical models of the human head and simple phantoms for validation of the SAR measurement system, and the limitations of these systems when used for measuring the spatial-peak mass-averaged SAR.

B4. Assessment of compliance with RF energy guidelines for mobile phone base stations

Compliance can be assessed through measurements or calculations. Both methods require a solid understanding of the physics of RF energy. Measurements require access to sophisticated and expensive equipment. Calculations require detailed knowledge about the power, antenna pattern and geometry of each antenna at a site.
Nothing as simple as distance from an antenna site is adequate for assessing compliance or estimating exposure levels. RF energy exposure may not even increase as you get closer to an mobile phone base station site.

Calculation: If the effective radiated power (ERP), the antenna pattern and the height of the base station antenna are known, then "worst case" calculations of ground level power density can be made. However, the calculation method is not simple and the ERP and antenna pattern are often unknown.

Measurement: Actual measurement of power density from mobile phone base stations requires sophisticated and expensive equipment and considerable technical knowledge. The instruments designed to measure power line fields and the instruments designed to test microwave ovens are not suitable for measuring base stations. Determining that base stations meet ANSI/IEEE, FCC, or ICNIRP guidelines is "relatively easy", but the instruments required cost well over US$3000. Actual measurement of the power-density from a base station antenna is much more difficult, as there are many other sources of RF energy at a typical site.

Annex C

Summary of exposure limit for various countries

Country	Reference Document	Exposure Limit
Australia	Maximum Exposure Levels to RF Fields – 3 kHz to 300 GHz	Based on ICNIRP
Canada	Safety Code 6 - Limits of Human Exposure to Radiofrequency Electromagnetic Fields in the Frequency Range from 3 kHz to 300 GHz	Not based on ICNIRP
France	EC 1999/519 - Council Recommendation On The Limitation Of Exposure Of The General Public To Electromagnetic Fields (0 Hz To 300 GHz)	Based on ICNIRP
Netherlands	EC 1999/519 - Council Recommendation On The Limitation Of Exposure Of The General Public To Electromagnetic Fields (0 Hz To 300 GHz)	Based on ICNIRP
New Zealand	New Zealand Standard 2772.1:1999 Radiofrequency Fields Part 1: - Maximum exposure levels 3 kHz - 300 GHz	Based on ICNIRP
Russia	GOST 12.1.006-84 Occupational safety standards system. Electromagnetic fields of radio frequencies. Permissible levels at work-places and requirements for control	Not based on ICNIRP
Singapore	Health Sciences Authority Health and Safety Guideline on EMF Exposure	Based on ICNIRP

Country	Document Reference	Limit
South Africa	Hazoudus Substance Act, 1973n(Act 15 of 1973) – Limit for Human Exposure to time-Varying Electric, Magnetic, and Electromagnetic Fields in the Frequency Range Up to 300 GHz.	Based on ICNIRP
Switzerland	Ordinance relating to Protection from Non-Ionizing Radiation (ONIR)	Based on ICNIRP - In addition, precautionary emission limitations for places of sensitive use are introduced.
United Kingdom	NRPB Doc. 15(2) – Advise on Limiting Exposure to Electromagnetic Fields (0-300 GHz)	Based on ICNIRP
United States	Radiofrequency Radiation Exposure Limits	Not based on ICNIRP

Annex D

ICNIRP

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) is an international independent scientific organization formally recognized by WHO, evaluates scientific results from all over the world and is responsible for providing guidance and advice on the health hazards of non-ionizing radiation exposure. ICNIRP was chartered in 1992.

The Organization maintains a close liaison and working relationship with all international bodies engaged in the field of non-ionizing radiation protection and represents radiation protection professionals worldwide through its close collaboration with the International Radiation Protection Association and its national societies.

ICNIRP works in conjunction with international and national health and research organizations as well as universities and other academic institutions. It's aim is to bring together independent experts to provide advice on the health issues relating to non-ionizing radiation exposure. ICNIRP has established four standing Committees covering:

1. Epidemiology;
2. Medicine and biology;
3. Physics and engineering; and
4. Biophysical aspects of optical radiation.

ICNIRP international membership comprises individual experts covering the disciplines of medicine, biology, epidemiology, physics, and engineering.

Annex E

WHO International EMF Project

E1. Introduction

Potential health effects of exposure to static and time varying electric and magnetic fields need scientific clarification. Electromagnetic fields of all frequencies represent one of the most common and fastest growing environmental influences, about which there is anxiety and speculation, are spreading. EMF exposure now occurs to varying degrees to all populations of the world, and the levels will continue to increase with advancing technology. Thus, even small health consequences from EMF exposure could have a major public health impact.

In May 1996, due to growing public health concerns expressed by many parties on possible health effects from exposure to an ever-increasing number and diversity of EMF sources, the World Health Organization (WHO) launched an international project to assess health and environmental effects of exposure to electric and magnetic fields, which became known as the International EMF Project.

As part of its charter to protect public health and in response to public concern over health effects of EMF exposure, the World Health Organization (WHO) established the International EMF Project in 1996 to assess the scientific evidence of possible health effects of EMF in the frequency range from 0 to 300 GHz.

The EMF Project encourages focused research to fill important gaps in knowledge and to facilitate the development of internationally acceptable standards limiting EMF exposure.

E2. Project objectives

Key objectives of the Project are to:

- Provide a coordinated international response to concerns about possible health effects of exposure to EMF,
- Assess the scientific literature and make a status report on health effects,
- Identify gaps in knowledge needing further research to make better health risk assessments,
- Encourage a focused research program in conjunction with funding agencies,
- Incorporate the research results into WHO's Environmental Health Criteria monographs where formal health risk assessments will be made on exposure to EMF,
- Facilitate the development of internationally acceptable standards for EMF exposure,

- Provide information on the management of EMF protection programs for national and other authorities, including monographs on EMF risk perception, communication and management, and
- Provide advice to national authorities, other institutions, the general public and workers, about any hazards resulting from EMF exposure and any needed mitigation measures.

E3. Project description

The Project is to assess health and environmental effects of exposure to static and time varying electric and magnetic fields in the frequency range 0 - 300 GHz. For the purpose of the project this range is divided into 4 categories:

- static (0 Hz),
- extremely low frequency (ELF, >0-300 kHz),
- intermediate frequencies (IF, >300Hz to 10MHz),
- radiofrequency (RF, 10 MHz-300 GHz) fields.

Scientific activities of the International EMF Project include review meetings to arrive at health risk assessments for various types of electromagnetic fields and their specific application. Independent expert groups, using accepted assessment criteria, review the literature on biological effects of EMF. These reviews are timed to allow needed research to be completed so that the results can be included in the publications on health risk assessments.

E4. The EMF Project within the WHO

The Project is located at the World Health Organization (WHO) headquarters in Geneva, Switzerland, since it is the only United Nations organization with a clear mandate to investigate detrimental health effects from exposure of people to non-ionizing radiation. The EMF Project is run within the Radiation and Environmental Health Unit which has in its action plan on radiation protection, activities which deal with both ionizing and non-ionizing radiation. This Unit is part of the Sustainable Development and Healthy Environments Cluster of WHO.

E5. EMF Risk Perception, communication and management

The International EMF Project will publish documents on risk perception, risk communication and risk management in order to improve communications among those concerned, including an increasingly skeptical public and workforce, about possible health risks of EMF exposure.

E6. International Advisory Committee (IAC)

An International Advisory Committee (IAC), consisting of representatives of international organizations, independent scientific institutions and national governments supporting the Project, provides oversight. All activities are coordinated and facilitated by the WHO Secretariat. The IAC meets on a yearly basis. Over the last 10 years, activities have closely followed the original work plan and most activities have or are being finalized. It is expected that the health risk assessments will be published by 2008.

International organizations supporting and participating in the Project include European Commission (EC), International Agency for Research on Cancer (IARC), International Commission on Non-Ionizing Radiation Protection (ICNIRP), International Electro technical Commission (IEC), International Labour Office (ILO), International Telecommunication Union (ITU), North Atlantic Treaty Organization (NATO) and United Nations Environment Programme (UNEP).

E7. Funding

Funding is provided by contributions from WHO member states and non-governmental organizations approved by WHO.

Annex F

Guide on How to Use Mobile Phone

The radiation exposure received by users from normal use of mobile phones can be very significant because of short distance to the body, in particular, during long conversation. The following are simple rules, which one can follow to minimize hazard from a mobile phone.

F1. Minimize usage

Try to minimize the use of mobile phone as much as possible by switching over to ordinary (fix) telephones. Use mobile phone only when it is really necessary or in situations where you cannot avoid using it.

F2. Shorter conversations

Avoid speaking for long periods on the mobile phone. Try to plan your calls in such a way that you use ordinary (fixed) telephones for long conversations.

F3. Use hand-free kit

Use hand-free kit that allows you to make conversation at a distance from the mobile phone. The distance involved will minimize the radiation exposure received from the phone.

F4. Reduce use of mobile phone in the car

Always use a hand-free kit when you want to use hand phone while driving. Speak as little as possible inside the car. If you have to speak a lot, stop the car and continue your conversation. This may also save you from getting involved in an accident.

F5. Protect your baby

Do not place a turned-on mobile phone next to your baby in a baby pram or pushed chair. The telephone emits microwave radiation once it is on even when it is not used.

F6. Avoid placing the phone close to the body with medical implant

It is also not advisable to place the mobile phone next to your heart if you have a pacemaker. If you are concern about possible interference with your pacemaker, please keep the mobile phone at least 15 cm away. This can be done by carrying the mobile phone in the breast pocket or hold the phone to the ear on the opposite side of the body. The mobile phone may also affect your hearing aids and, therefore, it is better not to place the devices close to each other. Please consult your doctor for an advice. It seems that the most suitable place to carry the mobile phone is in the trouser's leg pocket.

F7. Avoid using a mobile phone in certain places

Avoid using a mobile phone when you are in hospital compound, at a petrol pumps or when you are in the aircraft before taking off and landing. Using a mobile phone at these places or during this time may increase chances for the microwave radiation to interfere with the operation of certain critical electronic equipment or to induce spark that can eventually cause fire and explosion.

F8. Direct the antenna (if applicable)

Always pull out the antenna when you use the phone and direct it away from the head, not upright in parallel with the head. It may be marginal different, but it reduces the radiation into the head somewhat.

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