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| **SOUTH ASIAN TELECOMMUNICATIONS REGULATOR’S COUNCIL (SATRC)** |  |
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**REPORT ON**

**NON-IONIZING RADIATION SAFETY IN FREQUENCY BANDS USED FOR**

**MOBILE TELEPHONES**

**Prepared by**

**SATRC Working Group Spectrum**

**Adopted by**

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# EXECUTIVE SUMMARY

1. 14th SATRC Meeting, held from at Paro, adopted the SATRC Action Plan Phase V for the implementation year 2014-2016. Under this Action Plan, one of the items assigned to the Working Group (WG) on Spectrum is NON-IONIZING RADIATION SAFETY IN THE FREQUENCY BANDS USED FOR MOBILE PHONES.
2. The purpose of the work item is to study why SATRC countries should concern about this subject. The scope of the study is:-

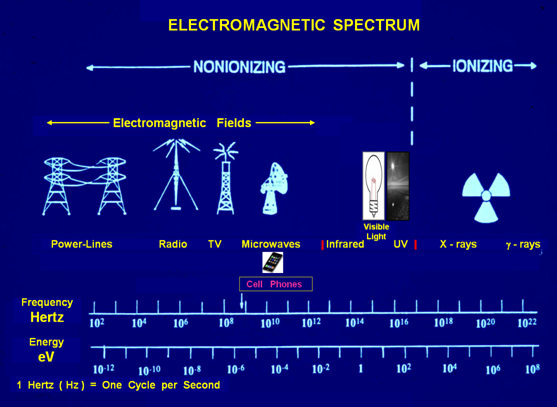
* To suggest the common standards which is accepted for SATRC countries
* To study the methods of standard measurement
* To suggest the necessary policies and regulations for decreasing the public complains and worry.
* To analyse the need for establishment of non-ionizing radiation protection centre in SATRC to evaluate the measurement of radiations and certify the radiation of BTS in SATRC countries.
* To suggest the necessary policies in environment compatibility
* To analyse the need for developing application for mobile phones through which people can check the status of RF map of capital cities in SATRC countries

1. Spectrum management is the combination of administrative, scientific and technical procedures necessary to ensure the efficient operation of radio communication equipment and services without causing interference. Simply stated, spectrum management is the overall process of regulating and administering use of the radio frequency spectrum. The goal of spectrum management is to maximize spectrum efficiency, minimize interference and eliminate unauthorized and improper use of the spectrum. Rules and regulations, based on relevant legislation, form a regulatory and legal basis for the spectrum management process. Spectrum monitoring serves as the eyes and ears of the spectrum management process. It is necessary in practice because in reality, authorized use of the spectrum does not ensure that it is being used as intended.
2. Globally it can be noted that the ICNIRP is expected to publish updated guidelines for RF in 2016 and that the WHO is currently conducting a health risk assessment for RF exposures. SATRC countries are encouraged to monitor those activities and to use their outcomes as a basis to consider future policy for EMF exposure.
3. ITU through its various recommendations cited in the report aims to create standard measurement techniques. In addition ITU also publishes Handbook on Spectrum Monitoring from time to time. All SATRC member countries need to ensure that the ITU recommendations are strictly adhered to.
4. The issue regarding establishing non-ionizing radiation protection centre in SATRC to evaluate the measurement of radiations and certify the radiations of BTS in SATRC countries was discussed in the working group meeting and it was concluded that at this point of time the need for having a non-ionizing radiation protection centre in SATRC did not exist.
5. For ensuring environment compatibility initially camouflaging should be made mandatory in areas of heritage, environmental or architectural importance.
6. At present the trial of Tarang Sanchar, a proposed National EMF Portal is being carried out in India. This would provide a common collaborative platform for entire end to end records of EMF exposure and paperless processing and retention of records for entire telecom network of the country. Once the portal goes live, the general public will have more access to information related to EMF since there will be more transparency and public themselves can see the compliance on sites, they will be more confident and hence their fear will be mitigated. Other SATRC member countries may also consider establishing such a portal. Depending on the maturation of the same and response by public, application for mobile phones can be developed.

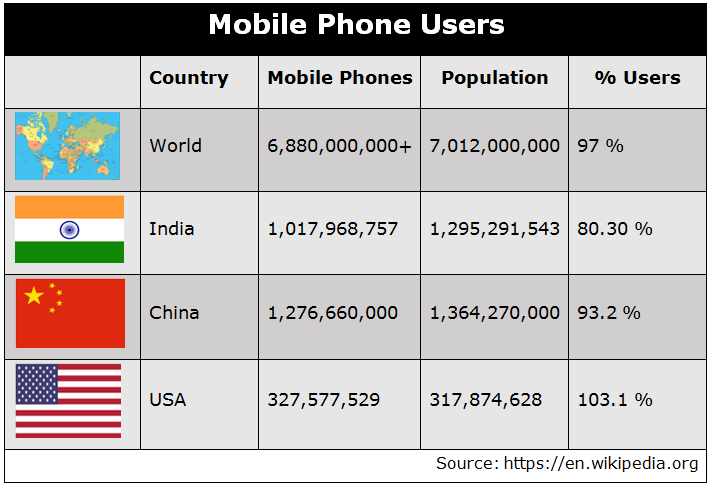
# CHAPTER-I: INTRODUCTION

1. **Background:**
2. Radio communications and wireless systems are a part of everyday life in today's society. All radio communications systems use radio frequency (RF) in the electromagnetic field (EMF) part of the electromagnetic spectrum. Wireless networks provide vital infrastructure and the underlying connections supporting the information and communication technologies (ICTs) for smart sustainable cities (SSC).
3. There has been growing public concern in some countries on possible adverse health effects due to Electro-magnetic field (EMF) Radiation from mobile towers and mobile handsets. Over the past few years, a number of health activists and resident organisations have started opposing the erection of telecom towers on rooftops of houses and in densely populated areas, claiming that radiation from such installations causes serious health risks.
4. There have been several studies suggesting either the presence or absence of risk to human beings from EMF radiation. The main areas of concern are the radiation emitted by the base transceiver stations (BTS) and mobile handsets. Concerns have also been raised that continuous exposure to EMF radiation emanating from telecom towers causes harmful thermal and non-thermal health effects. The effects of exposure to EMF have created an active scientific debate among the research agencies across the globe.
5. **Radio Waves**
6. Radio wave is a type of electro-magnetic field and existed in nature before man came into existence. There are electro-magnetic fields of various frequencies from outer space reaching the earth in addition to ultraviolet rays or visible light. Radio wave is not felt, but is something quite natural like the air or water. Our relationship with radio waves for use in communication has over 100 years of history.
7. Mankind began using radio waves about 100 years ago with the invention of wireless communication by Marconi and Tesla. In India the first wireless use was in 1902, and commercial radio broadcast started in 1927 and the first Television broadcast in 1959 and since then the radio waves have been contributing towards advancement of culture, security, and innumerable day to day services. It has now become part of our way of life, being used for TV, radio, mobile phone, weather satellite, GPS (Geographical Positioning System), ITS (Intelligent Traffic System), disaster management, remote sensing, security forces etc. It is important to understand the safety aspects of the use of EMF and quite obvious to have some anxieties against radio waves, as we cannot see it or feel it directly. With the new wireless technologies being introduced at a rapid pace coming out one after another our use of radio wave is poised to continue to increase.
8. **Electric field, magnetic field**
9. Electric fields come from the voltage that is used to make electric current flow in a wire. The voltage is like the water pressure which makes water flow in a plumbing system, and the electric current is like the water flow. Electric fields get bigger as the voltage increases. Electric field occurs around a conductor, such as power transmission line, electric cable/wire when voltage is put in. The strength / intensity of electric field is expressed with the unit Volt per meter (V/m).When there is an electric current in a conductor, a magnetic field is generated around it. Strength of the magnetic field is expressed with the unit ampere per meter (A/M).
10. **Electromagnetic field**
11. Electric field and magnetic field together are called “electro-magnetic field”. When electric and magnetic fields are alternately generated and propagated through space together, this wave is called electro-magnetic wave and the strength of EMF at the frequencies relevant to mobile communications is expressed with the units watt per square meter (W/m2).The number of oscillations of a wave in one second is called “frequency” and it is expressed in the unit Hz (hertz). In the cellular communication system radio waves are used for transmitting information between mobile phones and antennas. The electromagnetic field (i.e. EMF) includes electric and magnetic fields from the electricity supply, radio waves from TV, radio devices, medical devices, mobile phones, radar and satellite communications. The electro-magnetic field weakens very quickly as it moves away from the antenna according to the square-law relationship. It is reduced to ¼ when the distance from antenna doubles and 1/9 when distance is tripled and so on.
12. **Electromagnetic field radiation**
13. Electromagnetic field (EMF) radiation is the flow of photons through space. Each photon contains a certain amount of energy (termed a quantum), and the different types of radiations are defined by the amount of energy found in the photons. The electromagnetic spectrum is the range of all types of EM radiation. X-rays used in hospitals or the radio waves from a radio station are all part of this spectrum. However, there is an important difference. X-rays are part of the ionizing portion of the electromagnetic spectrum. Ionizing electromagnetic waves carry enough energy per quantum that they have the ability to break bonds between molecules. Fields whose quanta are insufficient to break molecular bonds are called 'non-ionizing radiation' (NIR). Radio waves are a form of NIR. (See further information at G).

**Figure 1.1 Electromagnetic Spectrum**



**Figure 1.2 Mobile Phone Users**



1. The radio frequency sources in India are the transmitting towers such as AM, FM radio towers, TV towers, Cell phone towers, etc. which emit radio frequency/ microwave radiation continuously. The level of EMF from sources has risen exponentially, by soaring popularity of wireless technology such as cell phones, cordless phones, Wi-Fi, WiMAX and other wireless devices. A cell phone that is ‘ON’ but not in use also radiates occasionally to update the network on its location.
2. The most common sources of exposure as shown in table 1.1 below, include the FM/AM radio, TV transmission, Cellular networks using GSM, CDMA, WLAN, Bluetooth, Zigbee[[1]](#footnote-1), WiFi and WiMax technologies, which occupy the VHF, UHF, L, and S band of frequencies. The effects due to FM, AM and TV transmissions are localized to the areas around the location of towers and the Bluetooth, Zigbee applications operate at low power levels. The peak and time average maximum powers for GSM-1800, GSM-900 and CDMA handsets are shown in the table. In operation, mobile phones adjust their output power dependent on the quality of the connection to the network and the data being transmitted. Measurements[[2]](#footnote-2) on real networks in the United States have reported that the median output powers for GSM handsets were 27% and for CDMA handsets were 0.7% of the maximum powers.

**Table 1.1 EMF Sources in India**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S.No.** | **R. F. Source** | **Operating Frequency** | **Transmission**  **Power** | **Numbers** |
| 1 | AM/FM Tower | 540 kHz-108 MHz | 1 kW-300 kW | 380 |
| 2 | TV Tower | 48 MHz-814 MHz | 10–500 kW | 1201 |
| 3 | Wi-Fi | 2.4 – 2.5 GHz | 10-100 mW | -‑ |
| 4 | Cell Towers | 800, 900 ,  1800, 2450MHz | 20 W | 0.91  Million |
| 5 | Mobile Phones | GSM-1800/  GSM-900  CDMA | 1 W (peak, 0.125 W average)  2 W (peak, 0.25 W average)  0.25 W | 1000+  Million |

1. The above RF sources have altered the landscape of human beings in countless beneficial ways, however created the environmental exposures to electromagnetic radiation (EMR) or Electromagnetic fields.
2. **Uses of Electromagnetic field radiation**
3. Apart from the use in telephony, some other important uses of electromagnetic radiation in our day to day life are as follows:

* Conversion of electromagnetic radiation from Sun (solar energy) to chemical energy (food) by plants through the process of photosynthesis.
* X-ray used for bone structure imaging at hospitals.
* X-ray used in Security Scanner at Airports and shopping malls.
* Microwave used in microwave ovens and radars.
* Radio waves used in radio and television broadcasts.
* Visible light used for normal vision.
* Infra-red waves used in night vision goggles and in TV remote controls.

1. **Types of EMF radiation**
2. There are two types of radiation: Non- ionizing radiation and ionizing radiation

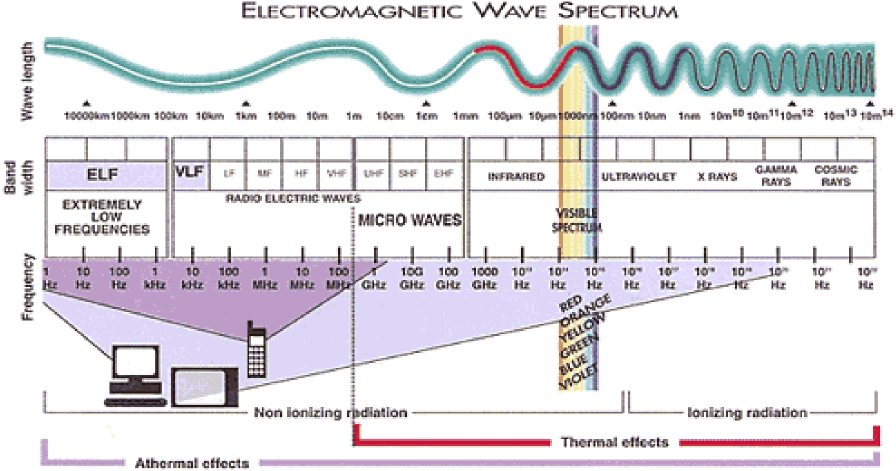
**Non-ionizing radiation**

1. The electromagnetic fields emission from mobile handsets and antenna are at relatively low frequency end of electromagnetic spectrum and the energy carried by them are unable to break chemical bonds in molecules i.e. the energy level associated with Radio Frequency and Microwave radiation are not great enough to cause the ionization of atoms and molecules. The Radio Frequency (RF) energy is, therefore, a non ionizing radiation like radiation from visible light. Cell phone is a very low level of radio frequency energy – too low to cause damage.

**Ionizing radiation**

1. Ionization is a process by which electrons are stripped from atoms and molecules. Those type of electromagnetic radiation with enough energy to ionize biological material include X- ray radiation and gamma ray radiations are examples of ionizing radiation. The ionizing radiation like from a medical X- ray, can present a health risk at certain doses.

**Figure 1.3: Types of EMF Radiations**



1. EM emissions in the frequency range of 1 Hz to about 2,400 THz (2,400,000 GHz) are termed as non-ionizing and do not have enough energy to alter the chemical bonds of the human body. EMF health effects related to the non-ionizing radiation include tissue heating at levels well above limits. EM emissions at frequencies above about 2,400 THz are termed as ionizing and have enough potential to alter the chemical bonds of human tissue and resulting in serious genetic damage on prolonged or acute high-level exposures.
2. **Effect of Ionization**
3. As some of the radiations can ionize atoms/molecules, they do have an adverse effect on the living organisms. They can break chemical bonds and damage vital molecules. If such damage is minor, cells may be able to repair themselves, otherwise cell death may occur. If the damage is at a higher rate, dead cells cannot be replaced quickly enough.
4. In Chapter II we will see the need for having safety standards against mobile radiations. Chapter III covers the practices adopted by various countries. Chapter IV gives the conclusion.

# CHAPTER-II: NEED FOR HAVING SAFETY STANDARDS AGAINST MOBILE RADIATIONS

1. **Radio Waves And Human Body**
2. Studies have shown that human beings are bio electrical systems. The heart and the brain are regulated by internal bioelectrical signals. Tiny electrical currents exist in the human body due to the chemical reactions that occur as part of the normal bodily functions, even in the absence of external electric fields. For example, nerves relay signals by transmitting electric impulses. Most biochemical reactions from digestion to brain activities go along with the rearrangement of charged particles.
3. In a human body due to the proximity of a mobile phone to the head, the head is the main recipient of the electro-magnetic energy. While a variety of modulation-dependent biological effects of RF energy have been reported, few such effects have been independently confirmed[[3]](#footnote-3).
4. A 2015 report for the European Commission[[4]](#footnote-4) concluded:

“Several interaction mechanisms are well established. These enable extrapolation of scientific results to the entire frequency range and wide-band health risk assessment. They have been used to formulate guidelines limiting exposures to EMF in the entire frequency range from static fields to 300GHz. A number of studies proposed other candidate mechanisms. However, none that operates in humans at levels of exposure found in the everyday environment has been firmly identified and experimentally validated nor do they enable concluding on potential health risks at other exposure conditions both with regard to amplitude and/or frequency.”

1. There have been growing public concern in some countries of possible adverse health effects due to EMF Radiation. The two areas of public concern are the radio signals emitted by the fixed infrastructure used in mobile telephony such as base stations and their antennas, which provide the link to and from mobile phones. This is because, in contrast to mobile handsets, it is emitted continuously. The field intensities drop rapidly with distance away from the base of the antenna because of the attenuation of power with the square of distance. There is also public concern about the use of mobile phones because even though they operate at much lower powers than the infrastructure, they are used much closer to the body.
2. The effects of EMF radiation can be described in two ways i.e. bio effects and health effects:
3. Bio effects are measureable responses to a stimulus or to a change in the atmosphere and are not necessarily harmful to our health. Biological effects can be of two types i.e. Thermal and Non-Thermal effects.

**Thermal Effects:**

* Refers to the heat generated due to absorption of EMF radiation.
* While using a cell phone, most of the heating effect occurs at the surface of the head, causing its temperature to increase by a fraction of a degree.
* Prolonged high levels of RF exposure may cause a thermal effect that may lead to increase in body temperature.

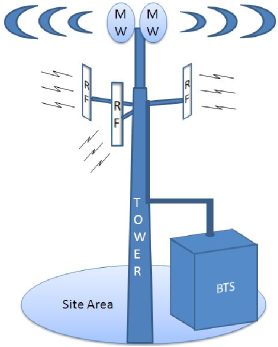
**Non-Thermal Effects:**

* Non-thermal effects describes effects that are reported to occur through mechanisms other than heating, which some reports suggest are possibly more harmful[[5]](#footnote-5). In a 2009 review of potential non-thermal interaction mechanisms the ICNIRP[[6]](#footnote-6) concluded:

“In conclusion, whilst it is in principle impossible to disprove the possible existence of nonthermal interaction, the plausibility of the nonthermal mechanisms discussed above is very low.”

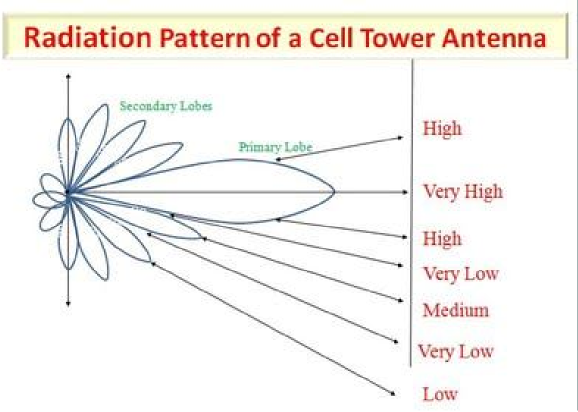
1. Health effects are the changes which may be short term or long term. The WHO[[7]](#footnote-7) explains that an adverse health effect causes detectable impairment of the health of the exposed individual or of his or her offspring; a biological effect, on the other hand, may or may not result in an adverse health effect.
2. **Mobile Service and EMF Radiation**
3. The RF signals in mobile services are primarily from two sources: - transmissions from BTS and transmissions from mobile handsets – both of which are at the relatively low frequency end of electromagnetic spectrum. The energy carried by them is unable to break chemical bonds in molecules. Thus, they fall under the non-ionizing radiation category.
4. **Radiation from Mobile BTS**
5. For providing mobile services, telecom service providers establish base transceiver stations (BTSs), at suitable locations, as per their Radio Frequency (RF) Network Planning for proper coverage of the area and for meeting capacity requirements. The number of BTS is influenced by many factors including the surrounding environment, the operating frequency, the allowable output power and the total spectrum available to an operator. Every antenna on a cell phone tower radiates electro-magnetic power. A typical BTS[[8]](#footnote-8) site diagram is shown below in figure 2.1.

**Figure 2.1: Typical BTS Site**

****

1. BTS also contain a number of radio transmitters and each of these typically has the same maximum output power. The outputs from the individual transmitters are then combined and fed via cables to the base station antenna, which is mounted at the top of a mast (or other suitable structure). Thus the radiated power would ideally be equal to the sum of the output power from the transmitters except for a small loss that occurs in the combiner and connecting cables. It should be noted that all the transmitters are not operational continuously; this depends on the call traffic in each of the sectors. However the level of exposure is maximum at the time of peak traffic when all the channels are utilized and hence sectors with higher call traffic carry the potential of having the highest levels of EM exposure. It was recently reported that measurements in India had found that the mean, the median, and the 95th percentile BTS output power values for 3G sites were found to be 24%, 21%, and 53%, respectively, of the maximum available power[[9]](#footnote-9).
2. The transmission power levels and the gain[[10]](#footnote-10) of the antennas used for transmission are other major factors to be considered when dealing with exposure levels. Typical gains for the sector antennas used with macro-cellular base stations in India are in the range 15–17 dBi for GSM900 systems and 16–18 dBi for GSM1800 systems. Omni directional antennas for macrocellular base stations are much less common than sector antennas, but generally have gains in the range 8–10 dB. However there are antennas with higher gain levels of 21 dB available recently in the market. Although the high gain antennas increase the efficiency and coverage, the exposure for buildings in the close proximity of line of sight of the main beam of the antennas could increase if the transmitter power is unchanged.

**Figure 2.2: Radiation from Mobile BTS**



1. The real source of EM radiation is the transmitting antenna – not the transmitter itself, because the transmitting antenna is the main source that determines electromagnetic field distribution in the vicinity of a transmitting station. Radiation will be highest from the primary lobes in the horizontal direction. There is also radiation from secondary lobes which ranges from medium to very low when transmitting horizontally as seen in the figure 2.2 above. Hence, the direct exposure to the primary lobes along the line of antenna is the most severe of the exposed radiation. The radiation levels relatively taper as one moves away from the line of the antenna to its side lobes.
2. In addition, the EMF exposure level also depend on the following:

* Frequency / wavelength of RF signal being transmitted;
* Radio Frequency Power radiated from the antenna;
* Exposure from other antennas located in the area;
* Variation in the power output of the source RF transmitter;

Areas very close to BTS antenna may exceed the recommended RF exposure levels for workers or the public and access to such areas should be restricted. However, the RF signal levels in areas that are typically accessible to the public are generally only a small fraction of the exposure limits. In 2012 a study[[11]](#footnote-11) analysed more than 170,000 measurements conducted since the year 2000 and reported from 23 countries, concluding that the global average across all the measurements was more than 7,000 times below the most restrictive international limit for the public. They also found little difference in the RF exposures from different mobile technologies and that levels had not changed much over time.

1. **Radiation from Mobile Handsets**
2. Exposure to low-frequency electromagnetic fields normally results in negligible energy absorption and no measurable temperature rise in the body. However, exposure to high-levels of electromagnetic fields at frequencies above 100 kHz can lead to absorption of energy and increase in body temperature. At frequencies between 100 kHz and 20 MHz, significant absorption may occur in the neck and legs; at frequencies in the range of 20 MHz to 300 MHz, relatively high absorption can occur in the whole body; when frequencies are in the range of around 300 MHz to several GHz, significant local, non-uniform absorption occurs; and in frequencies above 10 GHz, energy absorption occurs primarily at the body surface.
3. **Specific Absorption Rate (SAR)**
4. SAR (Specific Absorption Rate) is the rate at which Radio Frequency energy is absorbed in the human body over a given time and expressed as the power absorbed per unit mass. SAR values are expressed in the units of watts per kilo gram (W/kg) of tissue. This measurement is used to determine whether a mobile phone complies with safety norms/guidelines. Every model of mobile handset has specific SAR value determined at maximum output power under laboratory conditions.
5. SAR value is an important tool in judging the maximum possible exposure to RF energy from a particular model of cell phone. The SAR rating of mobile handset is a specified value which indicates that the device will never exceed the maximum level of consumer radio frequency exposure permitted but it does not indicate the amount of RF exposure the consumers experience during the normal use of the device. The actual SAR level of an operating device can be below the maximum value depending on number of factors such as how close the cell phones to a network base station i.e. distance from a transmission mast, phone is used indoor or outdoor, signal strength, how close the phone is held to the ear and other operating factors. Cell phone handsets constantly vary their power to operate at a minimum power necessary to communicate. A Cell phone which operates at lower power is considered more efficient. A recent study[[12]](#footnote-12) of 3G handsets operating in Indian reported that the mean output power for voice services was about 1% of the maximum possible available output power.
6. Different mobile handsets create varying electromagnetic fields owing to differences in their design and construction, as well as their electronics and antenna. Therefore, even though SAR values are an important indicator to compare the maximum possible EMF exposure, a single SAR value does not provide sufficient information about the amount of EMF exposure under practical usage conditions to reliably compare individual cell phone models.
7. **ICNIRP Guidelines for EMF Radiation**
8. International Commission on Non-Ionizing Radiation Protection (ICNIRP) is a body of independent scientific experts covering areas of Epidemiology, Biology, Dosimetry and Optical Radiation and a number of consulting experts. This body studies possible adverse effects on human health from exposure to non-ionising radiation. ICNIRP's principal aim is to disseminate information and advice on the potential health hazards of exposure to non-ionizing radiation. It is formally recognized as an official collaborating non-governmental organization (NGO) by the World Health Organization (WHO) and the International Labour Organization (ILO). ICNIRP[[13]](#footnote-13) is consulted by the European Commission. The WHO[[14]](#footnote-14) and the International Telecommunications Union (ITU)[[15]](#footnote-15) recommend that countries adopt the ICNIRP guidelines where no national limits exist. As per the ICNIRP Guidelines (1998), the levels of safety for the public are:

|  |  |
| --- | --- |
| **Frequency Range** | **Power Density**  **(Watt/Sq. Meter)** |
| **400 MHz to 2000 MHz (2 GHz)**  **2 GHz to 300 GHz** | **f/200**  **10** |

(f is the frequency of operation in MHz)

1. **EMF Radiation Norms in India for Mobile Towers (BTS)**
2. In India, monitoring of the radiation emanating from the BTS is carried out by the Department of Telecommunications (DoT). The DoT has issued instructions regarding setting up of acceptable EMF radiation limits and the testing procedure to be followed. The Telecom Enforcement Resource & Monitoring (TERM) Cells, a unit of DOT, tests up to 10% of BTS sites selected randomly by them. Additionally, BTS sites, against which there are public complaints, are also tested by TERM Cells. In 2008, DoT has adopted the ICNIRP Guidelines and prescribed limits/levels for antennas (Base Station Emissions) for general public exposure. Accordingly, the License conditions of telecom service providers were also amended by DoT in November 2008 by inserting a clause 43.6A in the Unified Access Services (UAS) license agreement. Clause 43.6A reads as under:

*“43.6 A. Licensee shall conduct audit and provide self-certificates annually as per procedure prescribed by Telecommunication Engineering Centre (TEC)/or any other agency authorized by licensor from time to time conforming to limits/levels for antennae (Base station Emissions) for general public exposure as prescribed by International Commission on Non-Ionizing Radiation Protection (ICNIRP) from time to time. The present limits/levels are reproduced as detailed below:*

|  |  |  |  |
| --- | --- | --- | --- |
| Frequency Range | E-Field Strength (Volt/Meter (V/m)) | H-Field Strength (Amp/Meter (A/m)) | Power Density (Watt/Sq. Meter (W/Sq. m)) |
| 400 MHz to 2000 MHz | 1.375 f1/2 | 0.0037f1/2 | f/200 |
| 2 GHz to  300 GHz | 61 | 0.15 | 100 |

*Note: The compliance in the form of Self Certificate shall commence six months after the date of issue of prescribed test procedure by TEC or any other agency authorized by licensor.”*

1. As per instructions issued by DoT, vide their letter No. 800-15/2010-VAS dated 08.04.2010 implementation of radiation within norms of EMF exposure of BTS is entrusted to TERM Cell of DoT. All the telecom service providers were also directed to submit to the respective TERM Cells self-certificates to the effect that they had met the radiation norms.
2. On 24.08.2010, the DoT set up an Inter-ministerial Committee (IMC) consisting of officers from DoT, Indian Council of Medical Research (Ministry of Health), Department of Biotechnology and Ministry of Environment and Forest to examine the effects of Electro Magnetic Field radiation from base stations and mobile phones.
3. The IMC has given its recommendations on various issues related to EMF radiation by mobile tower and handsets. The report states that:

*“Member Scientist, ICMR has indicated that the hot tropical climate of the country, low body mass index (BMI), low fat content of an average Indian as compared to European countries and high environmental concentration of radio frequency radiation may place Indians under risk of radio frequency radiation adverse effect.”*

1. So there is a need to explore the possibility of impact of geographical location on adverse health effect from EMF radiation from mobile towers. It should be noted that ICNIRP[[16]](#footnote-16) stated that the limits recommended in the 1998 guidelines did consider the effects of exposure under severe environmental conditions and potentially higher thermal sensitivity in certain population groups as well as differences in absorption of electromagnetic energy by individuals of different sizes.
2. The report also specifies monitoring of the EMF radiation. It also proposed that the provision of EMF radiation monitoring network may be considered similar to that of the national ambient air monitoring network or ambient noise monitoring network or weather monitoring stations. It also recommended provision of online monitoring of radiation levels through establishment of static testing and measuring centres at major cities. The collected data could then be sent to central servers for further processing. This is similar to the measurement of pollution levels (noise and air quality) by the Central Pollution Control Board, under the Ministry of Environment and Forests.
3. The report also recommends that the SAR value information is to be embossed and displayed on the handset. The SAR value information of different mobile handsets should be made available on the Government’s website and to the concerned regulatory agency. The report also recommends long-term scientific research related to health aspects of EMF radiation exposure and associated technologies.
4. The IMC has examined 90 international and national studies/reference papers related to EMF radiation before finalizing the report. In its report, IMC has indicated that most laboratory studies were unable to find a direct link between exposure to radio frequency radiation and health; and the scientific studies as yet have not been able to confirm a cause and effect relationship between radio frequency radiation and health. The effect of emission from cell phone towers is not known yet with certainty. Nevertheless, the IMC recommended lowering the mobile towers’ EMF exposure limits to 1/10th of the existing prescribed limit as a matter of abundant precaution. Subsequently, the Department of Telecommunications has accepted the recommendations of the IMC and amended the Clause 43.6 A of Unified Access Services License on 10.01.2013, to include the revised limits/levels:

*“43.6 A. …….. The present limits/levels are reproduced as detailed below:*

|  |  |  |  |
| --- | --- | --- | --- |
| Frequency  Range | E-Field Strength  (Volt/Meter (V/m)) | H-Field Strength  (Amp/Meter (A/m)) | Power Density (W/Sq. m) |
| 400 MHz to 2000 MHz | 0.434f1/2 | 0.0011f1/2 | f/2000 |
| 2 GHz to  300 GHz | 19.29 | 0.05 | 1 |

(f=frequency in MHz)”

1. Consequent to this revision by DoT, Indian standards are now 10 times more stringent than many countries (like USA, Canada, Japan and Australia) in the world which follow limits similar to the ICNIRP guidelines.A number of countries have specified their own radiation levels keeping in view the environmental and physiological factors. In India the prescribed reference level at 1800 MHz is 0.92 Watt/ m2 and at 900 MHz is 0.45 Watt/m2 as shown in Table below.

**Revised EMF radiation norms for mobile towers (BTS) in India**

|  |  |  |
| --- | --- | --- |
| **Frequency** | **ICNIRP Radiation**  **Norms** | **Revised DoT Norms effective from**  **01.09.2012** |
| **900 MHz** | 4.5 Watt/ sq.m | 0.45 Watt/sq.m |
| **1800 MHz** | 9 Watt/ sq.m | 0.9 Watt/sq.m |
| **2100 MHz** | 10.5 Watt/ sq.m | 1.05 Watt/sq.m   1. **EMF Radiation Norms in India for Mobile Towers(BTS)** |

1. **EMF Radiation Norms in Bangladesh for Mobile Towers (BTS)**
2. Bangladesh Telecommunication Regulatory Commission usually follows the radiation level safety limits issued by World Health Organization (WHO).
3. **EMF Radiation Norms in Bhutan for Mobile Towers (BTS)**
4. While Bhutan does not have specified radiation standards for BTS, they normally allow the exposure limit for the BTS antennas to be less than 0.1W/m2. In regard to the radiating power of the base station antenna, they do not allow it to be more than 50 Watts.
5. **EMF Radiation Norms in Maldives for Mobile Towers (BTS)**
6. As of now Maldives doesn’t have a standard of their own but they do follow International standards.
7. **EMF Radiation Norms in Nepal for Mobile Towers (BTS)**
8. The ICNIRP Standard. It is noted that the Draft Working Procedure with detail radiation standards of the BTS is being developed.
9. **EMF Radiation Norms in Pakistan for Mobile Towers (BTS)**
10. ICNIRP Guidelines of 1998 for public and professional exposure to radiation has been adopted as a national standard for Pakistan.
11. **EMF Radiation Norms in Sri Lanka for Mobile Towers(BTS)**
12. Sri Lanka is following ICNIRP guidelines for radiation standard for BTS.
13. **EMF Radiation limit for Mobile Towers (BTS) in other SATRC countries**
14. In addition to the SATRC countries that responded to the survey the GSMA[[17]](#footnote-17) reports that the limit applicable to BTS is ICNIRP in Afghanistan and Iran.
15. **EMF Radiation limit in India for Mobile Handsets**
16. With effect from 1st Sept. 2012, the SAR values for mobile phones in India have been revised to 1.6 W/kg averaged over 1 gram of human tissue.

**Revised EMF radiation norms for mobile handset**

|  |  |  |
| --- | --- | --- |
| **Frequency**  **(10 MHz to 10 GHz)** | **ICNIRP SAR Limit** | **Revised SAR Limit**  **effective from 01.09.2012** |
| General Public  Exposure | 2 Watt/Kg (averaged  over 10gm tissue) | 1.6 Watt/Kg (averaged  over 1 gm tissue) |

India has adopted the most stringent SAR values for mobile handsets when compared to other countries (at par with USA and Canada).

1. From 1st Sept. 2013, only mobile handsets with the revised SAR limit of 1.6 W/kg are permitted to be manufactured or imported into India.It is mandatory for manufacturers to display the SAR level on each mobile handset. Other guidelines in this regard are:

* SAR value information of the mobile handsets shall be available on the manufacturers’ website[[18]](#footnote-18) and the handset’s manual. The information on the SAR value shall be made available to the consumer at the point of sale.
* Mobile handsets manufactured and sold in India or imported from other countries shall be checked for compliance of SAR limit.
* The manufacturers in India shall provide self declaration of SAR value of the handset. In respect of imported handset, manufacturers apart from self declaration of SAR shall specify the SAR information in user documents for verification by the appropriate authority.
* Manufacturer’s mobile handset booklet shall contain the safety precautions.
* List of SAR values of different handsets shall be uploaded on DoT/TEC website.

1. **EMF Radiation limit in Bangladesh for Mobile Handsets**
2. At present Bangladesh follows the ICNIRP guidelines for radiation standard. In Section 6 of National Frequency Allocation Plan of Bangladesh reference levels for general public exposure to time-varying electric and magnetic fields by ICNIRP have been mentioned. These values are followed where appropriate. The Bangladesh Telecommunication Regulation Commission in association with other concerned organization of the country is working on this issue. The Standard Absorption Rate (SAR) value which is generally maintained in the country is 2 W/kg.
3. **EMF Radiation limit in Bhutan for Mobile Handsets**
4. At the moment, Bhutan does not have specified our own radiation standards in their country. However, they follow the international standards specified by the ICNIRP. The Bhutan InfoComm and Media Authority (BICMA) is doing a study in order to develop and specify own permissible radiation standards in alignment with the regional and international standards.
5. **EMF Radiation limit in Maldives for Mobile Handsets**
6. As of now Maldives doesn’t have a standard of their own but they do follow International standards.
7. **EMF Radiation limit in Nepal for Mobile Handsets**
8. The handset shall have the SAR standard of maximum 2 W/Kg, averaged over 10 gm of tissue.
9. **EMF Radiation Norms in Pakistan for Mobile Handsets**
10. Mobile handsets in Pakistan are required to comply with Specific Absorption Rate (SAR) limit of 2 W/Kg averaged over 10 gm of tissue.
11. **EMF Radiation limit in Sri Lanka for Mobile Handsets**
12. Sri Lanka is following ICNIRP guidelines for radiation standard.
13. **EMF Radiation limit for Mobile Handsets in other SATRC countries**
14. In addition to the SATRC countries that responded to the survey the GSMA[[19]](#footnote-19) reports that the limit applicable to handsets is ICNIRP in Afghanistan and that Iran applies the same limit as India.
15. **Theoretical and Measured Radiated Power**
16. To measure the power at a distance an antenna is used to receive the power and a spectrum analyzer or power meter is used to measure received power. The various ITU-T[[20]](#footnote-20) recommendations on EMF assessment and their highlights are explained below.
17. **ITU-T K.52** Guidance on complying with limits for human exposure to electromagnetic fields

* ITU-T K. 52aims to help with compliance with safety limits for human exposure to EMFs;
* Provides guidance on calculation method, and installation assessment procedure;
* Is based on safety limits provided by ICNIRP;
* Determines the likelihood of installation compliance based on accessibility criteria, antenna properties and emitter power.

1. **ITU-T K.61** Guidance on measurement and numerical prediction of electromagnetic fields for compliance with human exposure limits for telecommunication installations

* ITU-T K.61 helps telecommunication operators to verify compliance with exposure standards promulgated by local or national authorities;
* Provides guidance on measurement methods that can be used to achieve a compliance assessment;
* Provides guidance on the selection of numerical methods suitable for exposure prediction in various situations.

1. **ITU-T K.70** Mitigation techniques to limit human exposure to EMFs in the vicinity of radio communication stations – includes EMF Estimator software

* ITU-T K.70 defines techniques which may be used by telecommunication operators to evaluate the cumulative (total) exposure ratio in the vicinity of transmitting antennas and to identify the main source of radiation;
* Provides guidance on mitigation methods which allow reduction of radiation level;
* Provides guidance on procedures necessary in the environment (on site) in which, in most cases, there is a simultaneous exposure to multiple frequencies from many different sources.

1. **ITU-T K.83** *Monitoring of electromagnetic field levels*

* ITU-T K.83 provides guidance on how to make long-term measurements and monitoring of EMF in the selected areas that are under public concern, in order to show that EMFs are under control and under the limits.

1. **ITU-TK.91**Guidance for assessment, evaluation and monitoring of human exposure to radio frequency electromagnetic fields

* ITU-T K.91 provides guidance on how to assess and monitor human exposure to radio frequency (RF) electromagnetic fields (EMF) in areas with surrounding radio communication installations based on existing exposure and compliance standards, based on existing exposure and compliance standards in the frequency range of 9 kHz to 300 GHz.
* Answers to typical questions asked by the public on EMF, and to address typical misunderstandings on EMF matters in the society
* Provides education and information: promoting EMF information and education resources suitable for all communities, stakeholders and governments.

1. **ITU-T K.100** Measurement of radio frequency electromagnetic fields to determine compliance with human exposure limits when a base station is put into service

* ITU-T K.100provides guidance on how to measure radio frequency electromagnetic fields in order to determine compliance with human exposure limits when a base station is put into service

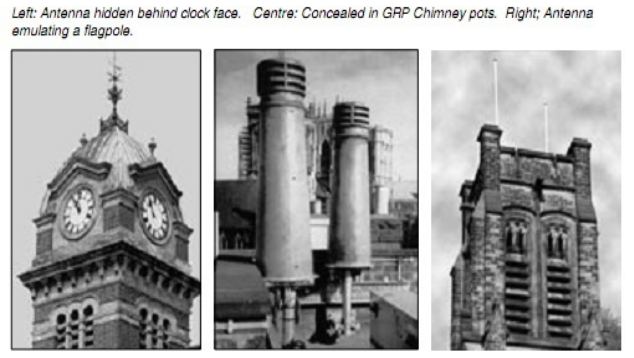
1. **Necessary policies and regulations for decreasing the public complains and worry**
2. **Adopt national EMF Exposure Standards:** Adoption of national limits provides consistent health protection and is the basis of uniform requirements for compliance monitoring. The WHO recommends that countries adopt ICNIRP based limits. However, there are no mandatory international RF exposure limits and some countries have chosen to adopt alternative limit values or other restrictions. The WHO notes that large disparities between national limits and international guidelines can foster confusion for regulators and policy makers and increase public anxiety. In response to requests from countries, the WHO[[21]](#footnote-21) has developed a Model Legislation that provides the legal framework for implementing protection programmes against non-ionizing radiation.
3. **Adopt national EMF Compliance Framework:** The compliance of mobile devices and BTS should be based on the international technical standards developed by the International Electrotechnical Commission (IEC)[[22]](#footnote-22) and the ITU. For mobile devices compliance information can be collected through manufacturer declarations as part of the normal type approval process for other technical requirements. SAR information can be made available to consumers via manufacturer websites[[23]](#footnote-23) or e-labels[[24]](#footnote-24). For mobile network BTS the operators should be responsible for self-declarations of compliance and conduct site assessments using standardised procedures. For many sites these assessments can be done using simplified criteria of power and antenna height or calculations. In more complex situations measurements may be needed to confirm compliance, however, there should be no general requirement to measure all sites. ITU-T K.100 provides specific guidance for BTS.
4. **Improve Public Confidence in BTS Compliance:** Adoption of national EMF standards is the first step in responding to concerns. As people cannot feel radio waves they may be concerned about the safety of antennas installed near to their homes or work places. Providing information on regulator websites confirming that operators must undertake compliance assessments will be assuring for many people. While some countries have implemented continuous RF monitoring systems their effectiveness in reducing public concern has not been well documented. A system operating in Portugal reported[[25]](#footnote-25) more than 6 million measurements and found no values that exceeded the limit values. In addition, where public concern remains high measurements of a random sample of BTS and reporting those results in a way that is understandable to the public will provide further reassurance.
5. **Develop a National Policy for Antenna Siting:** A consistent national policy for antenna siting benefits the public, municipalities and the mobile network operator. In addition to EMF compliance requirements such a policy should specify the information needed; a mandatory period for decisions on site applications and simplified procedures for small cell deployments and modifications to existing sites that are not substantial. It is recognised that mobile network antennas may need more careful visual design in areas of historical or environmental significance when compared to industrial areas. Mandatory design rules are not likely to provide sufficient flexibility for antenna deployments but simplified procedures for low-mounted antennas on rooftops or the side of buildings can encourage location of BTS antennas in such positions. The policy should also provide for site sharing where technically and commercially feasible. Governments at all levels are significant landowners and providing access to government buildings and land can enable to faster deployment of mobile broadband services.
6. **Provide Information to the Public:** It is important that regulatory authorities provide clear information to the public to address their concerns. Regulatory authorities need to take a lead on this as the mobile industry may not be trusted. The information should be based on the scientific conclusions of the WHO. For mobile devices[[26]](#footnote-26) this might include information on the current research consensus, how mobile phones operate and how people that are concerned can reduce their exposure (for example, using a hands-free kit or sending text messages). Such information should avoid repeating misinformation, for example, there is no scientific basis to define ‘sensitive’ groups as these possibilities were already considered in the development of the WHO recommended limits. For mobile network[[27]](#footnote-27) BTS, information on how compliance is monitored, typical exposure levels and that levels are similar to long existing broadcast TV and radio is important. There are particular approaches to risk communication that have been shown to be effective and the WHO[[28]](#footnote-28) has produced a handbook on *Establishing a Dialogue on Risks from Electromagnetic Fields* that provides guidance.
7. **Establishing non-ionizing radiation protection centre in SATRC**
8. The issue was discussed in the working group meeting and it was concluded that at this point of time the need for having a non-ionizing radiation protection centre in SATRC did not exist.
9. **Necessary policies in environment compatibility**
10. Concerns have been raised regarding deterioration of skyline in metro and major districts due to erection of large number of telecom towers. Most current towers in India are lattice type and aesthetically unattractive. Alternative tower designs like monopole towers are available which are arguably more attractive. In some countries, innovative methods like camouflaging, landscaping and stealth structures are used to minimise the adverse visual impacts of some telecom towers as depicted in figures 2.3 and 2.4. Such techniques are rarely being used in India and other SATRC countries.

**Figure 2.3: Camouflaging of towers with structures**

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**Figure 2.4: Towers Integrated with surrounding Structure**



1. TRAI vide its recommendations on Telecommunications Infrastructure Policy dated 12.04.2011 had recommended to the DoT that camouflaging should be made mandatory in areas of heritage, environmental or architectural importance.
2. **Developing application for mobile phones through which people can check the status of RF map of capital cities in SATRC countries**
3. In India work has commenced on Tarang Sanchar portal which is a set of web services for all stakeholders-DoT/TEC, TERM Cells, General Public and Telecom Service Providers for EMF compliance of telecom towers. The TSPs were facing problem in sharing all the dataamongst them due to the size and scale of this procedural issue of sharing data on shared sites, which included over 1,100,000 BTSs of all the TSPs spread over the country. Thus, a need was felt to have an exhaustive and comprehensive database of all the EMF emitting sources being used in Mobile Communicationin order to have better accuracy, timely sharing of change information amongst operators and eliminating other in‐efficiency of self certificate submission. The portal is presently under testing and will have the following highlights
   * A common database will hold pan‐India site portfolio based on data provided by the Operators.
   * Each operator will have exclusive control on site tenancies and RF technical parameters.
   * There would be workflows for ensuring site EMF compliance through site surveys, Broadband / Selective Frequency Tests.
   * New sites and site upgrades will be streamlined by the portal to achieve higher efficiencies and exploit synergies of a common database.
   * Significant reduction in the efforts and costs spent on compliance individually by each operator.
4. General public will have access to articles related to EMF awareness and a GIS database of telecom towers in their locality with EMF compliance status.
5. The ITU launched the EMF-Guide and mobile app in India in December 2014 and additional UN language support in 2015. It is now available in 6 languages provides information and education resources on Electromagnetic Fields suitable for all communities, stakeholders and governments and is available online at http://emfguide.itu.int/ or via de iOS, Blackberry World and Google Play app stores. The Mobile app is designed for smart phones, tablets or desktops.

# CHAPTER-III: INTERNATIONAL PRACTICES

1. The biological effects of radio waves are being explored. Various studies have been conducted in different countries; however, there is no conclusive evidence of adverse effect of low-level EMF radiation on human health. In order to assess the scientific evidence of possible health effects of EMR in the frequency range from 0 to 300 GHz, the World Health Organization (WHO) established the International EMF Project in 1996. WHO released a fact sheet on “Electromagnetic fields radiation and public health: Base stations and wireless technologies” in May 2006 wherein it has held that:

*“Considering the very low exposure levels and research results collected, there is no convincing scientific evidence that the weak RF signals from cell phone towers and wireless networks cause adverse health effects”* and in its fact sheet on “Electromagnetic fields radiation and public health: mobile phones” in June 2011 held that

*“...to date, no adverse health effects have been established as being caused by mobile phone use”.*

1. In its latest update in September 2013, WHO had stated that:

*“While an increased risk of brain tumors from the use of mobile phones is not established, the increasing use of mobile phones and the lack of data for mobile phone use over time periods longer than 15 years warrant further research of mobile phone use and brain cancer risk. In particular, with the recent popularity of mobile phone use among younger people, and therefore a potentially longer lifetime of exposure, WHO has promoted further research on this group and is currently assessing the health impact of RF fields on all studied endpoints.”*

1. **United States of America**
2. The Federal Communications Commission (FCC) is required by the National Environmental Policy Act of 1969, among other things, to evaluate the effect of emissions from FCC-regulated transmitters on the quality of the human environment. Several organizations, such as the American National Standards Institute ([ANSI](http://www.ansi.org/)), the Institute of Electrical and Electronics Engineers, Inc. ([IEEE](http://www.ieee.org/)), and the National Council on Radiation Protection and Measurements ([NCRP](http://www.ncrponline.org)) have issued recommendations for human exposure to RF electromagnetic fields.
3. On August 1, 1996, the Commission adopted the NCRP's recommended Maximum Permissible Exposure limits for field strength and power density for the transmitters operating at frequencies of 300 kHz to 100 GHz.  In addition, the Commission adopted the specific absorption rate (SAR) limits for devices operating within close proximity to the body as specified within the ANSI/IEEE C95.1-1992 guidelines.
4. The potential hazards associated with RF electromagnetic fields are discussed in OET Bulletin No. 56, *"Questions and Answers About the Biological Effects and Potential Hazards of Radio frequency Electromagnetic Fields."* This is an informative bulletin written as a result of increasing interest and concern of the public with respect to this issue. The expanding use of radio frequency technology has resulted in speculation concerning the alleged "electromagnetic pollution" of the environment and the potential dangers of exposure to non-ionizing radiation. This publication is designed to provide factual information to the public by answering some of the most commonly asked questions.
5. The OET Bulletin No. 65, *“Evaluating Compliance With FCC Guidelines for Human Exposure to Radio frequency Electromagnetic Fields”* was issued to provide guidance in the implementation of the Commission's new exposure limits and policies. The bulletin provides acceptable methods of determining compliance to Commission limits through the use of mathematical and empirical models.
6. The Local and State Government Advisory Committee and the FCC have developed a guide, *“A Local Government Official's Guide to Transmitting Antenna RF Emission Safety: Rules, Procedures, and Practical Guidance”* to aid local governmental officials and citizens in understanding safety issues related to radio frequency emissions from telecommunications towers.
7. On March 27, 2013, the FCC voted to advance its review of its various rules pertaining to the implementation of the National Environmental Policy Act (NEPA) requirements related to radiofrequency (RF) emissions from radio transmitters. The FCC has divided this process into three parts: a *Report and Order* (*Order*) and a *Further Notice of Proposed Rulemaking* (*Further Notice*) in ET Docket No. 03-137, and a *Notice of Inquiry* (*Inquiry*) in a new docket, ET Docket No. 13-84.  In the *Order* the FCC concludes several technical and semantic issues initiated in 2003 that revise and update its regulations implementing NEPA. In the *Further Notice* the FCC proposes to further update and revise its procedures beyond its 2003 proposals.  In the *Inquiry* the FCC requests comment to determine whether its RF exposure limits and policies need to be reassessed. Since consideration of the limits themselves is explicitly outside of the scope of ET Docket No. 03-137, the FCC opens a new docket, ET Docket No. 13-84, with the *Inquiry* to consider these limits in light of more recent developments.  The *Inquiry* is intended to open discussion on both the currency of our RF exposure limits and possible policy approaches regarding RF exposure.
8. **Australia**
9. The [Australian Radiation Protection and Nuclear Safety Agency](http://www.arpansa.gov.au/) (ARPANSA) is the Australian Government's primary authority on radiation protection and nuclear safety. It is the role of ARPANSA to assess the relevant scientific research and provide expert advice. This forms the basis for the protection of the Australian public from the harmful effects of radiation, including radiofrequency (RF) electromagnetic energy (EME) emitted by radio communications sources. ARPANSA sets the RF EME human exposure limits within Australia. The exposure limits are contained in the Radiation Protection Standard for Maximum Exposure Levels to Radiofrequency Fields – 3 kHz to 300 GHz (2002) (the ARPANSA Standard). The ARPANSA Standard also includes requirements for protection of the general public and the management of risk in occupational exposure, together with additional information on measurement and assessment of compliance.
10. The Australian Communications and Media Authority’s (ACMA) EME regulatory instruments reference the ARPANSA exposure limits for fixed installations and end-user devices. The exposure limits contained in the ARPANSA Standard are only enforceable if they are referenced in other regulatory arrangements (including ACMA regulatory arrangements and under occupational health and safety requirements).
11. The limits in the ARPANSA Standard are closely aligned with the 1998 guidelines of the International Commission on Non-Ionizing Radiation Protection (ICNIRP) for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz), which are endorsed by the World Health Organization. In 2009, ICNIRP issued a statement confirming the validity of their guidelines, taking into account scientific advances in the 10 years since they were published. In 2014, ARPANSA published the *Report by the ARPANSA Radiofrequency Expert Panel on Review of Radiofrequency Health Effects Research – Scientific Literature 2000–2012*. The report found that the exposure limits in the ARPANSA Standard continue to provide a high degree of protection against the known health effects of EME exposure. It should be noted that the ARPANSA standard replaced an older Australian standard that was more restrictive. So for example, the old standard specified a SAR limit of 1.6 W/kg in 1 g whereas the new standard adopts the ICNIRP limit of 2 W/kg in 10 g. A similar change was made to the limits applying to base stations.
12. ARPANSA provides on its website background [information on EME](http://www.arpansa.gov.au/RadiationProtection/basics/rf.cfm) and a series of [fact sheets](http://www.arpansa.gov.au/RadiationProtection/Factsheets/index.cfm#rf) to help explain the current thinking on communications equipment (including mobile phones) and health, based on substantiated scientific research. Other useful information includes a [base station survey report](http://www.arpansa.gov.au/radiationprotection/basestationsurvey/index.cfm) and [environmental EME reports](http://www.arpansa.gov.au/emereports/index.cfm).
13. **Singapore**
14. The Info-communications Development Authority of Singapore (IDA), as the telecommunications regulatory authority, regulates the use of radiofrequency (RF) spectrum in Singapore. In particular, IDA requires its licensees to comply with prescribed technical specifications, such as the emission power of mobile phone base stations, so that base stations operate within the standards developed by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). These ICNIRP guidelines are adopted by the World Health Organization (WHO). IDA works closely with the National Environment Agency (NEA), the national authority for radiation protection, to ensure that RF radiation safety requirements from mobile phone base stations are met.
15. IDA prescribes conformity with the following European recommendations for assessing compliance of mobile devices with the ICNIRP limits:

|  |  |
| --- | --- |
| **EN 50360:2001** | Product standard to demonstrate the compliance of mobile phones with the basic restrictions related to human exposure to electromagnetic fields (300 MHz – 3 GHz) |
| **EN 50361:2001** | Basic standard for the measurement of Specific Absorption Rate related to human exposure to electromagnetic fields from mobile phones (300 MHz – 3 GHz) |

1. Compliance with the radiation safety standards specified above does not by itself confer immunity from legal obligations and requirements imposed by national health or safety authorities. IDA may invalidate the equipment registration if so requested by the relevant authority for reasons of safety or hazards that would likely be caused to users.
2. Further, the equipment supplier shall provide the SAR information in printed form or in other appropriate form such as in the user guide or as a leaflet or brochure in the equipment package. Furthermore, the supplier shall provide each unit of approved Mobile Terminal with advisory information pertaining to electrical safety and non-ionising radiation hazards and on the safe operation of the Mobile Terminal at potentially hazardous areas such as in moving vehicles, in aircrafts and at fuel depots, chemical plants and blasting sites.
3. **United Kingdom**
4. The Office of Communications (Ofcom) regulates the operation of mobile networks in relation to their use of radio frequencies but does not have any duties related to the recommendations for exposure to EMF emissions. We do not set emission safety levels and we have neither the expertise nor the remit to participate in matters concerning biological or health research. However, the following general advice provides background information and indicates where further information may be found.
5. The Department for Communities and Local Government (DCLG) *Code of best practice on mobile phone network development* was updated in 2013.  This sets out the need for certificates of ICNIRP compliance to be provided with planning applications and for operators to continue to ensure all sites remain compliant.
6. The UK Health and Safety Executive (HSE) is one of a number of public bodies which regulate work that causes or could cause EMF exposure of workers or the public and has published information which covers matters relating to mobile telephony. Public Health England has also published advice on *Mobile phone base stations: radio waves and health*.
7. Ofcom has carried out measurements of representative samples of cellular base stations in publicly accessible areas which indicate that, even in the vicinity of cellular masts, measurements are consistently found to be very significantly below these levels.  Ofcom’s remit is restricted to carrying out sample measurements of emission levels so as to allow those with an interest to assess compliance with the above ICNIRP guidance.
8. **Hong Kong**
9. For hand-held mobile phones which operate in close proximity to human body, the radiation exposure is quantified in terms of “Specific Absorption Rate” (S.A.R). S.A.R. measures the amount of RF energy actually absorbed in a human body. Currently, there are two commonly adopted S.A.R. limits, one recommended by the International Commission on Non-Ionising Radiation Protection (ICNIRP) and the other by the Institute of Electrical and Electronics Engineers (IEEE). In consultation with the Director of Health, the S.A.R. limits of ICNIRP and IEEE are adopted by the Communications Authority (CA) as the safety standard with respect to RF radiation from hand-held mobile phones. The S.A.R. limit of both the ICNIRP and the IEEE applicable to hand-held mobile phones is 2 W/kg.
10. From 1 April 2003 onwards, hand-held mobile phones to be type-approved must comply with the S.A.R. limits of the ICNIRP or the IEEE. Office of Communications Authority (OFCA) operates a voluntary labelling scheme for hand-held mobile phones. Under the scheme, manufacturers, suppliers and dealers are authorized to affix a label prescribed by the CA to mobile phones which have been evaluated to be in compliance with the RF radiation standard.
11. If a consumer wants to be sure that his equipment meets the safety standard, he may choose a mobile phone with the label prescribed by the CA. Alternatively, a consumer may inspect a list of type-approved mobile phones which is posted on OFCA’s homepage.
12. There is no proof that hand-held mobile phones in normal use can be harmful. But if you remain concerned, you may consider taking the following measures. These measures include limiting conversations on the hand-held mobile phones, avoiding contacts with antennas when the phones are operating and making greater use of mobile phones with a hands-free kit. In addition, because a mobile phone transmits a stronger signal in areas of bad reception, you may wish to avoid using your phone in areas of poor reception.
13. **Brazil**
14. The SAR enforced by Brazil is 2 W/kg, a level that is in conformance with the International Commission on Non-Ionizing Radiation Protection (ICNIRP) Guidelines on Human Exposure to Radiofrequency Electromagnetic Fields and that [Agencia Nacional de Telecomunicacoes](https://en.wikipedia.org/wiki/Agencia_Nacional_de_Telecomunicacoes) (Anatel) adopted temporarily in July 1999, until such time as the corresponding Brazilian regulation, developed on the basis of domestic and international studies, is concluded.
15. Anatel released a software that presents the results of theoretical calculations of the total exposure ratio, referred to thermal effect, and estimated using a free space propagation model and the national radiocommunication station database. Anatel ́s Enforcement Division measurements are integrated in this software, so that in places where there are no measured values, the calculated values are presented.
16. Finally, Anatel has established an open dialogue with society, operators, lawmakers and other governmental authorities to present clear information of what is being done in Brazil and worldwide regarding EMF exposure issue, always following WHO points of view.
17. **Qatar**
18. The rapid development of the wireless services and networks in the State of Qatar leads the Communications Regulatory Authority (CRA) to continuously develop regulations and Procedures and Standards containing details of the construction aspects of Cellular Mobile Base Stations and Towers and exposure to radio frequency electromagnetic fields. CRA has chosen to adopt the International Standards recommended by the World Health Organization (WHO) and International Telecommunications Union (ITU) which are in line with ICNIRP Procedures and Standards and are designed to provide protection against all established health hazards. These Procedures and Standards shall:

* serve to protect the general public from exposure to Radio Frequency (RF) electromagnetic fields (EMF) within the frequency range of cellular mobile services;
* require Licensees in Qatar to ensure that the construction and ongoing operation of all Cellular Mobile Base Stations and Towers and related RF equipment complies with ICNIRP public exposure Procedures and Standards ;
* include a substantial safety margin to assure that no adverse health effects are experienced when EMF levels are within the established limits.

1. The Procedures and Standards also serve to limit human exposure to radio frequency and electromagnetic fields by:

* Protecting the public of Qatar from any adverse health effects;
* Providing best practice processes for demonstrating compliance with recognized international exposure limits and protection of the public;
* Planning, designing and operating radio communications infrastructure to minimize RF EMF exposure;
* Ensuring that relevant authorities are informed and consulted before radio apparatus is deployed;
* Maintaining the well-being of Qatar’s community, physical or otherwise.

1. Licensees in the State of Qatar shall adhere to the health protection standards specified in the “Procedures and Standards for Limiting Exposure to Time-varying Electric, Magnetic and Electromagnetic Fields” published by the ICNIRP in 1988 and reconfirmed in 2009. In the event that a new version of the ICNIRP Procedures and Standards is released, Licensees shall adhere to the new standards and furnish compliance within 90 days unless they contain less onerous standards than the previous version, in which case the more onerous standards shall apply, unless specified otherwise by CRA. CRA may conduct audits from time to time to ensure that the limits for public exposure to EMF set by the ICNIRP Procedures and Standards are not exceeded.
2. **Malaysia**
3. The guidelines prepared by MOH and various agencies, together with the Standards and Industrial Research Institute of Malaysia (SIRIM) in 2011, are as follows:

* Guidelines For Limiting Exposure to Time - Varying Electric, Magnetic and Electromagnetic Fields – Part 1: For Frequency up to 3 kHz
* Guidelines For Limiting Exposure to Time - Varying Electric, Magnetic and Electromagnetic Fields – Part 2: For Frequency From 3 kHz to 300 GHz

1. These were prepared with reference to the International Commission on Non-Ionizing Radiation Protection (ICNIRP) standards for exposure limits, as recommended by the World Health Organization (WHO).
2. The Malaysian Communications and Multimedia Commission (MCMC) has determined a mandatory standard titled “Commission Determination on the Mandatory Standard for Electromagnetic Field Emission from Radio - communications Infrastructure”, registered in late 2010, to regulate the Communication and Multimedia industry. This mandatory standard is targeted at the industry service providers owning the transmitters. The mandatory standard is based on ICNIRP and the need for service providers to submit EMF emission simulations as recommended by ITU.
3. The Malaysian Nuclear Agency (MNA), in conjunction with the MOH and MCMC, conducts annual NIR conferences on Non-Ionizing Radiation. These conferences serve as a platform for professionals as well as for the public and civil society groups to get a more balanced and accurate knowledge of the various aspect of NIR.
4. The MCMC, with cooperation from the MOH, MNA and Universities together with other government agencies continue to conduct seminars/ forums on mobile phones and base stations and power transmission lines. This is done with the aim of creating awareness and disseminating the necessary information to address the concerns of the general public and to allay their fears on the adverse health effects from exposure to EMF.
5. **Other countries**
6. The website of the WHO[[29]](#footnote-29) contains a database providing information on the existence of EMF exposure legislation. According to the WHO over 80% of participating countries surveyed have legislation on exposure to EMF.
7. The GSMA has produced maps providing information on the public exposure limits applicable to mobile devices[[30]](#footnote-30) and network[[31]](#footnote-31) antennas. As of the date of preparation of this report the GSMA reports that for mobile devices Excluding countries or territories with unknown limits, 149 apply the ICNIRP limit and 19 use the FCC limits from 1996. Two countries have been identified that retain the old Soviet power density limits for devices but it is unclear whether these are applied to mobile phones. Manufacturers typically apply the ICNIRP limit where no country regulations exist. GSMA reports that for mobile networks, excluding countries or territories with unknown limits, 124 apply ICNIRP, 11 follow the FCC limits from 1996, and 36 have other limits.

# CHAPTER-IV: CONCLUSION

1. Spectrum management is the combination of administrative, scientific and technical procedures necessary to ensure the efficient operation of radio communication equipment and services without causing interference. Simply stated, spectrum management is the overall process of regulating and administering use of the radio frequency spectrum. The goal of spectrum management is to maximize spectrum efficiency, minimize interference and eliminate unauthorized and improper use of the spectrum. Rules and regulations, based on relevant legislation, form a regulatory and legal basis for the spectrum management process. Spectrum monitoring serves as the eyes and ears of the spectrum management process. It is necessary in practice because in reality, authorized use of the spectrum does not ensure that it is being used as intended.
2. Government policies for electromagnetic fields (EMFs) should be evidence based, harmonised internationally and draw on the existing recommendations by expert bodies such as World Health Organisation (WHO). Compliance standards used to determine that exposure from wireless network antennas or mobile devices meet the recommended exposure limits should be based on International Telecommunication Union (ITU) recommendations and Indian Electrotechnical Commission(IEC) standards. Around 30,000 research samples put forth by WHO since 1971 corroborate that there is no tower radiation impact on human health. Presently many of the SATRC countries except India do not have any national radiation standards and are following the ICNIRP guidelines. In India the standards are quite stringent. There is a strong demand from the industry to review the standards so that they are harmonised with the international standards. Globally it can be noted that the ICNIRP[[32]](#footnote-32) is expected to publish updated guidelines for RF in 2016 and that the WHO[[33]](#footnote-33) is currently conducting a health risk assessment for RF exposures. SATRC countries are encouraged to monitor those activities and to use their outcomes as a basis to consider future policy for EMF exposure.
3. The radio frequency spectrum is a limited natural resource and it is essential that it is used in the most effective and efficient manner by all radio communication users the world over. This is so that various radio communication networks can function in an interference-free radio environment. Radio communication technology is advancing at a rapid pace. With the emerging of new technologies and the phenomenal growth of radio communication services, requirements for the radio frequency spectrum and the satellite orbit are increasing at an astronomical rate. Effective and efficient spectrum management is the key element for ensuring the co-existence of various radio communication networks, without causing interference to each other. ITU through its various recommendations cited in the report aims to create standard measurement techniques. In addition ITU also publishes Handbook on Spectrum Monitoring from time to time. All SATRC member countries need to ensure that the ITU recommendations are strictly adhered to.
4. The public concerns for the EMF are very high in the region. A large number of public appeals regarding the electromagnetic field radiation from base stations are submitted to administrations and operators every year. Government and operators deal with the complaints and offer proper answers and related information which are based on scientific evidence. To help the general public understand the issues of electromagnetic field exposure to human beings, the EMF information web sites need to be launched. They should provide the EMF related information and guidelines for the safe use of home appliances and mobile phones as well by the way of interactive and bilateral communications. Public information dissemination centres need to be established which will help the general public understand the reality of the electromagnetic field coming from the electric power related facilities and power lines as well. In an effort to carry out the risk communications with the general public, newsletters also need to be published on a periodical basis. Interaction with Resident Welfare Associations (RWAs) can also be used to allay public fear.
5. The issue regarding establishing non-ionizing radiation protection centre in SATRC to evaluate the measurement of radiations and certify the radiations of BTS in SATRC countries was discussed in the working group meeting and it was concluded that at this point of time the need for having a non-ionizing radiation protection centre in SATRC did not exist.
6. Most of the current towers in the region are lattice type and aesthetically unattractive. Use of camouflaging and similar techniques involves certain cost, which may be passed to the end consumers if it is mandated. On the other hand it is also important to ensure the aesthetics of certain geographical areas of heritage, environmental or architectural importance. There is a need to encourage the operators to adopt such techniques. Every city has its own characteristics and looks; therefore, different cities have different aesthetic requirements depending upon their location, historical values and local sentimental factors. These requirements can suitably be assessed by local bodies. With the availability of fibre, solutions like active Distributed Antennae System (DAS) can be deployed. Solutions like DAS and emerging “Light Radios” will lead to reduction in number of towers. For ensuring environment compatibility initially camouflaging should be made mandatory in areas of heritage, environmental or architectural importance.
7. At present the trial of Tarang Sanchar, a proposed National EMF Portal is being carried out in India. This would provide a common collaborative platform for entire end to end records of EMF exposure and paperless processing and retention of records for entire telecom network of the country. Once the portal goes live, the general public will have more access to information related to EMF since there will be more transparency and public themselves can see the compliance on sites, they will be more confident and hence their fear will be mitigated. Other SATRC member countries may also consider establishing such a portal. Depending on the maturation of the same and response by public, application for mobile phones can be developed.

**Annexure-I**

**RESPONSE FROM BANGLADESH**

**Q1. What are the radiation standards specified in your country for Mobile handsets?**

At present Bangladesh follows the ICNIRP guidelines for radiation standard. I n Section:6 of National Frequency Allocation Plan of Bangladesh reference levels for general public exposure to time-varying electric and magnetic fields by ICNIRP have been mentioned. These values are followed where appropriate.

The Bangladesh Telecommunication Regulation Commission in association with other concerned organization of the country is working on this issue.

**Q2. What are the radiation standards specified in your country for BTS?**

Bangladesh Telecommunication Regulatory Commission usually follows the radiation level safety limits issued by World Health Organization (WHO). The Standard Absorption Rate (SAR) value which is generally maintained in the country is 2W/kg. In Bangladesh there is no specific standard to measure radiation.

**Q3. What are the methods used for standard measurement of radiation in your country?**

Currently, there is no specific method which can be used for measuring radiation. But Commission does have some spectrum monitoring equipment which can be used to passively calculate the level of radiation from different electromagnetic equipment. Besides this, the Commission sometimes has to rely on the operators for their equipment to carry out such measurements.

**Q4. What are the policies and regulations for decreasing the public complaints and worry?**

If any complaint is lodged by any party, the Commission deals with it in a case by case basis. On the other hand, most of the operators have cells similar to ‘Corporate Social Responsibility’ who take action when such types of complaints are received from the public. However, at present there are no policies or regulations for decreasing the complaints and worry regarding non-ionizing radiation from BTS’s or handsets.

**Q5. What are the existing policies for environment compatibility (Camouflaging of Mobile Towers) in your country?**

Recently operators are approaching for camouflaged mobile towers. BTRC along with the operators are working on it. Currently Bangladesh does not have policies regarding Camouflaging of Mobile towers.

**Q6. Are there any applications existing for display of RF map of the capital city of your country? If yes, please provide details. If no, is something under development?**

At present, no such application is used in Bangladesh.

**Annexure-II**

**RESPONSE FROM BHUTAN**

**Q1. What are the radiation standards specified in your country for Mobile handsets?**

At the moment, we haven’t specified our own radiation standards in our country. However, we do follow the international standards specified by the ICNIRP. The Bhutan InfoComm and Media Authority is doing a study in order to develop and specify our own permissible radiation standards in align with the regional and international standards.

**Q2. What are the radiation standards specified in your country for BTS?**

While we do not have specified radiation standards in our country for BTS, we normally allow the exposure limit for the BTS antennas to be less than 0.1W/m2. In regard to the radiating power of the base station antenna, we do not allow it to be more than 50watt.

**Q3. What are the methods used for standard measurement of radiation in your country?**

Currently, the Authority do not have a monitoring equipment and the human capacity to undertake technical works in monitoring of such standard measurement of radiation for compliance. However, we rely on the industries for their testing equipments to carry out the measurement of radiation standards.

**Q4. What are the policies and regulations for decreasing the public complaints and worry?**

We do inform the public through the media on awareness and education of such issues.

**Q5. What are the existing policies for environment compatibility (Camouflaging of Mobile Towers) in your country?**

At the moment, we don’t have policies in regard to the Camouflaging of Mobile towers.

However, any mobile operators intending to build mobile towers shall need environmental clearance from the Environmental Commission. During the request of environmental clearance, detailed environmental assessment will be carried out before the issue of clearance.

**Q6. Are there any applications existing for display of RF map of the capital city of your country? If yes, please provide details. If no, is something under development?**

At the moment, we don’t have. It is not even under development. In near future, we may develop.

**Annexure-III**

**RESPONSE FROM MALDIVES**

**Q1. What are the radiation standards specified in your country for Mobile handsets?**

As of now we don’t have a standard but we do follow International standards

**Q2. What are the radiation standards specified in your country for BTS?**

As of now we don’t have a standard but we do follow International standards

**Q3. What are the methods used for standard measurement of radiation in your country?**

We depend on the radiation data provided by the service providers.

**Q4. What are the policies and regulations for decreasing the public complaints and worry?**

We do aware the public through forum and public media

**Q5. What are the existing policies for environment compatibility (Camouflaging of Mobile Towers) in your country?**

At the moment, we don’t have policies in regard to the Camouflaging of Mobile towers.

**Q6. Are there any applications existing for display of RF map of the capital city of your country? If yes, please provide details. If no, is something under development?**

We don’t have RF mapping as of now but it is an issue we need to work out.

**Annexure-IV**

**RESPONSE FROM NEPAL**

**Q1. What are the radiation standards specified in your country for Mobile handsets?**

Specific Absorption Rate: The handset shall have the SAR standard of maximum 2 W/Kg, averaged over 10 gm of tissue

**Q2. What are the radiation standards specified in your country for BTS?**

The ICNIRP Standard. It is noted that the Draft Working Procedure with detail radiation standards of the BTS is being developed.

**Q3. What are the methods used for standard measurement of radiation in your country?**

No specific standard measurement methods defined however ITU standards for measurement is encouraged to follow

**Q4. What are the policies and regulations for decreasing the public complaints and worry?**

No specific Policies and regulations for decreasing the public complaints and worry. However public notice have been announced from time to time stating that the mobile towers don't cause harmful impact to the public and occupational if install and operate within prescribed standard.

NTA has recently procured EMR Measurement Tool to measure the cumulative effect in a field of particular interest in the vicinity of the BTS

**Q5. What are the existing policies for environment compatibility (Camouflaging of Mobile Towers) in your country?**

Telecommunication Infrastructure Sharing Directive/Working Procedure have been formulated and implemented to protect the environment and to minimize the duplication of large passive infrastructure .

**Q6. Are there any applications existing for display of RF map of the capital city of your country? If yes, please provide details. If no, is something under development?**

No. Nothing under development. However it is essential to provide the RF map of the city to assure safety for the general public

**Annexure-V**

**RESPONSE FROM PAKISTAN**

1. **What are the radiation standards specified in your country for Mobile handsets?**

Mobile handset in Pakistan are required to comply with Specific Absorption Rate (SAR) limit of 2 W/Kg averaged over 10 gm of tissue.

1. **What are the radiation standards specified in your country for BTS?**
   1. ICNIRP), Guidelines of 1998 for public and professional exposure to radiation has been adopted as a national standard for Pakistan.
   2. Pakistan Telecommunication Authority (PTA) has Gazette notified regulations “Protection from Health Related Effects of Radio Base Station Antennas Regulation - 2008”
   3. As per the aforesaid regulations following public density exposure limit has been set:

400 MHz ~ 2000 MHz < f\* / 2000 mW/cm2

2GHz ~ 300 GHz < 1 mW/cm2

*\* is frequency in MHz*

1. **What are the methods used for standard measurement of radiation in your country?**

PTA has been conducting audit/survey of sample BTS sites across Pakistan for last 5 to 6 years regularly to check the compliance level as specified in the regulations. This audit/survey is conducted as confidential and the operators are not prior informed.

1. **What are the policies and regulations for decreasing the public complaints and worry?**

Public complaints are thoroughly investigated. All concerns regarding public health effects due to radiation are addressed and complainants are informed/counselled that there are no health effects from such radiation. In addition, public awareness through print media is also conducted for general public.

1. **What are the existing policies for environment compatibility (Camouflaging of Mobile Towers) in your country?**

At present there are no such policies/obligations.

1. **Are there any applications existing for display of RF map of the capital city of your country? If yes, please provide details. If no, is something under development?**

No there is no such application and not in development at the moment.

**Annexure-VI**

**RESPONSE FROM SRI LANKA**

**Q1. What are the radiation standards specified in your country for Mobile handsets?**

Sri Lanka is following ICNIRP guidelines for radiation standard.

**Q2. What are the radiation standards specified in your country for BTS?**

Sri Lanka is following ICNIRP guidelines for radiation standard for BTS also.

**Q3. What are the methods used for standard measurement of radiation in your country?**

Narda NBM 550 Broadband Field Meter is used.

**Q4. What are the policies and regulations for decreasing the public complaints and worry?**

TRCSL formulated a cabinet approved policy named “National Policy on Antenna Structure” especially for the safety for the people from harmful radiation and protection of environment. Based on this policy, “Guidelines on Antenna Structure” was introduced to follow for construction of towers, BTSs and antennas.

**Q5. What are the existing policies for environment compatibility (Camouflaging of Mobile Towers) in your country?**

“National Policy on Antenna Structure” is used.

**Q6. Are there any applications existing for display of RF map of the capital city of your country? If yes, please provide details. If no, is something under development?**

At present, no such application is used.

1. ZigBee is an IEEE 802.15 standard, used to create personal area networks built from small, low-power digital radios. [↑](#footnote-ref-1)
2. Measured radiofrequency exposure during various mobile-phone use scenarios, Kelsh et al., Journal of Exposure Science and Environmental Epidemiology, 21(4):343–354, July 2011. [↑](#footnote-ref-2)
3. Biological Effects of Radiofrequency Fields: Does Modulation Matter?, Foster et al., Radiation Research, 162(2):219–225, August 2004. [↑](#footnote-ref-3)
4. Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) Opinion on Potential health effects of exposure to electromagnetic fields (EMF), adopted 27 January 2015. [↑](#footnote-ref-4)
5. R.F. Pollution Reduction in Cellular Communication; Sumit Katiyar , Prof. R. K. Jain, Prof. N. K. Agrawal [↑](#footnote-ref-5)
6. Exposure to high frequency electromagnetic fields, biological effects and health consequences (100 kHz-300 GHz): Review of the scientific evidence on dosimetry, biological effects, epidemiological observations, and health consequences concerning exposure to high frequency electromagnetic fields (100 kHz to 300 GHz), International Commission on Non-Ionizing Radiation Protection, ICNIRP, 16/2009. [↑](#footnote-ref-6)
7. http://www.who.int/peh-emf/about/WhatisEMF/en/index1.html [↑](#footnote-ref-7)
8. A base transceiver station (BTS) is an equipment that facilitates wireless communication between user equipment and a network. It has the equipment for encrypting and decrypting communications, spectrum filtering tools etc. Antennas may also be considered as components of BTS to facilitate the functioning of BTS. Typically a BTS will have several transceivers which allow it to serve several different frequencies and different sectors of the cell. [↑](#footnote-ref-8)
9. Power Level Distributions of Radio Base Station Equipment and User Devices in a 3G Mobile Communication Network in India and the Impact on Assessments of Realistic RF EMF Exposure, Joshi et al., IEEE Access, 3(1051-1059), Published: 07 July 2015. [↑](#footnote-ref-9)
10. Antenna gain (expressed in decibels) is defined as the ratio of the power produced by the antenna from a source on the antenna's beam axis to the power produced by a hypothetical lossless isotropic antenna. As a transmitting antenna, this describes how well the antenna converts input power into radio waves headed in a specified direction. As a receiving antenna, this describes how well the antenna converts radio waves arriving from a specified direction into electrical power. [↑](#footnote-ref-10)
11. Comparative international analysis of radiofrequency exposure surveys of mobile communication radio base stations, Rowley et al., Journal of Exposure Science and Environmental Epidemiology, 22(4):427-427, 2012. [↑](#footnote-ref-11)
12. Power Level Distributions of Radio Base Station Equipment and User Devices in a 3G Mobile Communication Network in India and the Impact on Assessments of Realistic RF EMF Exposure, Joshi et al., IEEE Access, 3(1051-1059), Published: 07 July 2015 [↑](#footnote-ref-12)
13. http://www.icnirp.org/en/about-icnirp/aim-status-history/index.html [↑](#footnote-ref-13)
14. http://www.who.int/peh-emf/standards/en/ [↑](#footnote-ref-14)
15. http://www.itu.int/rec/T-REC-K.52-200412-I/en [↑](#footnote-ref-15)
16. International Commission on Non-Ionizing Radiation Protection (ICNIRP) Guidelines For Limiting Exposure To Time-Varying Electric, Magnetic, and Electromagnetic Fields (up to 300 GHz), Health Physics, 74(4):494-522, April 1998. [↑](#footnote-ref-16)
17. http://www.gsma.com/publicpolicy/mobile-and-health/networks-map [↑](#footnote-ref-17)
18. See for example http://sartick.com/ [↑](#footnote-ref-18)
19. http://www.gsma.com/publicpolicy/mobile-and-health/devices-map [↑](#footnote-ref-19)
20. http://www.itu.int/en/ITU-T/emf/Pages/default.aspx [↑](#footnote-ref-20)
21. http://www.who.int/peh-emf/standards/emf\_model/en/ [↑](#footnote-ref-21)
22. http://www.iec.ch/ [↑](#footnote-ref-22)
23. http://sartick.com/ [↑](#footnote-ref-23)
24. For example Canada: http://www.ic.gc.ca/eic/site/ceb-bhst.nsf/eng/tt00099.html [↑](#footnote-ref-24)
25. The moniT Project: Electromagnetic Radiation Exposure Assessment in Mobile Communications, Oliveira et al., IEEE Antennas and Propagation Magazine, 49(1):44-53, February 2007. [↑](#footnote-ref-25)
26. http://www.who.int/entity/mediacentre/factsheets/fs193/en/index.html [↑](#footnote-ref-26)
27. http://www.who.int/entity/peh-emf/publications/facts/fs304/en/index.html [↑](#footnote-ref-27)
28. http://www.who.int/peh-emf/publications/risk\_hand/en/ [↑](#footnote-ref-28)
29. http://www.who.int/gho/phe/emf/legislation/en/ [↑](#footnote-ref-29)
30. http://www.gsma.com/publicpolicy/mobile-and-health/devices-map [↑](#footnote-ref-30)
31. http://www.gsma.com/publicpolicy/mobile-and-health/networks-map [↑](#footnote-ref-31)
32. http://www.icnirp.org/en/activities/work-plan/index.html [↑](#footnote-ref-32)
33. http://www.who.int/peh-emf/research/rf\_ehc\_page/en/ [↑](#footnote-ref-33)