# EMF Policies, Guidelines and Standards

Human Exposure to Radio Frequency Electromagnetic Field

**Aamir Riaz**
International Telecommunication Union – Regional Office for Asia and the Pacific
aamir.riaz@itu.int

# Scope

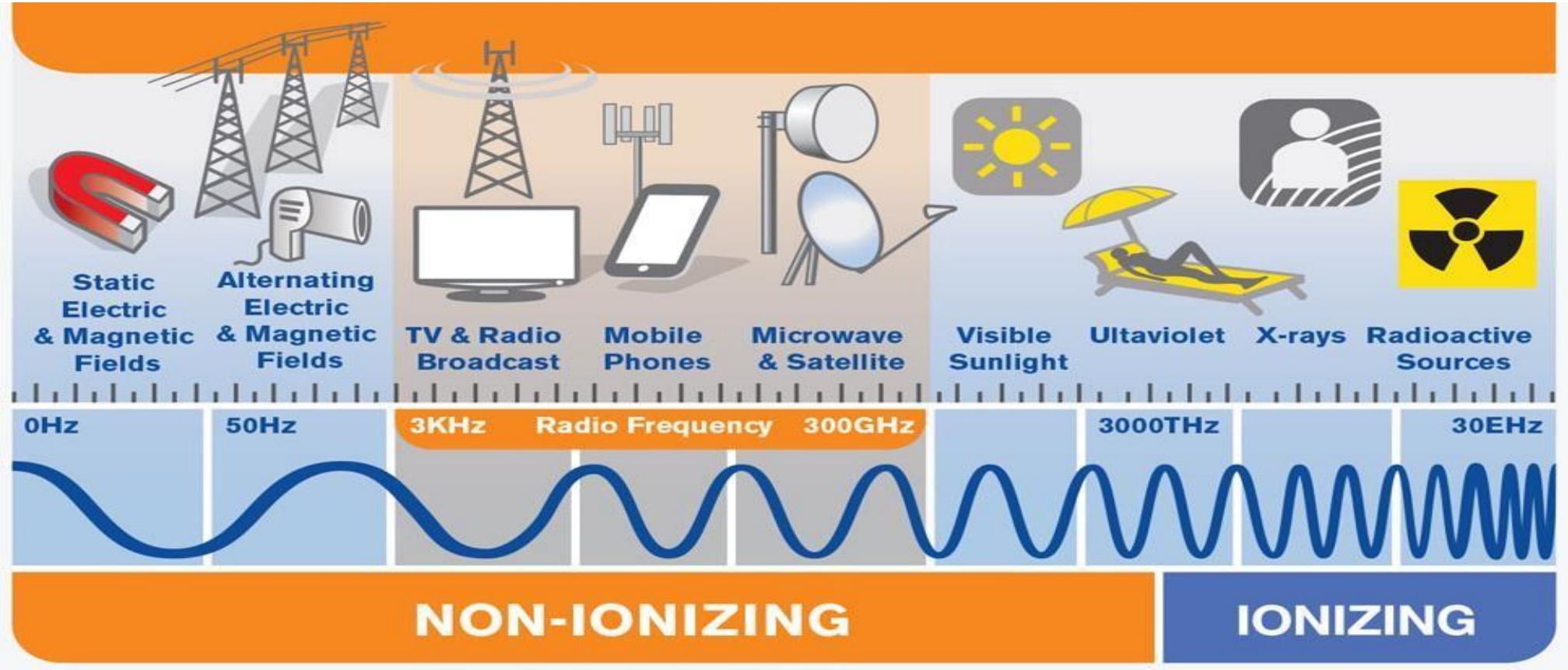
- Organizations working on EMF exposure issues
- ITU activities on EMF exposure issues
- Case studies and Comparisons of Exposure Limits
- EMF measurements and case studies
- Guidelines and Recommendations

# Radio-Electric Spectrum: *General Technical Usage*

| Band | Frequency range | Range | Common use | Bandwidth |
|---|---|---|---|---|
| **VLF (myriametric waves)** | 3-30 kHz | 1 000 km | Long-range radionavigation | Very narrow |
| **LF (kilometric waves)** | 30-300 kHz | 1 000 km | Long-range radionavigation | Very narrow |
| **MF (hectometric waves)** | 300-3 000 kHz | 2-3 000 km | Long-range radionavigation | Moderate |
| **HF (decametric waves)** | 3-30 MHz | Up to 1 000 km | Fixed point-to-point, Global **broadcasting** | Wide |
| **VHF (metric waves)** | 30-300 MHz | 2-300 km | Broadcasting, Mobile, WAN | Very wide |
| **UHF (decimetric waves)** | 300-3 000 MHz | < 100 km | Broadcasting, Mobile, Satellite | Very wide |
| **SHF (centimetric waves)** | 3-30 GHz | 30-2 000 km | Fixed, Broadcasting, Mobile, WAN, Satellite communications | Very wide up to 1 GHz |
| **EHF (millimetric waves)** | 30-300 GHz | 20-2 000 km | Broadcasting, Fixed point-to- point, Mobile, Satellite communications | Very wide up to 10 GHz |

# Radio-Electric Spectrum

Artificial boundary, based on technologic development



# Differentiating Ionizing and Non Ionizing Radiation

Electromagnetic radiation at frequencies above the ultra-violet band are classified as "**IONIZING RADIATION**",

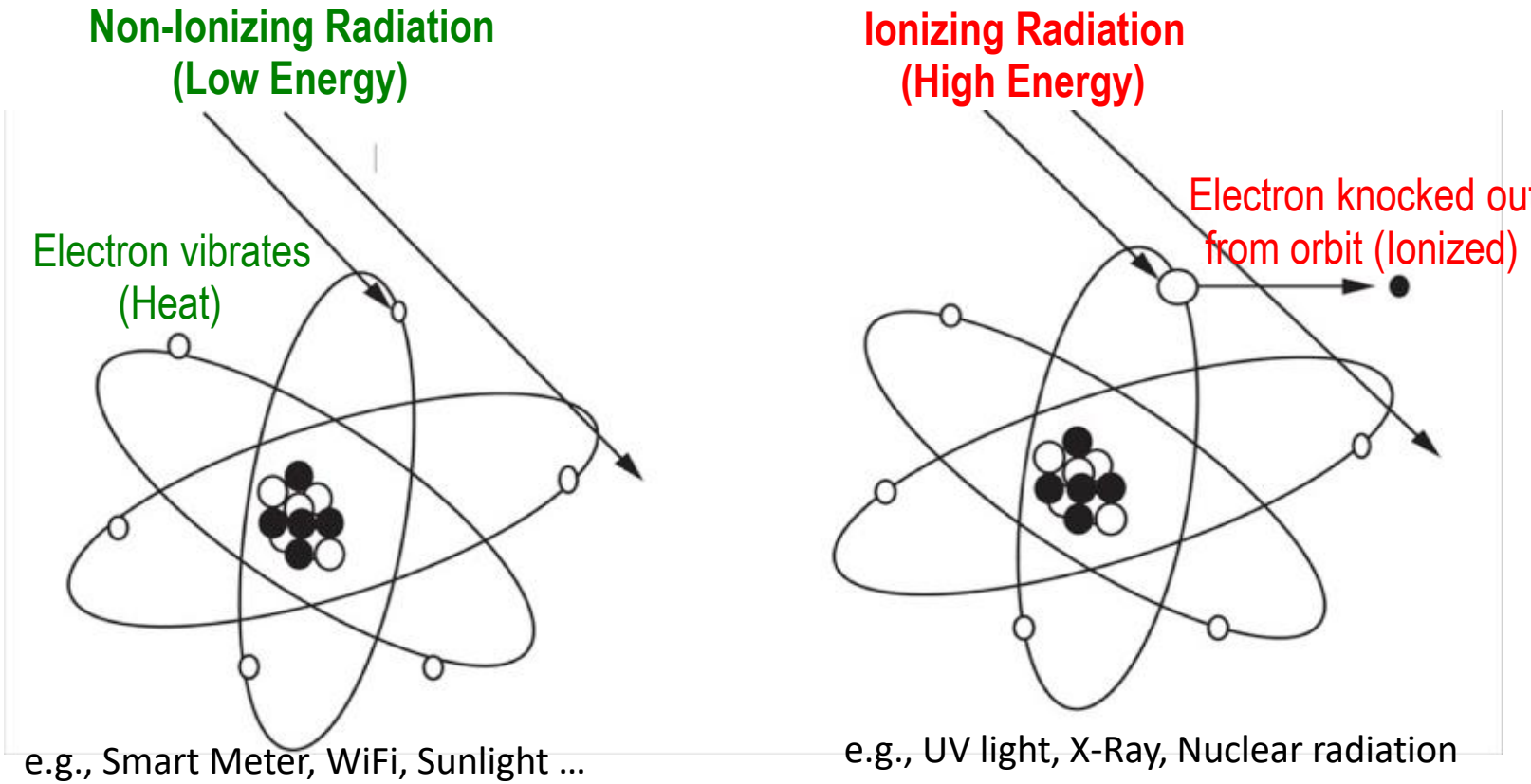
- **Reason**: *when incident on matter they have enough energy to effect changes in the atoms, by liberating ionizing electrons and thus altering their chemical bonds.*

- ✓ Ionizing radiation occurs at frequencies above 2,900 THz ($2{,}900 \times 10^{12}$ Hz).
- ✓ This frequency limit corresponds to a wavelength of about 103.4 nm; and minimum ionization energy of 12eV.

Extremely high frequency radiation such as Ultraviolet (UV) and X-rays is called "Ionizing Radiation" because it has enough energy to affect the matter it strikes, by breaking chemical bonds (ionization) , thus altering their chemical and biological nature

# Differentiating Ionizing and Non Ionizing Radiation

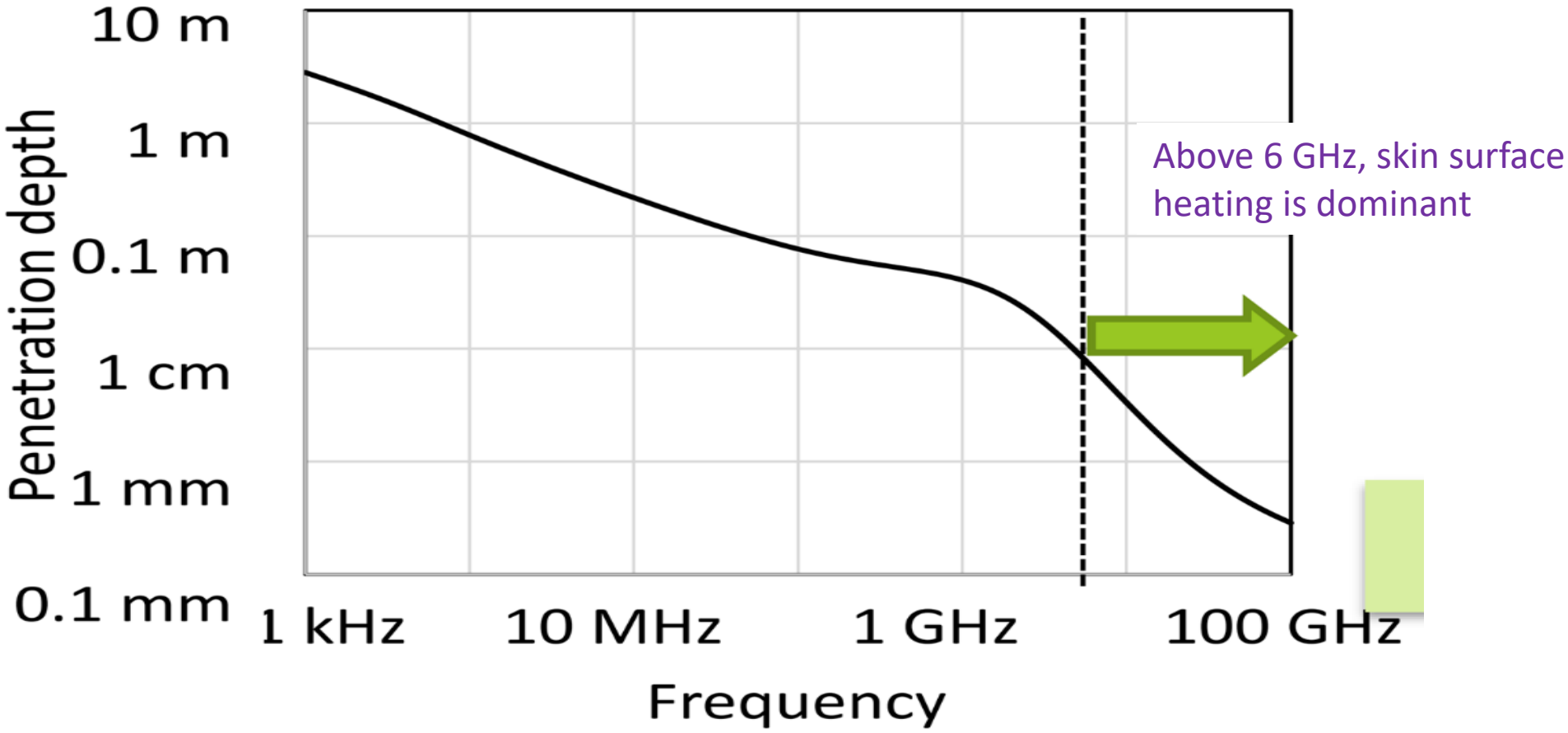
**Electromagnetic radiation at those frequencies below the UV band are generally classified as "Non-Ionizing Radiation" (NIR) because they typically lack the energy to effect changes in atomic structure.**




**The short term thermal heating capabilities of RF (e.g., microwave ovens) are well known. The question is whether there are some other long term health effects, e.g., cancer.**

**Source:** ITU workshop on "Human Exposure to EMFs" Jafar Keshvari, Chairman, International Electrotechnical Commission, "Scientific basis of the EMF exposure standards" Quito, Ecuador, 14Aug2013

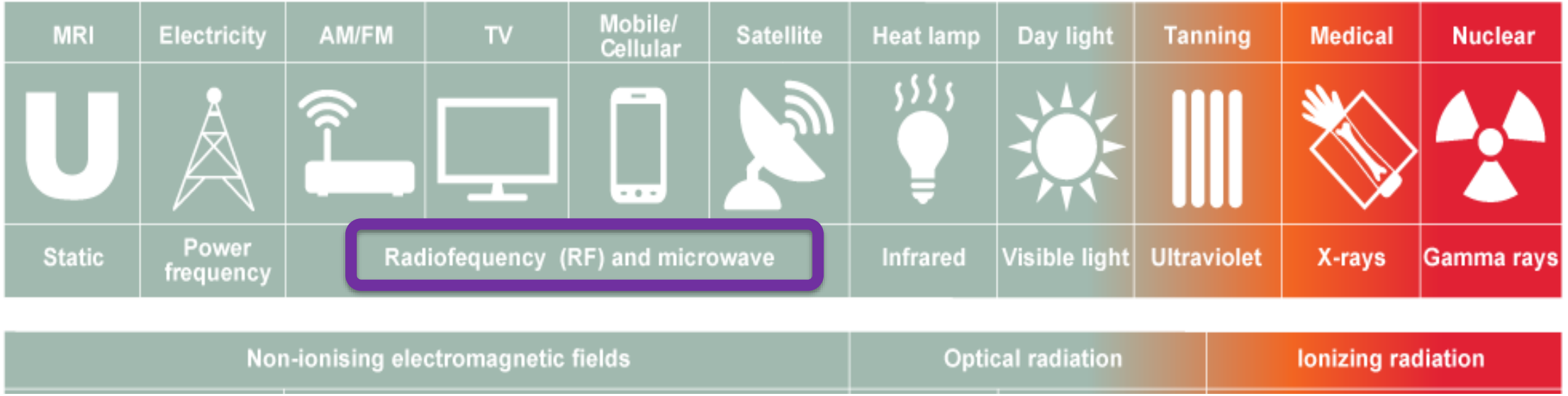
# Penetration depth becomes shallower; source, Akimasa Hirata in 5G higher RF



# ICNIRP guidelines 2020: Quantities and corresponding SI units used in these guidelines.

| Quantity | Symbol | Unit (SI) |
|---|---|---|
| Absorbed energy density | $U_{ab}$ | joule per square meter (J $m^{-2}$) |
| Incident energy density | $U_{inc}$ | joule per square meter (J $m^{-2}$) |
| Plane-wave equivalent incident energy density | $U_{eq}$ | joule per square meter (J $m^{-2}$) |
| Absorbed power density | $S_{ab}$ | watt per square meter (W $m^{-2}$) |
| Incident power density | $S_{inc}$ | watt per square meter (W $m^{-2}$) |
| Plane-wave equivalent incident power density | $S_{eq}$ | watt per square meter (W $m^{-2}$) |
| Induced electric field strength | $E_{ind}$ | volt per meter (V $m^{-1}$) |
| Incident electric field strength | $E_{inc}$ | volt per meter (V $m^{-1}$) |
| Incident electric field strength | $E_{ind}$ | volt per meter (V $m^{-1}$) |
| Incident magnetic field strength | $H_{inc}$ | ampere per meter (A $m^{-1}$) |
| Specific energy absorption<br>Specific energy absorption rate | SA SAR | joule per kilogram (J $kg^{-1}$)<br>watt per kilogram (W $kg^{-1}$) |
| Electric current | I | ampere (A) |
| Frequency | f | hertz (Hz) |
| Time | t | second (s) |

# The RF spectrum



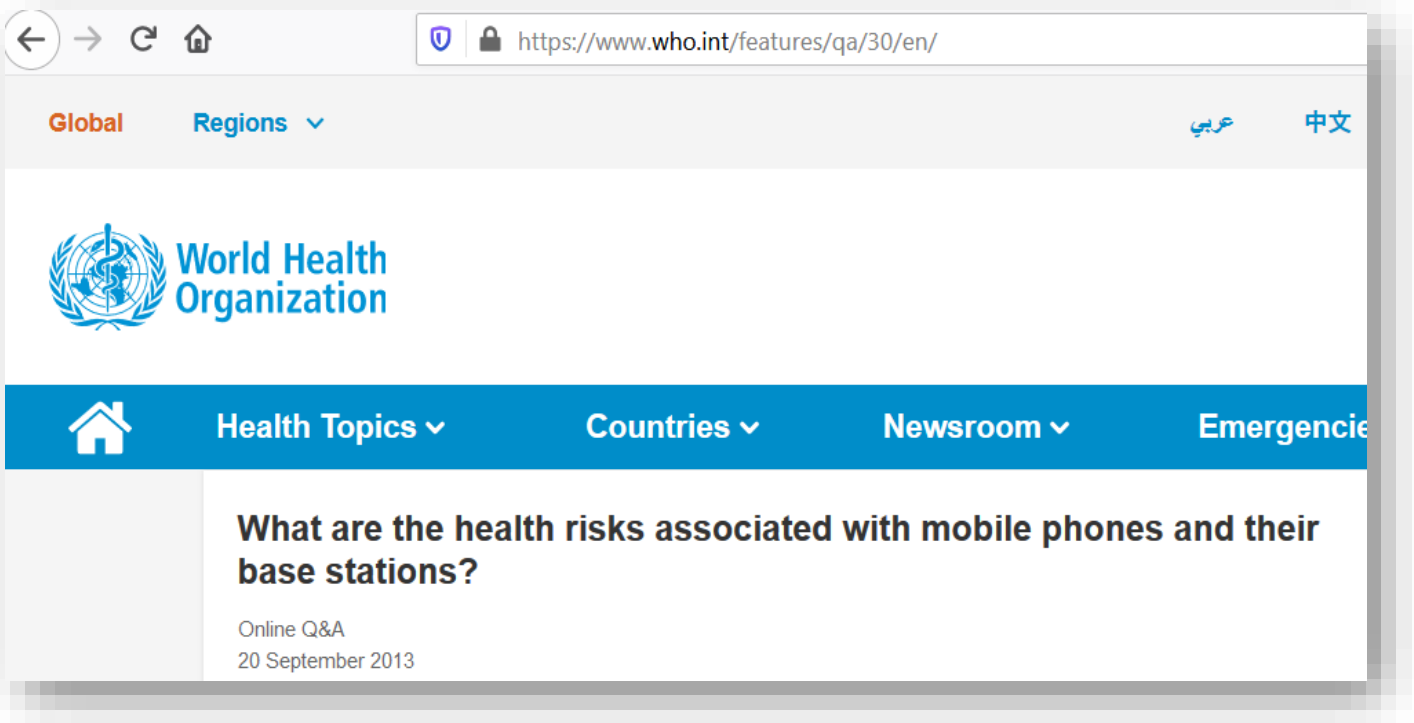

- RF signals are a form of non-ionizing electromagnetic energy.
- Very strong radio signals can cause heating of the body.
- Protection standards developed to limit exposure.

**Source**: RF-EMF presentation at WRC-19

# Organizations working on EMF exposure issues

World Health Organization

World Health Organization




**Conclusions**

While an increased risk of brain tumours 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 …….

**Source:** http://www.who.int/features/qa/30/en/

World Health Organization

**EMF Project** http://www.who.int/peh-emf/project/EMF_Project/en/index.html

- International **EMF Project** in established 1996 to assess the scientific evidence of possible health effects of EMF in the frequency range from 0 to 300 GHz.

- The mandate of the International EMF Project is to assess the health and environmental effects of exposure to static and time varying electric and magnetic fields in the frequency range 0 - 300 GHz. For the purposes of the EMF Project, this range is divided into: static (0 Hz), extremely low frequency (ELF, >0-300 kHz), intermediate frequencies (IF, >300Hz to 10MHz), and radiofrequency (RF, 10 MHz-300 GHz) fields.

World Health Organization

- “Studies to date provide no indication that environmental exposure to RF fields, such as from base stations, increases the risk of cancer or any other disease”

- **Published a database of EMF policies**
  - https://www.who.int/gho/phe/emf/legislation/en/

- Collaboration with ITU on the subject
  - ITU reviewed the recent WHO publications: *Environment Health Criteria (EHC) monograph, Fundamental Safety Principles and Fact Sheet.*

**Source**: BDT SG 2 Q7/2 report

World Health Organization

- **Several challenges for governments including**
  - Rapidly evolving radio frequency technologies are launched on the market before any health evaluation,
  - Disparities in risk management measures and regulations around the world which compound concerns from the public.

- **Recommends Governments to**
  - Delineate clear roles and responsibilities on this topic,
  - Adopt health-based standards and ensure their compliance.
  - Promote public information programmes and dialogue with stakeholders
  - Enable further research to reduce scientific uncertainty.

EMF exposure now occurs to varying degrees to all populations of the world, and the levels will continue to increase with advancing technology, Thus even a small health consequence from exposure to EMF could have major public health impact

**Source**: BDT SG 2 Q7/2 report

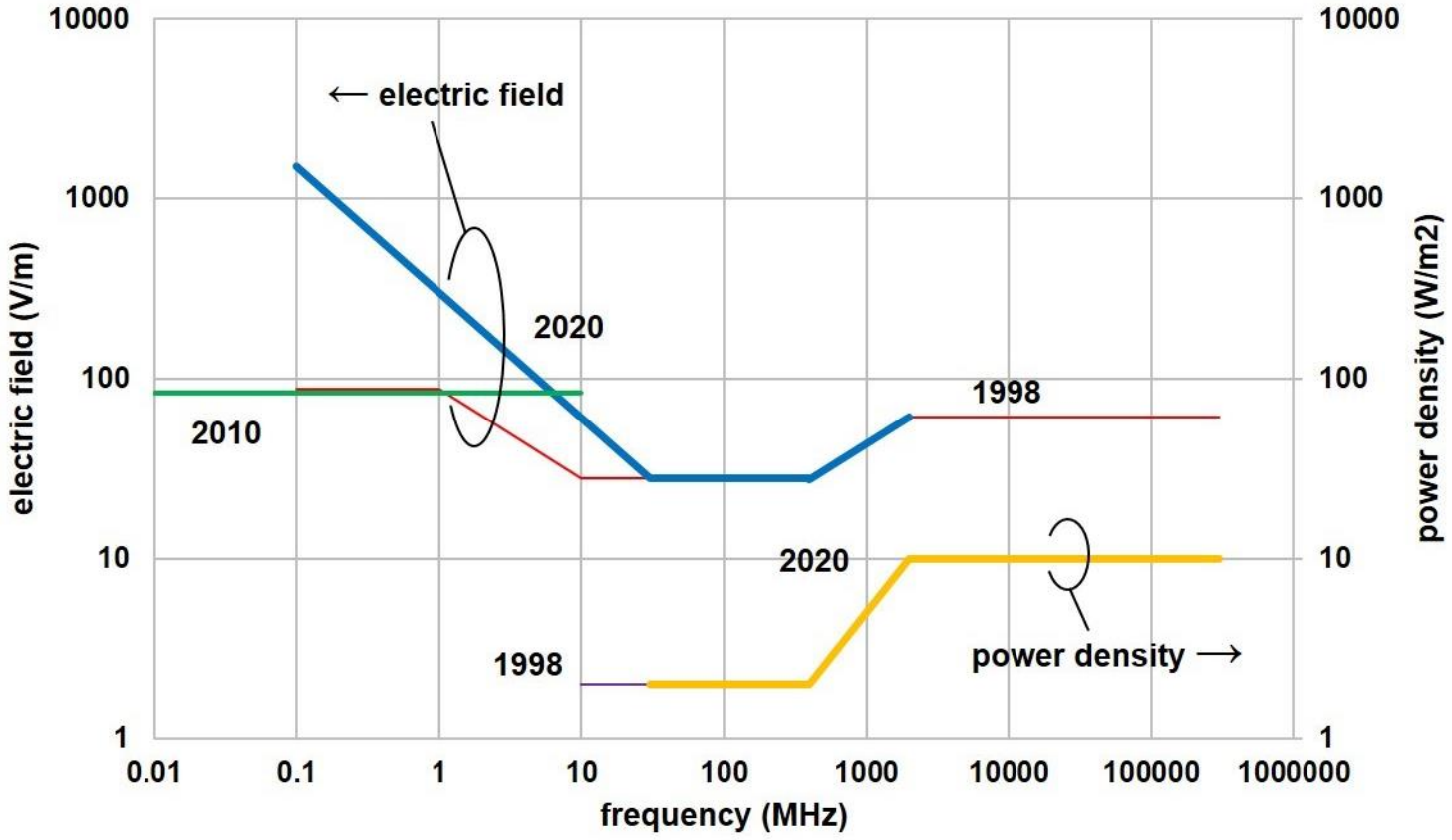
# Organizations working on EMF exposure issues

ICNIRP
INTERNATIONAL COMMISSION ON
NON-IONIZING RADIATION PROTECTION

- ICNIRP is the International Commission on  Non-Ionizing Radiation Protection.
- **Publicly funded body of independent scientific experts** consisting of a main Commission of 14 members, its Scientific Expert Group and its Project Groups.
- Expertise is brought to **address the important issues of possible adverse effects on human health of exposure to  non-ionizing radiation**.
- ICNIRP is **independent from industry** in both membership and funding.
- ICNIRP is a non profit  making body and is legally registered as such in Germany.
- ICNIRP seeks to provide a service of  information provision or advice to all persons.

# ICNIRP RF EMF Guidelines 2020

Superseeds 1998 p.511 reference levels and 2010 guidelines for occupational & general public exposure




**Whole body average** reference levels for the **general public** for the ICNIRP (1998), ICNIRP (2010) and ICNIRP (2020) guidelines, for the 100 kHz to 300 GHz frequency range.

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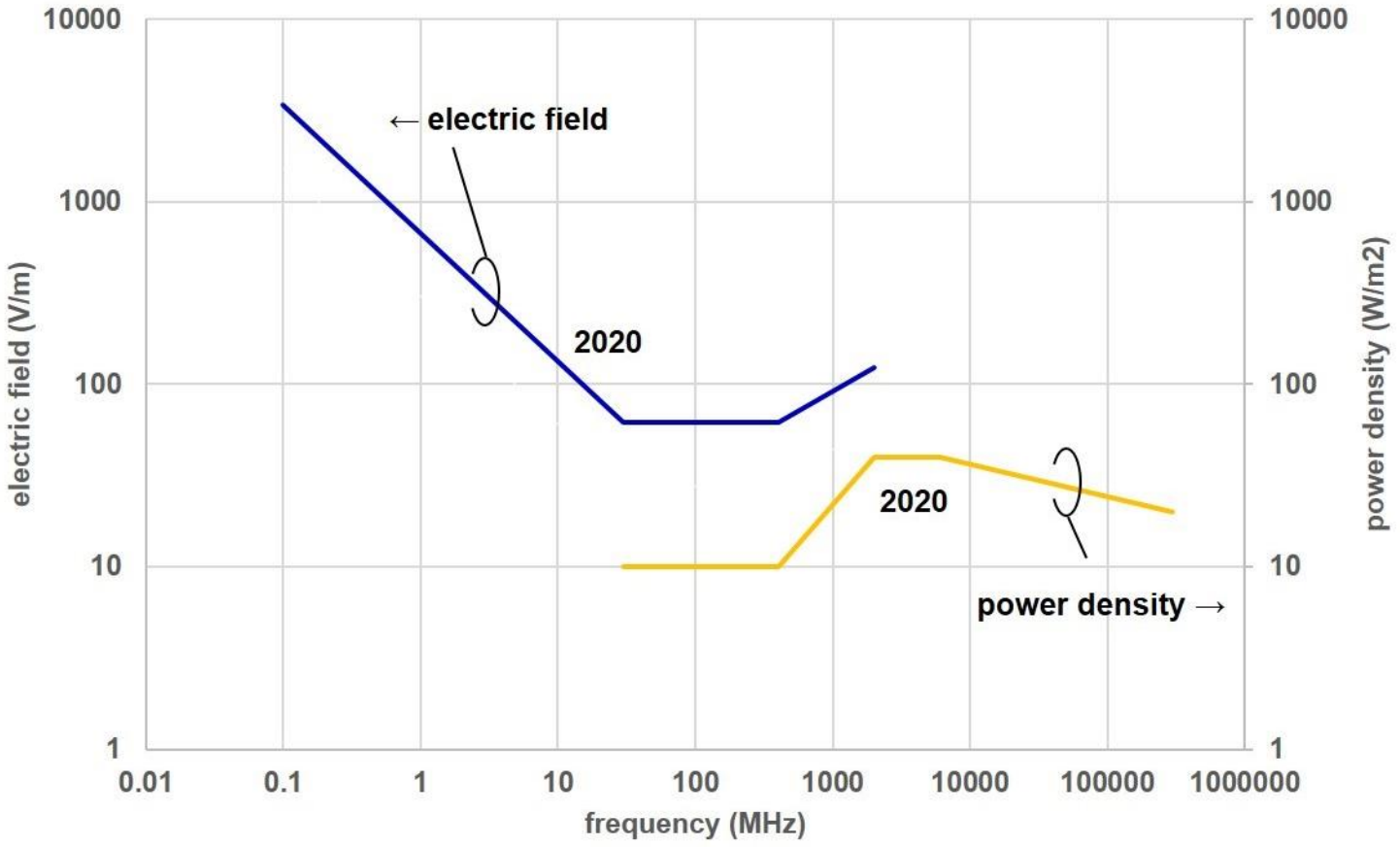
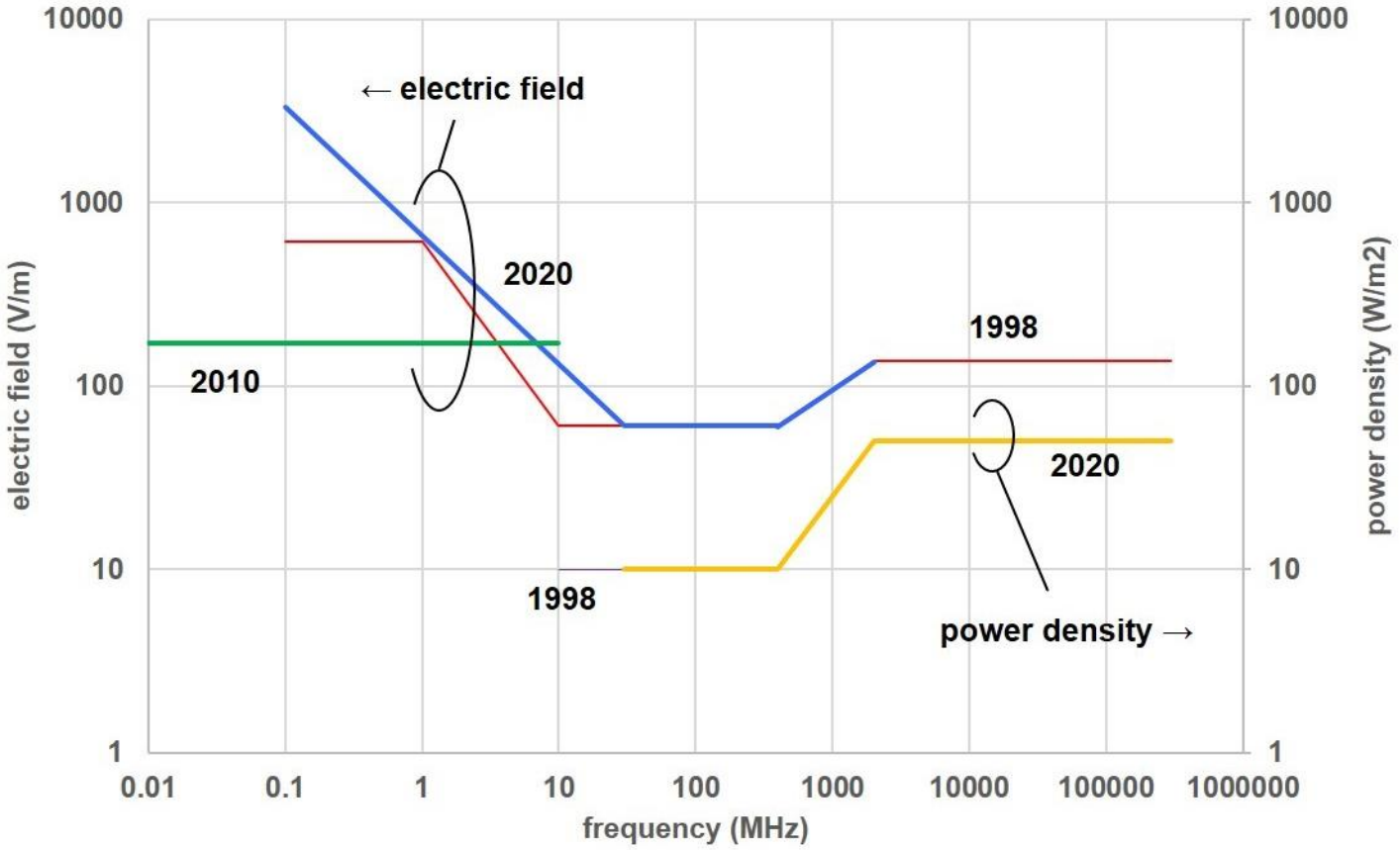



Reference levels for **the general public applying to local exposures ≥6 min** for the ICNIRP (2020) guidelines, for the 100 kHz to 300 GHz frequency range.

**Note**: Local exposure reference levels were not given in the ICNIRP (1998) and ICNIRP (2010) guidelines.

# ICNIRP RF EMF Guidelines 2020

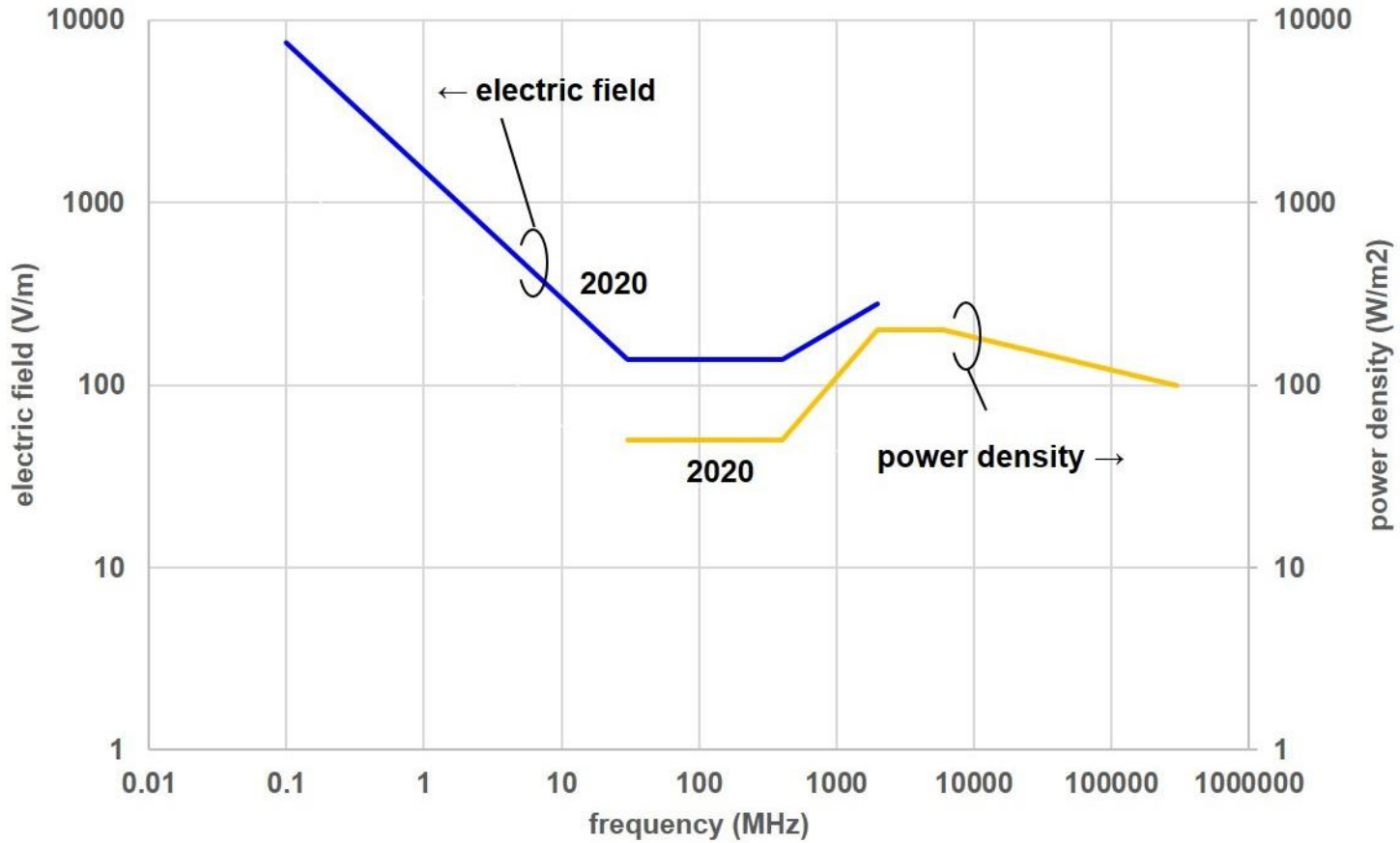
Superseeds 1998 p.511 reference levels and 2010 guidelines for occupational & general public exposure




**Whole body average** reference levels for the **Workers** for the ICNIRP (1998), ICNIRP (2010) and ICNIRP (2020) guidelines, for the 100 kHz to 300 GHz frequency range.

# ICNIRP RF EMF Guidelines 2020

Superseeds 1998 p.511 reference levels and 2010 guidelines for occupational & general public exposure




Reference levels for **the workers applying to local exposures ≥6 min** for the ICNIRP (2020) guidelines, for the 100 kHz to 300 GHz frequency range.

**Note**: Local exposure reference levels were not given in the ICNIRP (1998) and ICNIRP (2010) guidelines.

# Organizations working on EMF exposure issues

IEEE

**Updated IEEE C95.1-2019 reference levels**: *Safety factors applying 100 kHz- 6 GHz based on thermal effects*

1. **Whole body averaged**
   - Behavioral effects in animals over many frequencies,
   - threshold at 4 W/kg10X - 0.4 W/kg for upper tier
   - 50X - 0.08 W/kg for lower tier

2. **Localized exposure** (averaged in 10 g)
   - Cataract observed in rabbits,
   - threshold at 100 W/kg  10X – 10 W/kg for upper tier
   - 50X – 2 W/kg for lower tier

# IEEE C95.1-2019 Table 5—DRLs (100 kHz to 6 GHz)

| Conditions | Persons in unrestricted environments SAR (W/kg)[a] | Persons permitted in restricted environments SAR (W/kg)[a] |
|---|---|---|
| Whole-body exposure | 0.08 | 0.4 |
| Local exposure[b] (head and torso) | 2 | 10 |
| Local exposure[b] (limbs and pinnae) | 4 | 20 |

**DRL**: Dosimetric Reference Limits

[a] SAR is averaged over 30 min for whole-body exposure and 6 min for local exposure (see B.6 for averaging time).

[b] Averaged over any 10 g of tissue (defined as a tissue volume in the shape of a cube). The averaging volume of 10 g of tissue would be represented as a 10 $cm^3$ cube (approximately 2.15 cm per side)

# IEEE C95.1-2019 Table 6—DRLs (6 GHz to 300 GHz)

| Conditions | Epithelial power density (W/m2)[a,b,c] | |
|---|---|---|
| | Persons in unrestricted Environments | Persons permitted in restricted environments |
| Body surface | 20 | 100 |

[a] Epithelial power density through body surface is averaged over 6 min.

[b] Averaged over any 4 $cm^2$ of body surface at frequencies between 6 GHz and 300 GHz (defined as area in the shape of a square at surface of the body).

[c] Small exposed areas above 30 GHz: If the exposed area on the body surface is small (< 1 $cm^2$ as defined by −3 dB contours relative to the peak exposure), the epithelial power density is allowed to exceed the DRL values of Table 6 by a factor of 2, with an averaging area of 1 $cm2^2$ (defined as area in the shape of a square at the body surface).

# IEEE C95.1-2019 Table 7—ERLs for whole-body exposure of persons in unrestricted environments (100 kHz to 300 GHz)

| Frequency range (MHz) | Electric field Strength (E)[a,b,c] (V/m | Magnetic field strength (H)[a,b,c] (A/m) | Power density (S)[a,b,c] (W/m²) | | Averaging time (min) |
|---|---|---|---|---|---|
| | | | $S_E$ | $S_H$ | |
| **0.1 to 1.34** | 614 | $16.3/f_M$ | 1000 | $100\,000\ f^2$ | |
| **1.34 to 30** | $823.8/f_M$ | $16.3/f_M$ | $1800 / f^2$ | $100\,000 / f^2$ | |
| **30 to 100** | 27.5 | $158.3/f^{1.668}_M$ | 2 | $9\,400\,000 / f^{3.336}$ | 30 |
| **100 to 400** | 27.5 | 0.0729 | 2 | | |
| **400 to 2000** | | | $f_M/200$ | | |
| **2000 to 300 000** | | | 10 | | |

NOTE—$S_E$ and $S_H$ are plane-wave-equivalent power density values, based on electric or magnetic field strength respectively, and are commonly used as a convenient comparison with ERLs at higher frequencies and are sometimes displayed on commonly used instruments.

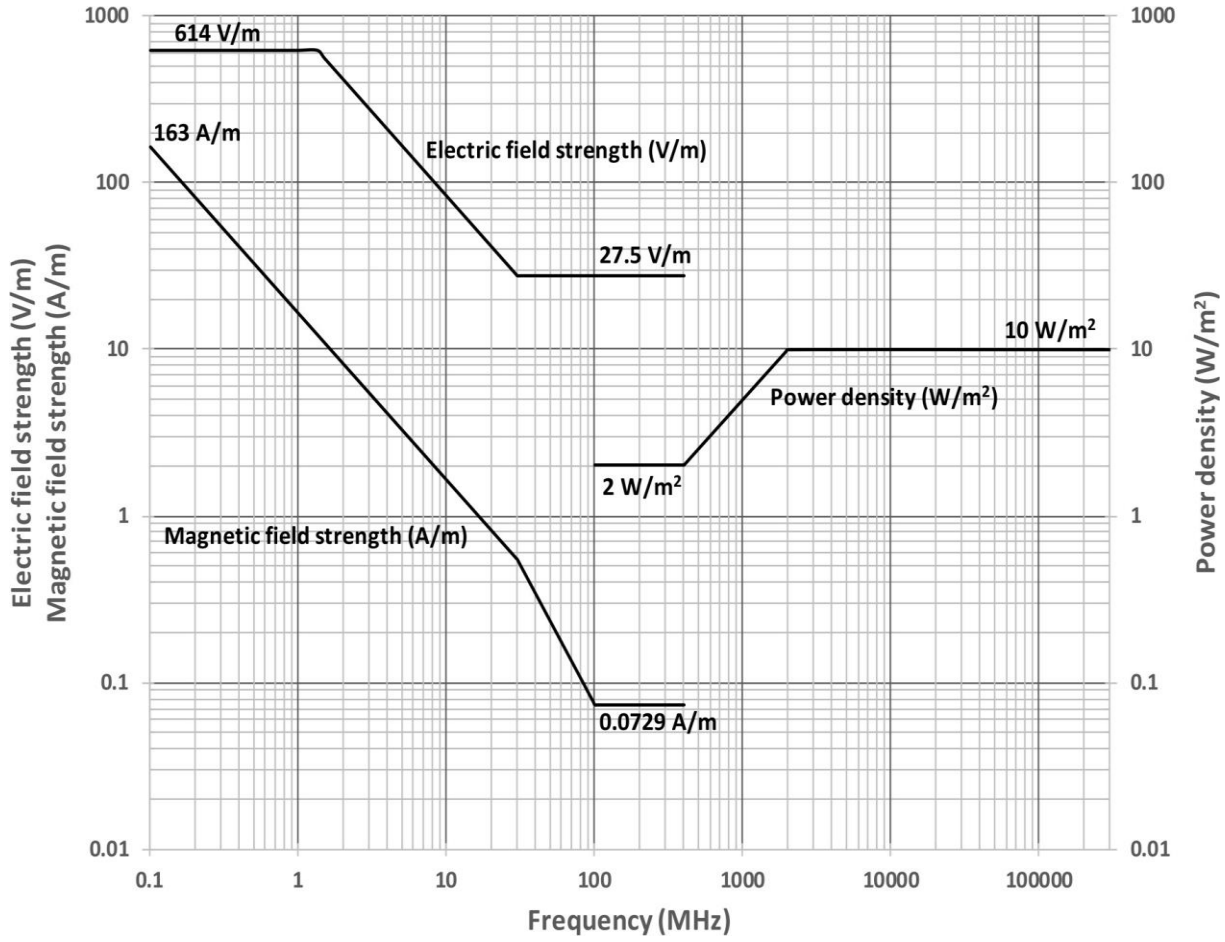
[a] For exposures that are uniform over the dimensions of the body, such as certain far-field plane-wave exposures, the exposure field strengths and power densities are compared with the ERLs in Table 7. For more typical nonuniform exposures, the mean values of the exposure fields, as obtained by spatially averaging the plane-wave-equivalent power densities or the squares of the field strengths, are compared with the ERLs in Table 7.

[b] $f_M$ is the frequency in MHz.

[c] The *E*, *H*, and *S* values are those rms values unperturbed by the presence of the body.

At low frequencies (e.g., 1 MHz) the wavelength is high (300 m.), so only part of the signal's energy heats our body

# IEEE C95.1-2019 Fig. 3: Graphical representations of the ERLs in Table 7 for electric and magnetic fields and plane-wave-equivalent power density—Persons in unrestricted environments



# IEEE C95.1-2019 Table 8—ERLs for whole-body exposure of persons permitted in restricted environments (100 kHz to 300 GHz)

| Frequency range (MHz) | Electric field Strength (E)[a,b,c] (V/m | Magnetic field strength (H)[a,b,c] (A/m) | Power density (S)[a,b,c] (W/m$^2$) | | Averaging time (min) |
|---|---|---|---|---|---|
| | | | $S_E$ | $S_H$ | |
| 0.1 to 1.0 | 1842 | $16.3/f_M$ | 9 000 | $100\,000\ f_M^2$ | 30 |
| 1.0 to 30 | $1842/f_M$ | | $1800/f_M^2$ | | |
| 30 to 100 | 61.4 | | 10 | | |
| 100 to 400 | | 0.163 | 10 | | |
| 400 to 2000 | | | $f_M/40$ | | |
| 2000 to 300 000 | | | 50 | | |

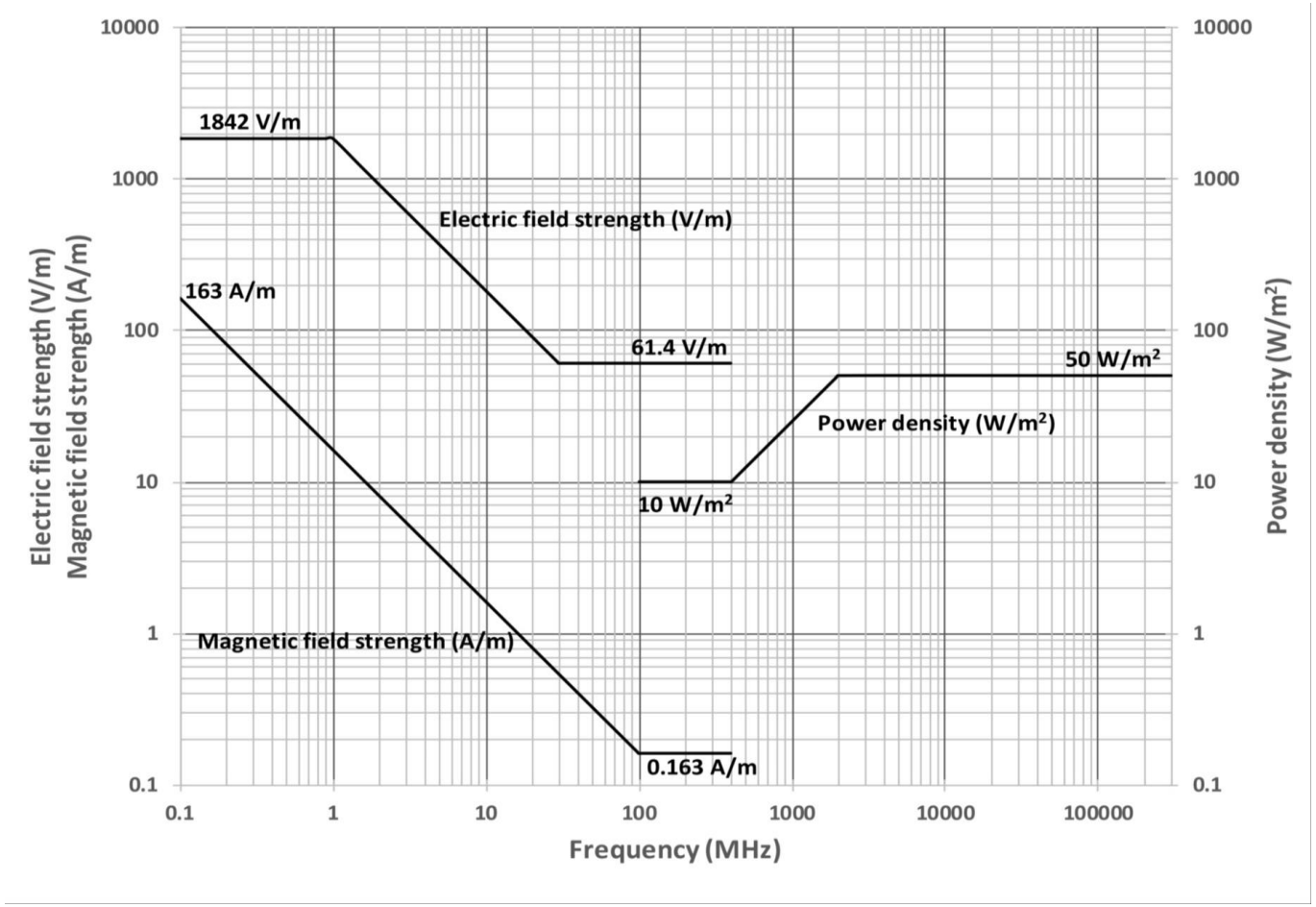
NOTE—SE and SH are plane-wave-equivalent power density values, based on electric or magnetic field strength respectively, and are commonly used as a convenient comparison with ERLs at higher frequencies and are sometimes displayed on commonly used instruments.

a For exposures that are uniform over the dimensions of the body, such as certain far-field plane- wave exposures, the exposure field strengths and power densities are compared with the ERLs in Table 7. For more typical nonuniform exposures, the mean values of the exposure fields, as obtained by spatially averaging the plane-wave-equivalent power densities or the squares of the field strengths, are compared with the ERLs in Table 7.

b fM is the frequency in MHz.

c The E, H, and S values are those rms values unperturbed by the presence of the body.

IEEE C95.1-2019 Fig. 4: **Graphical representations of the ERLs in Table 8 for electric and magnetic fields and plane-wave-equivalent power density—Persons permitted in restricted environments**



# Organizations working on EMF exposure issues

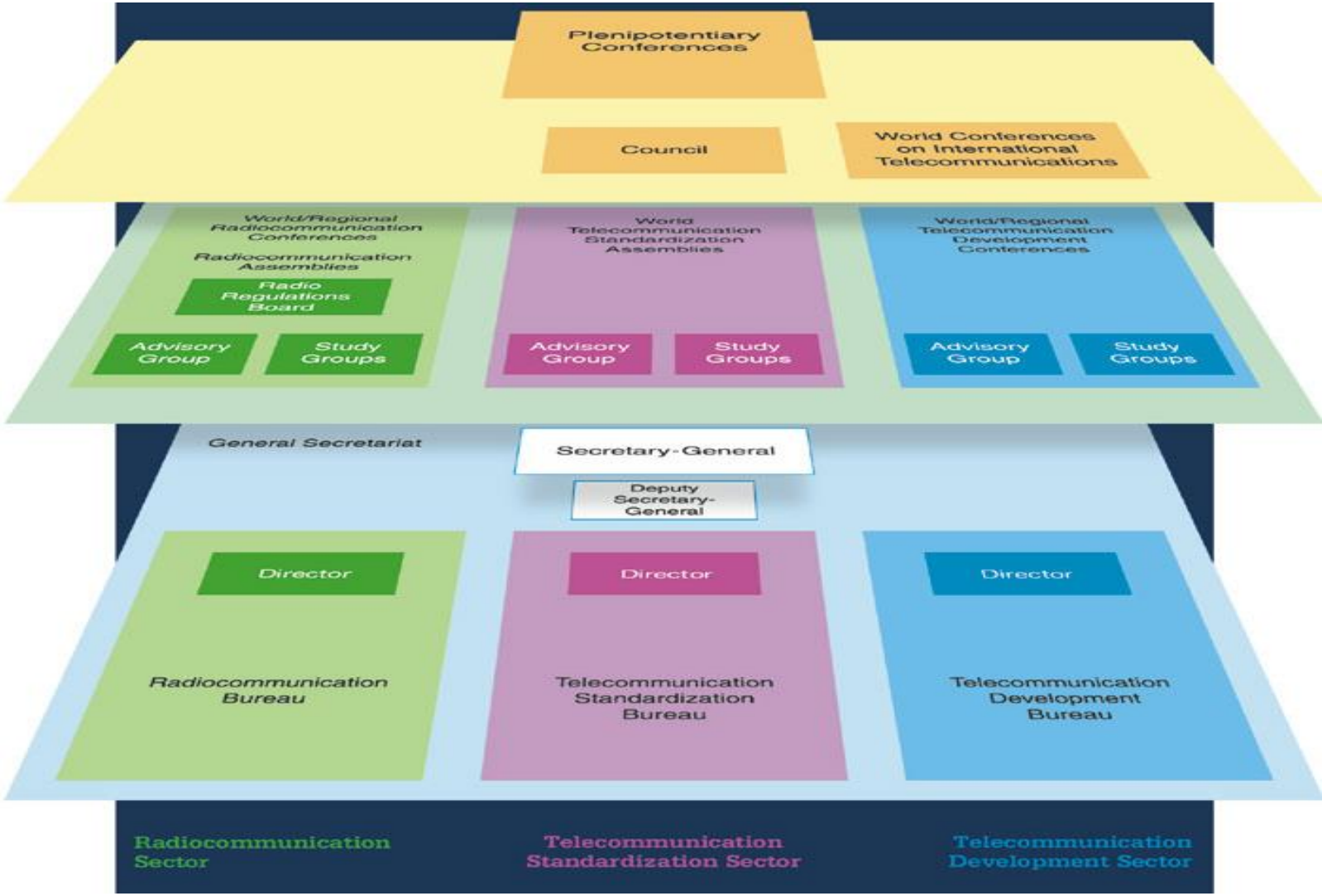
# International Electrotechnical Commission (IEC)

- IEC TR 62669:2019 Edition 2.0 Case studies supporting IEC 62232 - Determination of RF field strength, power density and SAR in the vicinity of radiocommunication base stations for the purpose of evaluating human exposure (5G update)
- IEC TR 63170:2018 Edition 1.0 (2018-08-15) Measurement procedure for the evaluation of power density related to human exposure to radio frequency fields from wireless communication devices operating between 6 GHz and 100 GHz (5G applications)
- IEC PAS 63151:2018 Edition 1.0 (2018-01-15) Measurement procedure for the assessment of specific absorption rate of human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices - Vector measurement-based systems (Frequency range of 30 MHz to 6 GHz)
- IEC TR 62905:2018 Edition 1.0 (2018-02-06) Exposure assessment methods for wireless power transfer systems
- IEC TR 63167:2018 Edition 1.0 (2018-06-05) Assessment of contact current related to human exposure to electric, magnetic and electromagnetic fields

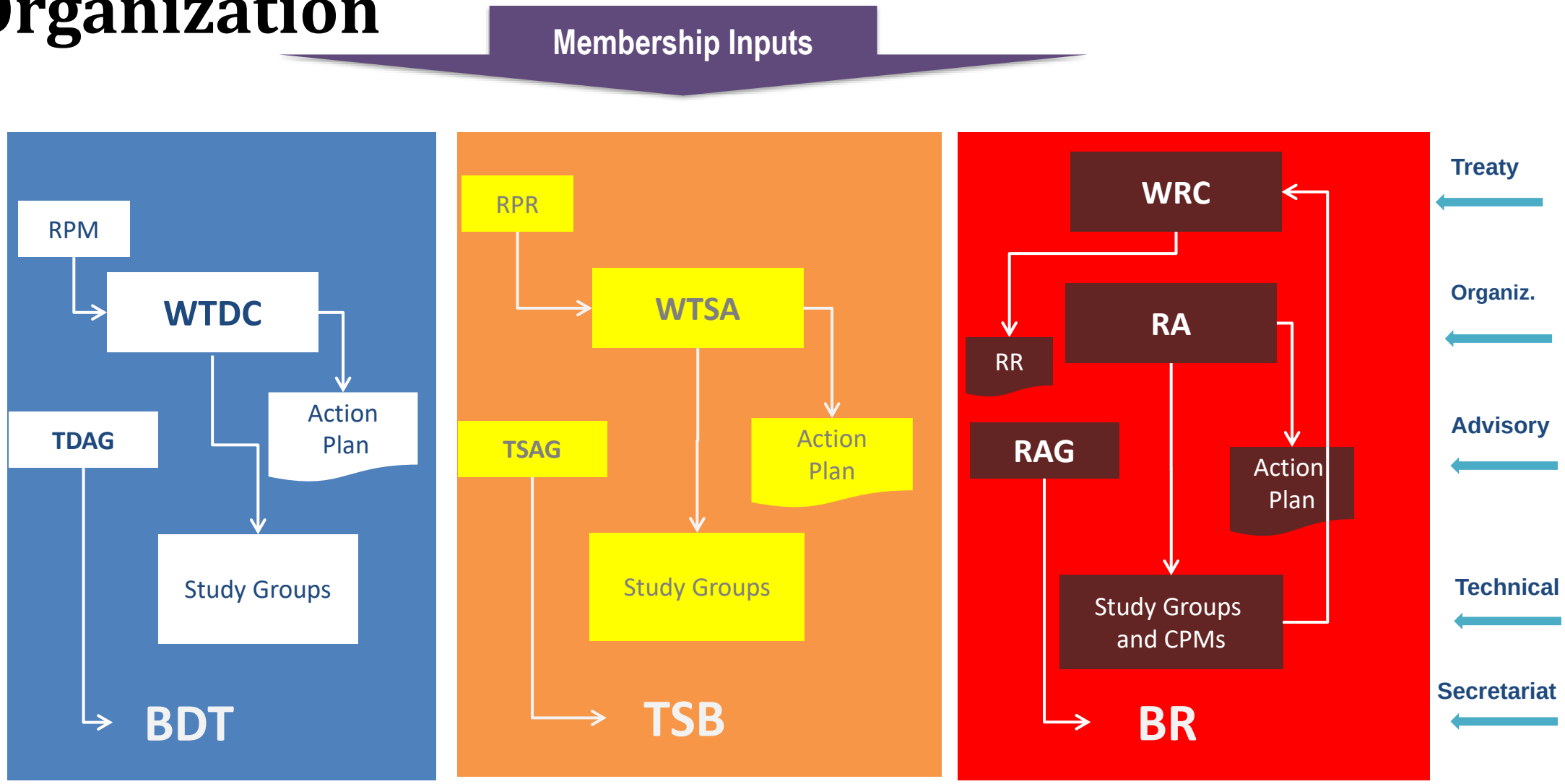
# ITU activities on EMF exposure issues

# ITU – Organization

Each sector has separate mandate, but all work cohesively towards connecting the world



# ITU – Organization



# ITU overall mandate

1. ITU Plenipotentiary Resolution 176 (Rev. Busan, 2014): *Human exposure to and measurement of electromagnetic fields*
2. ITU-T – Resolution 72 on “Measurement concerns related to human exposure to electromagnetic fields”
3. ITU-D– Resolution 62 on "Measurement concerns related to human exposure to EMF"
4. ITU-D Question 7/2 (Continuation of Q 23/1) *Strategies and Policies Concerning Human Exposure To Electromagnetic Fields*
5. ITU-T SG5: Environment and Climate Change: Question 7/5 (Continuation of Q3/5): Human exposure to electromagnetic fields (EMFs) due to radio systems and mobile equipment

# Inter-sectoral Activities

- ITU-D/R/T EMF activities to avoid overlap, mainly:
  - *D: **Strategies** & **Policies** concerning human exposure to EMF*
  - *R: EMF **measurements** from **base stations** to assess human exposure*
  - *T: **Simulation**, assessment, **5G***
- Comments to the new ICNIRP guidelines on “Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields, (100 kHz TO 300 GHz)”.
  - *32 comments have been included and sent to ICNIRP; see TD696-R1 and ICNIRP main Revisions, presentation of Dr. Rongen, Chair ICNIRP*
- ITU EMF guide

**BACKGROUND PAPER**

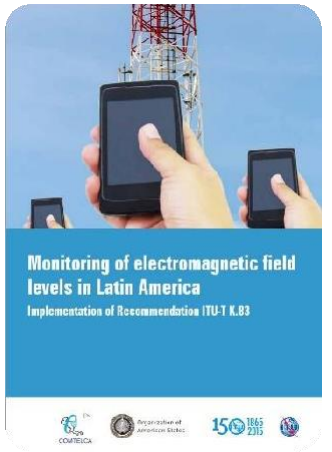
**ITU REGIONAL FORUM FOR EUROPE: 5G STRATEGIES, POLICIES, AND IMPLEMENTATION**


**IMPLEMENTING 5G FOR GOOD: DO EMFs MATTER?**



Version 1.3

# Best practices to raise awareness on EMF

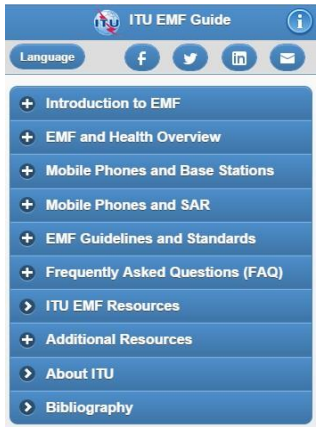



## Key elements for successful public communications:

1) Information easy to understand;
2) Open and transparent dialogues;
3) Providing stakeholders with trusted sources of information.

## ITU's Public information on EMF:

1) ITU EMF Guide – key information source
2) EMF Website
3) Report on "Monitoring of electromagnetic field levels in Latin America"
4) Best practices to reduce exposure from mobile devices




The EMF Guide mobile app in the 6 UN official languages is available online at http://emfguide.itu.int. It is also available in Malay.

# A practical guide for EMF measurements to assess human exposure

- Basic knowledge for a successful EMF assessment measurement process
- Available types of measurement instruments with specific features for EMF assessment

  - Personal monitor for occupational exposure
  - Broadband meters
  - Frequency selective meters
  - Handheld spectrum analyser with isotropic- antennas, 9 kHz to 6 GHz
  - Frequency selective meter dedicated to EMF, with isotropic-antenna

- **How to assess the exposure due to specific services**

  - General approach for services where extrapolation is not required
  - GSM base stations
  - UMTS base stations
  - LTE base stations

# ITU-D EMF related activities

**ITU-D**
**/DEVELOPMENT/**

- WTDC-17 Resolution 62 (Rev. Buenos Aires, 2017)
- Report for WTDC 2021 titled : **Policies, Guidelines, Regulations and Assessments of Human Exposure to RF-EMF**
  - *To provide content on the establishment of limits for maximum exposure to non-ionizing electromagnetic radiation from radio base stations.*

# ITU-D EMF related activities

**ITU-D**
**/DEVELOPMENT/**

- SG-2 Question 7/2 final report to WTDC 2017: **Strategies and policies concerning human exposure to electromagnetic fields**
  - *https://www.itu.int/pub/D-STG-SG02.07.1-2017*

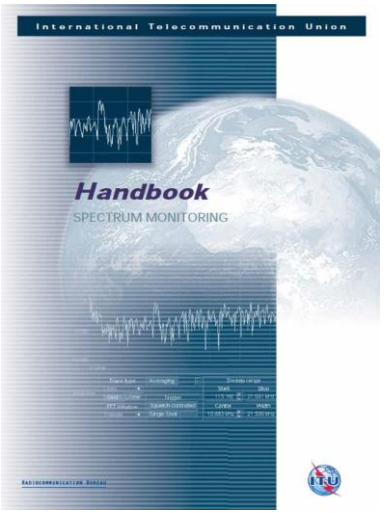
At October 2020 meeting of Q 7/2, this text was adopted:
"Administrations are encouraged to follow the ICNIRP Guidelines or IEEE Standard, or limits set by their own experts. The best practice for Administrations that choose to use international RF-EMF exposure limits is to limit the exposure levels to the thresholds specified in ICNIRP (2020) Guidelines."

| Deliverable | Label | Title |
|---|---|---|
| WTDC-17 | Resolution 62 (Rev. Buenos Aires, 2017) | Assessment and measurement of human exposure to electromagnetic fields |
| Question 7/2 | Final Report to WTDC-2017 | Strategies and policies concerning human exposure to electromagnetic fields |
| Question 7/2 | Draft Report to WTDC-2021 | Policies, Guidelines, Regulations and Assessments of Human Exposure to RF-EMF |
| ITU indicators | 24th Edition/July 2020 | Mobile-cellular subscriptions (billions) and world-average cellular-penetration per 100 inhabitants |

*| Meet the sectors*

# ITU-R
## /RADIOCOMMUNICATIONS/

# ITU-R activities on EMF




- **Handbook on Spectrum Monitoring**
  - Section 5.6 on Non-Ionizing Radiation (NIR) measurements
    - Explains NIR limits & exposure quotient
    - Instruments for NIR measurements including
      - *Broadband isotropic probes and meters*
      - *Tri-axis antennas and field strength meters*
      - *Transportable station*
      - *standard field strength measurement equipment*
    - Measurement procedures for different radio services (incl. mobile, broadcasting, etc.)
    - Reporting methods

- **ITU-R Report SM.2452 "Electromagnetic field measurements to assess human exposure" provides significant measurements' information.**

# Some ITU-R Recommendations on EMF related issues

| | |
|---|---|
| **[ITU-R BS.1195]** | Recommendation: Transmitting antenna characteristics at VHF and UHF |
| **[ITU-R BS.1698]** | Recommendation: Evaluating fields from **terrestrial broadcasting transmitting** systems operating in any frequency band for assessing exposure to non-ionizing radiation. |
| **[ITU-R P.1238]** | Recommendation: Propagation data and prediction methods for the planning of indoor radiocommunication systems and radio local area networks in the frequency range 300 MHz to 100 GHz. |
| **[ITU-R P.1411-9]** | Recommendation: Propagation data and prediction methods for the planning of short-range outdoor radiocommunication systems and radio local area networks in the frequency range 300 MHz to 100 GHz. |
| **[ITU-R P.2108-0]** | Recommendation: Prediction of Clutter Loss. |
| **[ITU-R P.2109-0]** | Recommendation: Prediction of Building Entry Loss. |

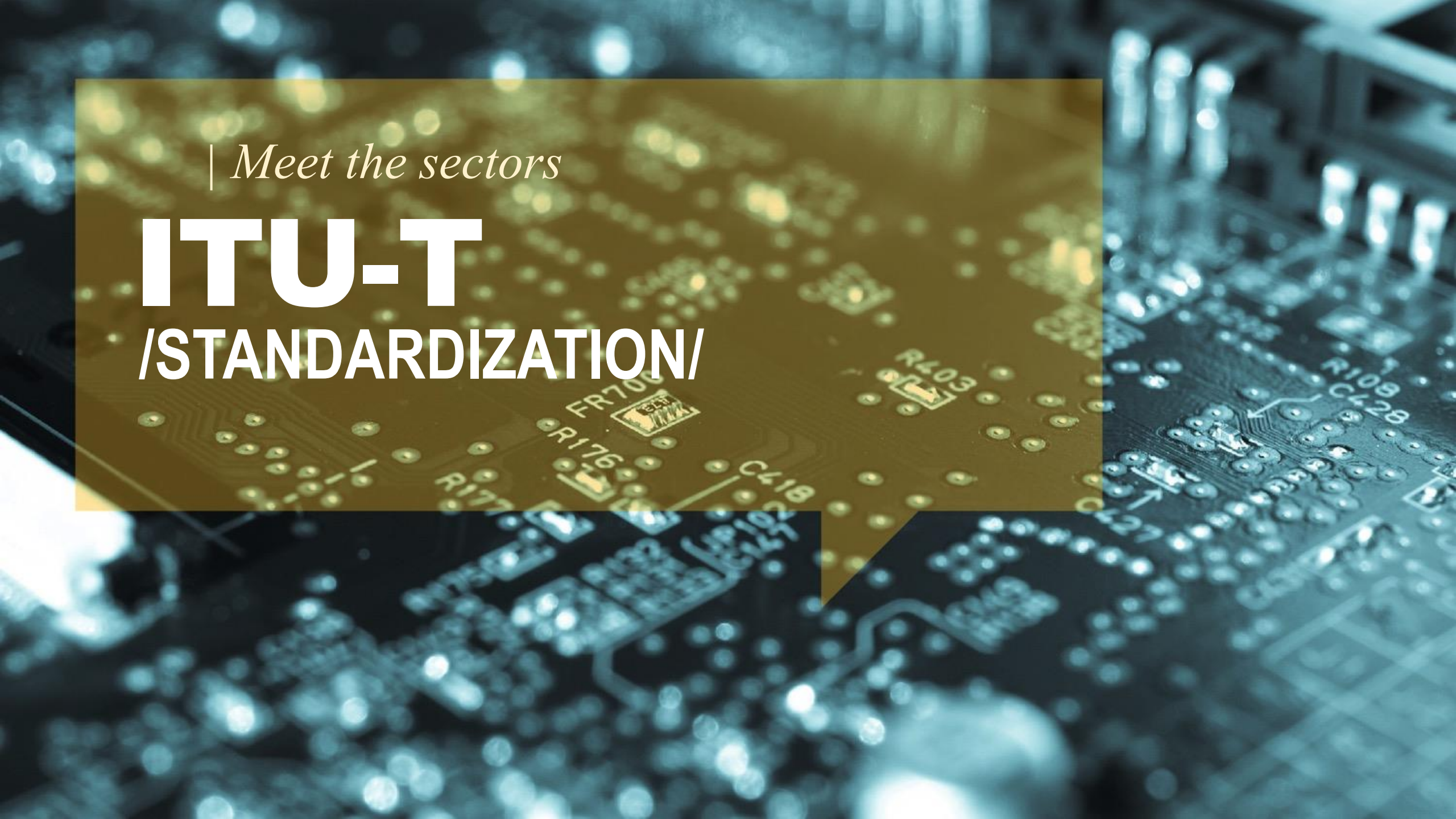
# Some ITU-R Recommendations on EMF related issues

- **ITU-R Working Parties 5A, 5B, 5C and 5D share these views:**
  - "exposure limits should be established, based on scientific evidence, endorsed by the World Health Organization (WHO). The establishment of restrictive exposure limits may impact the deployment of wireless networks".

- **ITU-R Study Group 1 Working Party 1C working on "Spectrum monitoring" views**
  - that administrations conducting monitoring tasks may place more emphasis on measurements from cellular, broadcasting and amateur radio stations, relative to the voluntary personal handsets and terminals. WP1C is pleased to continue collaboration with ITU-D and ITU-T on this matter.

- **New Question 1/239 on "Electromagnetic field measurements to assess human exposure" is studying:**
  - What are the measurements techniques to assess the human exposure from wireless installations of all types?
  - How can measurement results be presented?

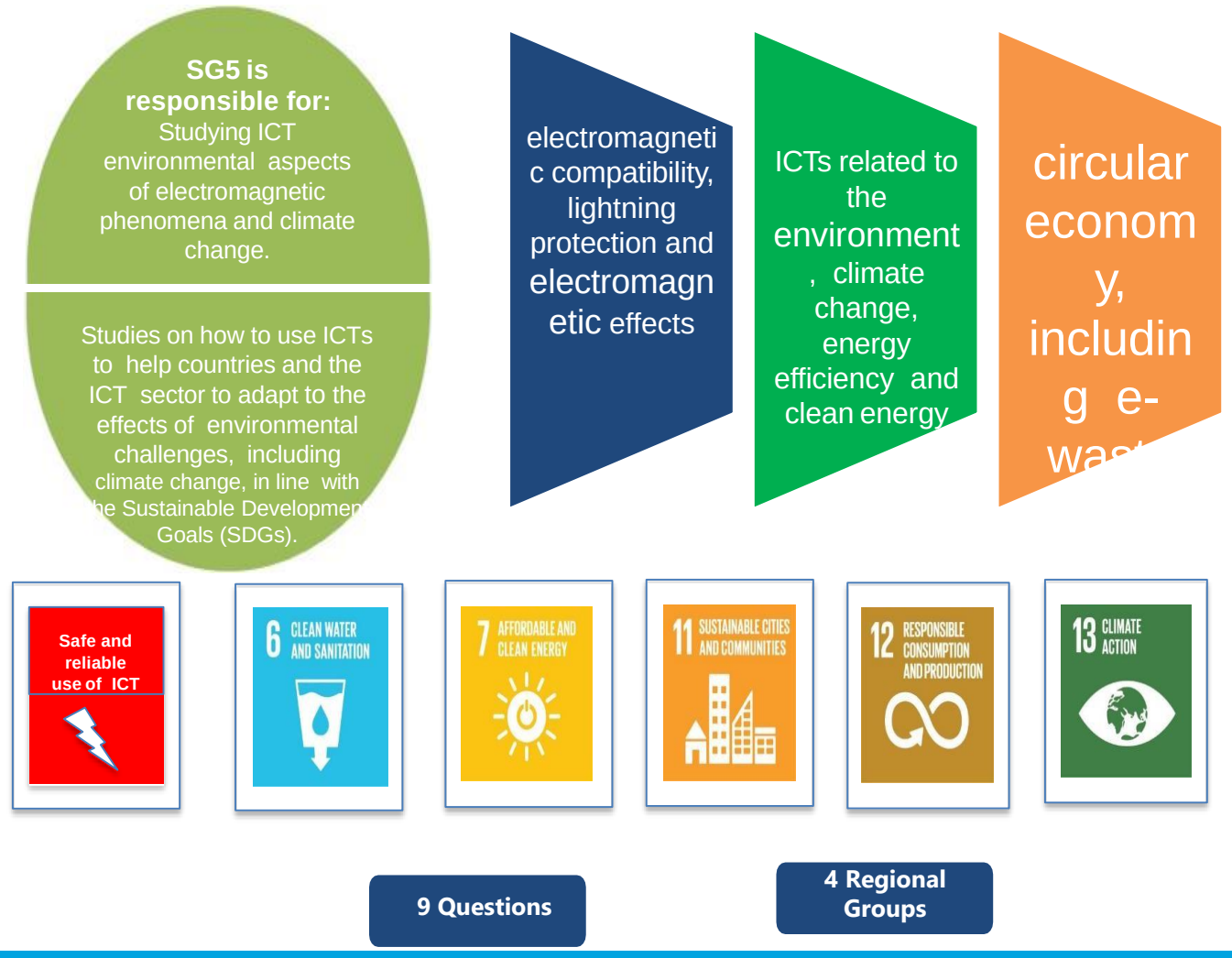
**Source**: BDT SG 2 Q7/2 report


| Meet the sectors
ITU-T
/STANDARDIZATION/

# ITU-T activities on EMF

**Study Group 5 is the ITU-T Study Group responsible for studies on methodologies for evaluating the ICT effects on climate change and publishing guidelines for using ICTs in an eco-friendly way.**

- Under its environmental mandate SG 5 is also responsible for studying the electromagnetic compatibility (EMC) of devices and networks.
- K series of recommendations
- ITU-T EMF studies are advanced in Study Group 5 Question 3/5: “Human exposure to electromagnetic fields (EMFs)



# ITU-T activities on EMF

**Relevant Recommendations of ITU-T SG5**

Microsoft Word Document

Some Recommendations of ITU-T SG 5 such as K.52, K61, K70 K.83, K.90, K.91, K.100 and K.113 have adopted ICNIRP limits and recommend best practice and mitigation techniques in the protection against non-ionizing radiation, taking into consideration areas near transmitters and base stations with many radiating sources representing different radio communication and broadcasting systems.

# Some new ITU-T Supplements on EMF

- K.Suppl.16 to ITU-T K.series (ex.K.Supp-5G_EMF_Compliance): “EMF compliance assessments for 5G wireless networks” see document TD723

- Supplement 4 to ITU-T K.91 on “EMF considerations in smart sustainable cities” see TD724-R1
- New version of software EMF-estimator (Appendix I to K.70) and software K.52-calculator; see TD721 & TD722

- new App VIII “Manhole BS” & App IX “EMF monitoring & info platform” see TD725 & TD727-R1

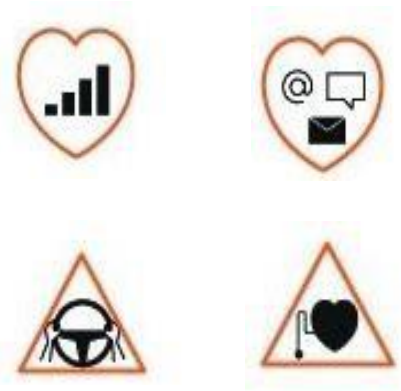
- **Supplement ITU-T K.Suppl.13** on RF-EMF exposure levels from mobile and portable devices during different conditions of use

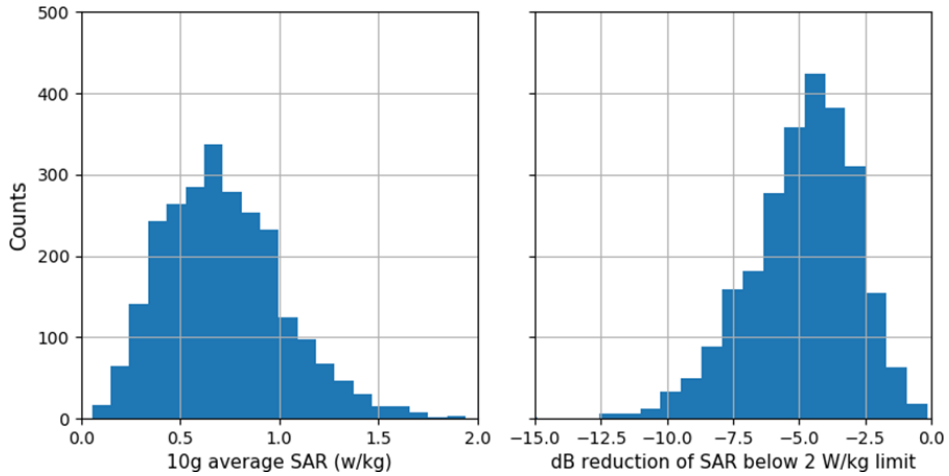
- **Supplement ITU-T K.Suppl.14** on impact of RF-EMF exposure limits stricter than the ICNIRP or IEEE guidelines on 4G and 5G mobile network deployment

# **Supplement ITU-T K.Suppl.13:** RF-EMF exposure levels from mobile and portable devices during different conditions of use

ITU-T K.Suppl.13 describes the various factors that determine the level of RF-EMF exposure, as defined by the specific absorption rate (SAR) that is induced in the users of mobile and portable radiocommunication devices. Based on this technical information **practical information and guidance is provided for users of mobile devices**. This Supplement presents:

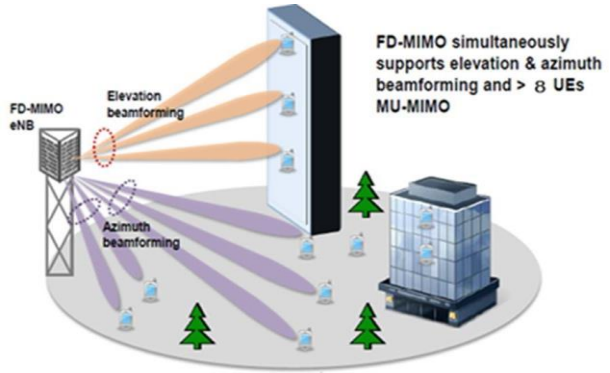
- **Best practices presented in a way understandable for the general public;**
- **Best practices presented with scientific justifications.**

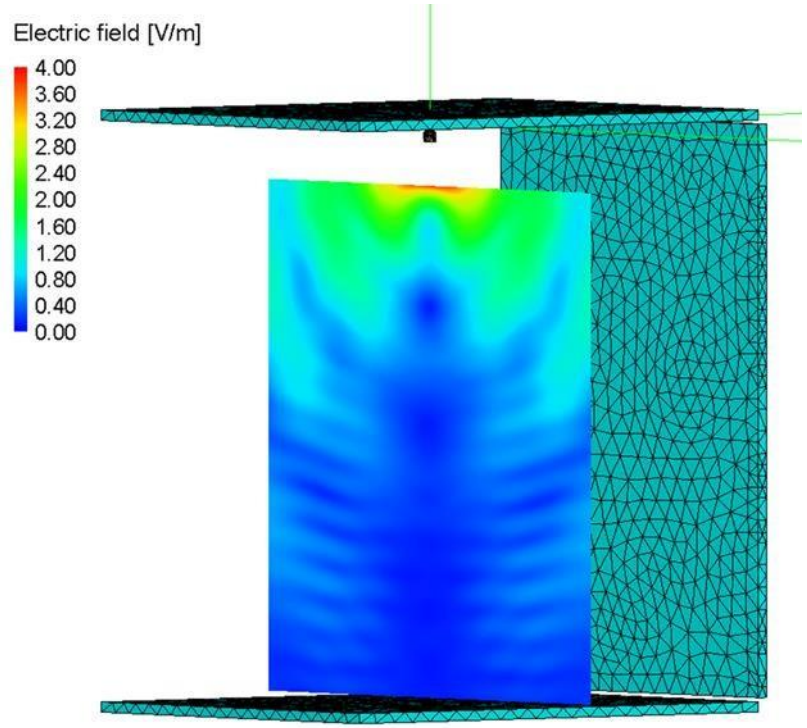




# K Suppl. 9 (11/2017) 5G technology and human exposure to RF EMF

- Higher frequencies and higher throughput
- Shared infrastructure
- Smart antennas
- Small cells
- Internet of things (IoT), M2M



# Case studies and Comparisons of Exposure Limits

Comparison made before latest ICNIRP guidelines

# **EXPOSURE LIMITS:** Overall comparison of power density and SAR

| Country | PD 1,000 MHz (W/m²) | SAR (W/kg) |
|---|---|---|
| United States of America | f/150 =6.67; 133/% | 1.6, averaged over 1g tissue |
| Japan | | 2.0, over 10 g |
| France and United Kingdom | f/200 =5; 100% | |
| Republic of Korea | | 1.6, averaged over 1g tissue |
| Canada | 0.02619f 0.6834 =2.94; 59% | |
| People's Republic of China | 0.4; 8% | 2.0 W/kg, over 10 g |

**Source**: BDT SG 2 Q7/2 report

# Comparison of PFDs

## Limits for spectrum bands of mobile networks below 6 GHz

| | Power flux density ($\mu W/cm^2$) to protect population) | | | | |
|---|---|---|---|---|---|
| | **800 MHz** | **900 MHz** | **1800 MHz** | **2100 MHz** | **2600 MHz** |
| **FCC (USA)** | 533 | 600 | | 1000 | |
| **Canada** | 253 | 274 | 440 | 489 | 565 |
| **Turkey** | 100 | 112.5 | 225 | 250 | |
| **China** | | | 10 | | |
| **Italy** | | | 10 | | |
| **Poland** | | | 10 | | |
| **Switzerland** | | | 9.5 | | |

## Limits for spectrum bands above 5 GHz

| Power flux density ($\mu W/cm^2$) (to protect population) | |
|---|---|
| **USA, Canada, South Korea, Japan, the majority of European countries** | 1000 |
| **China, Italy, Poland, Hungary, Lithuania, Bulgaria** | 10 |
| **Switzerland: Average level**<br>**Ukraine in sensitive locations (schools, hospitals)** | 9.5<br>4.25 |
| **Likhtenstein** | 0.1 |

**Source**: Mr Pavel, Megafone Russia

# EMF measurements and case studies

# French measurements of EMF public exposure

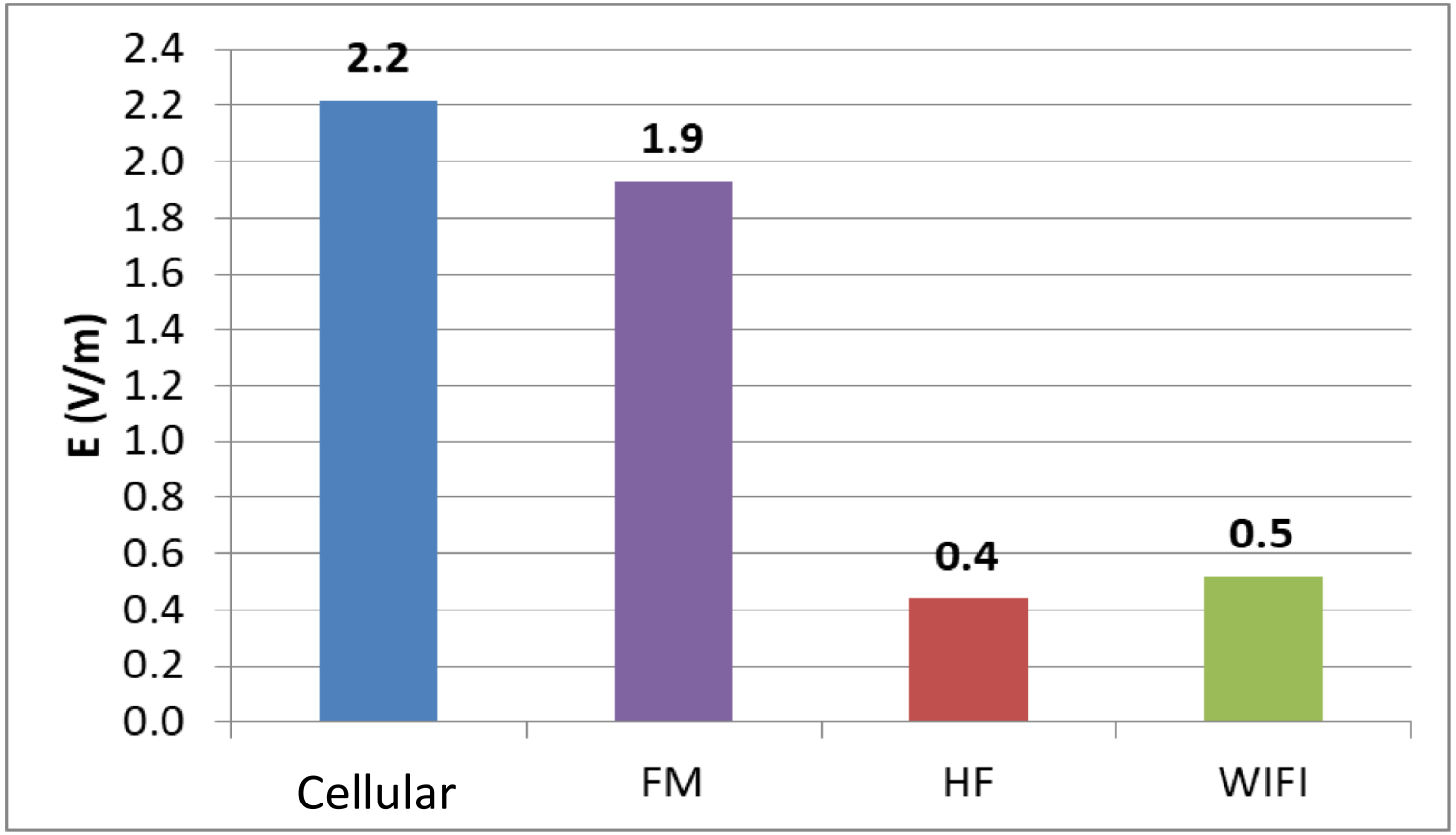
ANFR: *Agence nationale des fréquences*

ANFR (2018) results achieved in 2017 as part of the national monitoring system

1. ANFR publishes its annual study on the analysis of over 2,500 measurements of EMF exposures carried out in 2017. All these measures comply with the statutory exposure limit values of the public. The **exposure levels measured in 2017 are broadly comparable to those observed each year since 2014, with a median field strength of 0.36 V/m**
2. This study also shows that **90% of the measured levels are lower than 1.6 V/m**. These levels **are slightly higher in urban areas (1.67 V/m) than in rural areas (0.95 V / m), and higher outdoors (1.93 V/m) than indoors (1,34 V/m)**
3. In nearly 60% of cases, mobile networks are the main source of exposure. In rural areas, however, only 51% of cases cellular exposure dominates. Similarly, in rural areas, in 25% of cases, no significant source is measured, while outdoor mobile relays dominate in more than 70% of cases.
4. Compared with the results obtained in the two previous years (nearly 3,000 measurements in 2016 and more than 3,500 measurements in 2015), **the characteristics of the measurements requested and the levels of exposure recorded appear stable.**

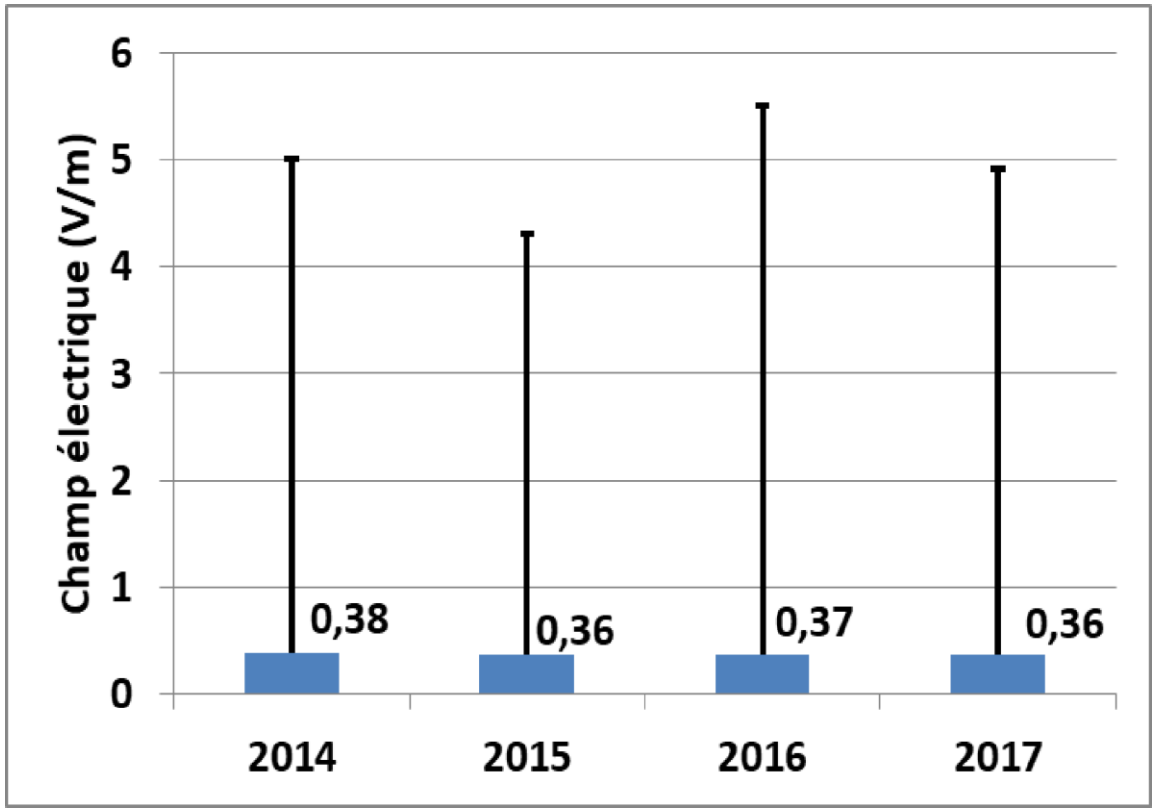
# ANFR: Principal Contributors to the RF-EMF exposure

when cellular dominates, 90% of the measured levels are < 2.2 V/m




See ANFR Sept. 2018 , Fig 11

# ANFR: median values (blue bars) and 99% percentiles (black lines) 2014-2017




Median level 4,500 times below limit

See ANFR Sept. 2018 Fig. 9

# OFCOM: results of EMF exposure measurements

Close to sixteen 5G-enabled mobile phone base stations showing RF-EMF levels at a total of 22 5G sites in 10 UK cities, including also measurements for 2G, 3G and 4G:

1. EMF exposure levels from 5G-enabled base stations remain at small fractions of the reference levels for public exposure in ICNIRP (1998) Guidelines (400–2,000 MHz)
f (MHz)/200 (W/m2), and 2–300 GHz 10 (W/m2);

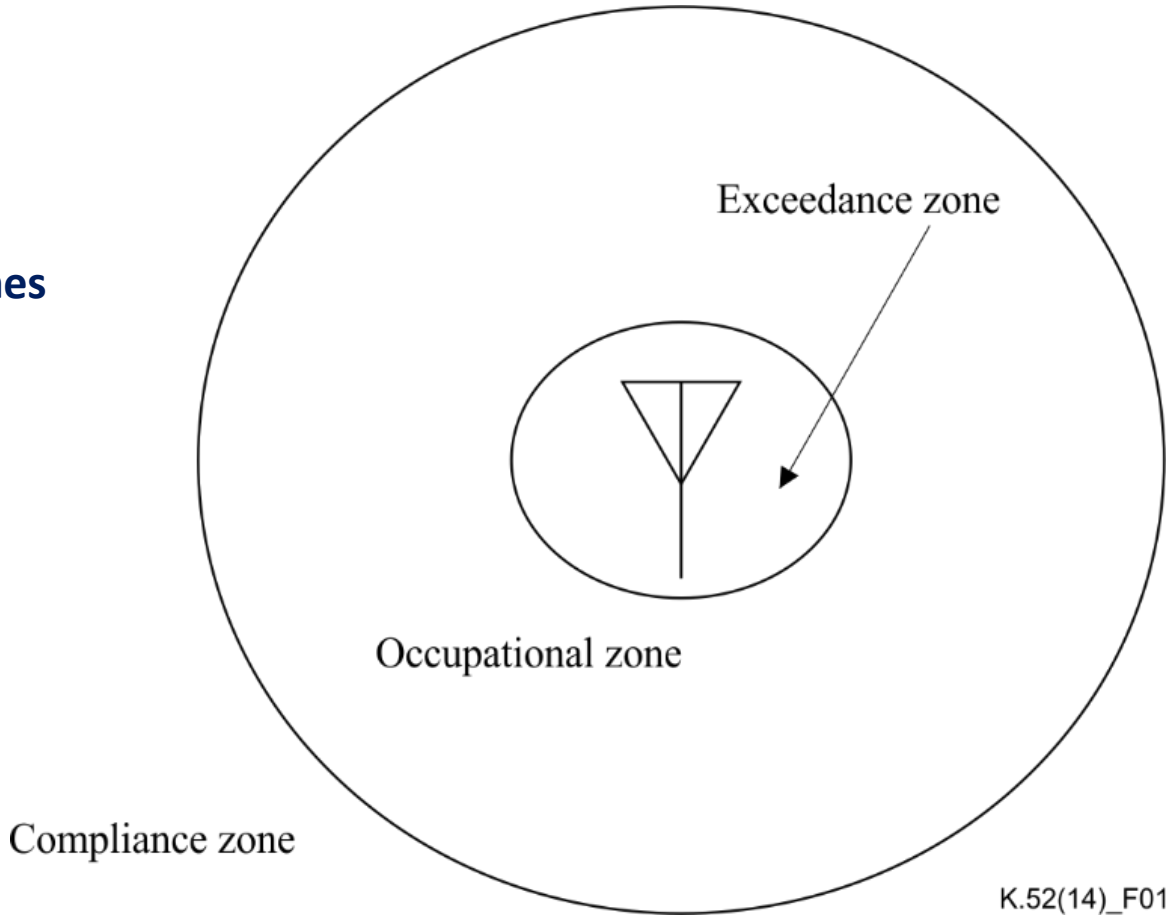
2. The highest level recorded being approximately 1.5% of the power-density reference level.

3. In all locations, the largest contribution to the measured levels comes from previous generations of mobile technology (2G, 3G, 4G);

4. The highest level observed in the band used for 5G was just 0.039% of the reference level.

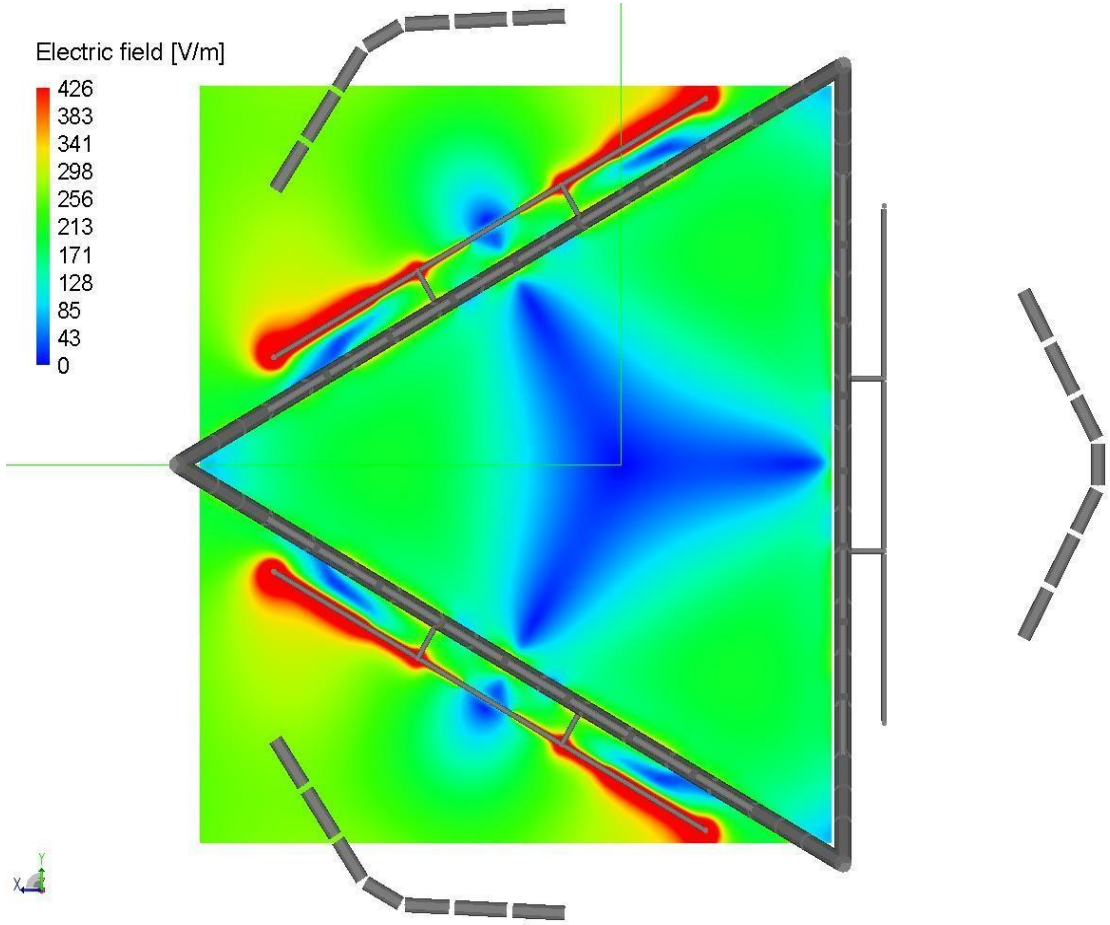
# Demonstrating Compliance and Exposure Zones

**Illustration of exposure zones**




see ITU-T 2018 K.52 Fig 1

# Near-field electric field-strength in close proximity of antennas at a side view : FM broadcasting

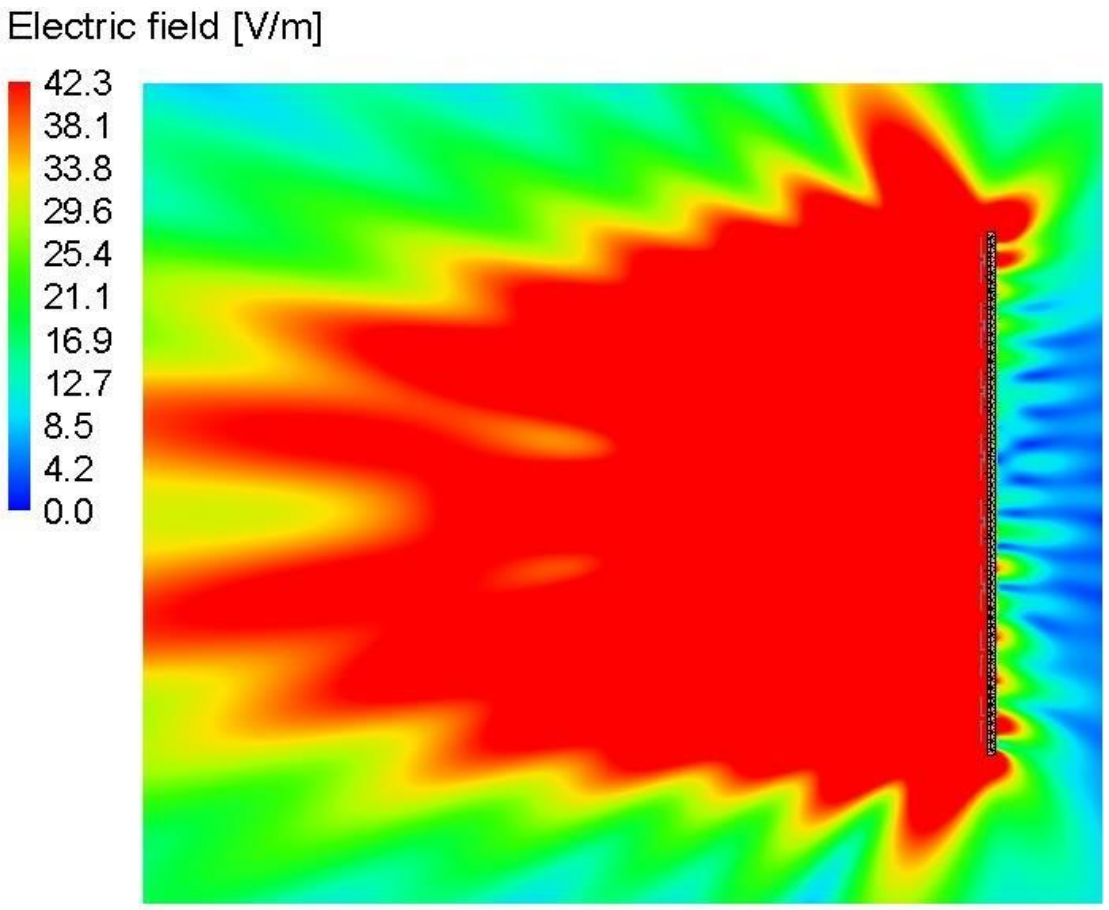



**horizontal cross-section,**
***f* = 88 MHz,**
**Pinput =18.8 kW,**
**attenuation =1.18 dB,**
**ERP = 120 kW**

see ITU-T 2016 Fig. 6-5

# Near-field exposure levels in close proximity, at a side view :GSM downlink

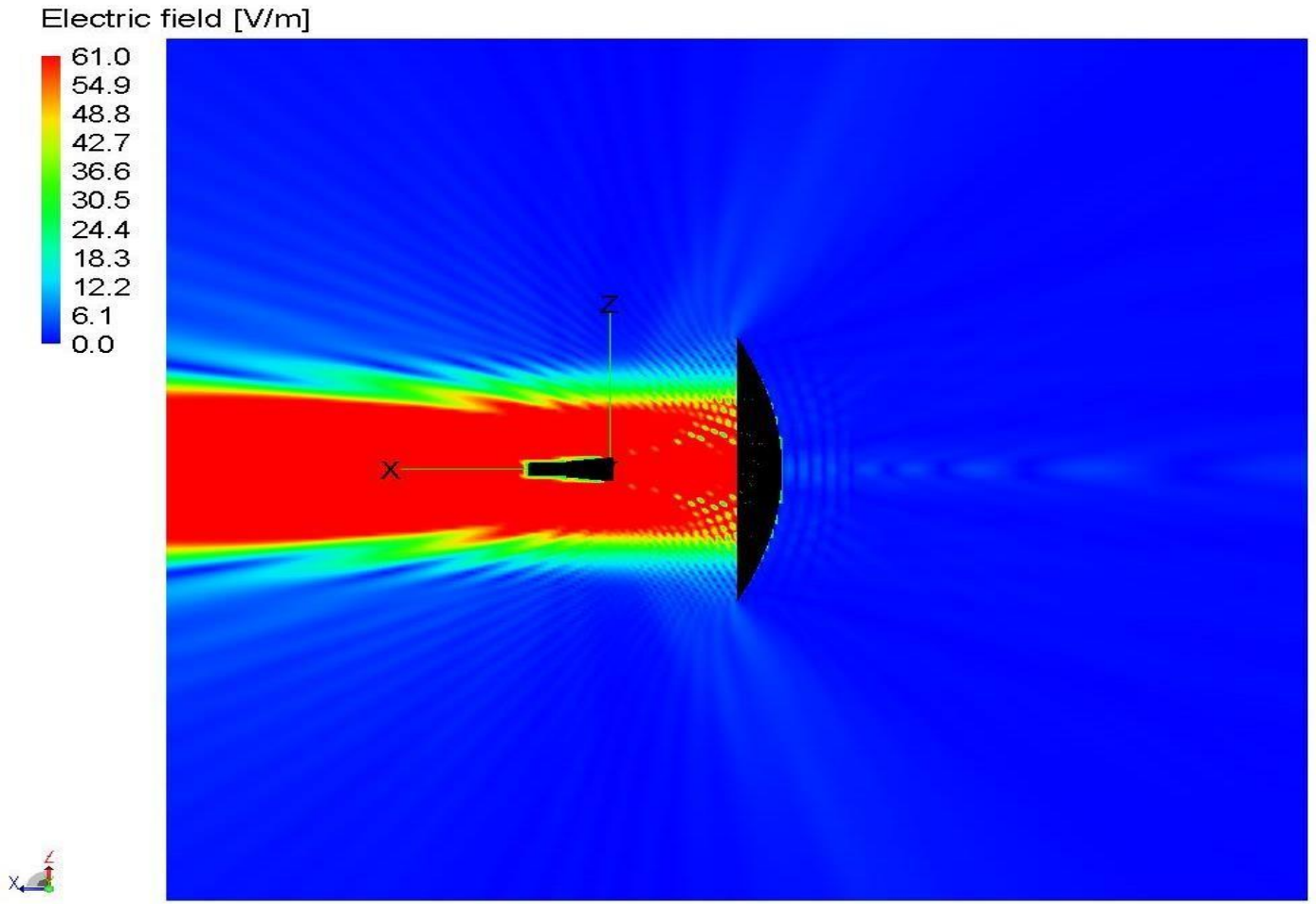
4 m height,
4.5 m width,
without a concrete wall,
$f$ = 947.5 MHz




see ITU-T 2016 Fig.9-4

# Near-field Exposure levels in close proximity, vertical cross-section :point to point

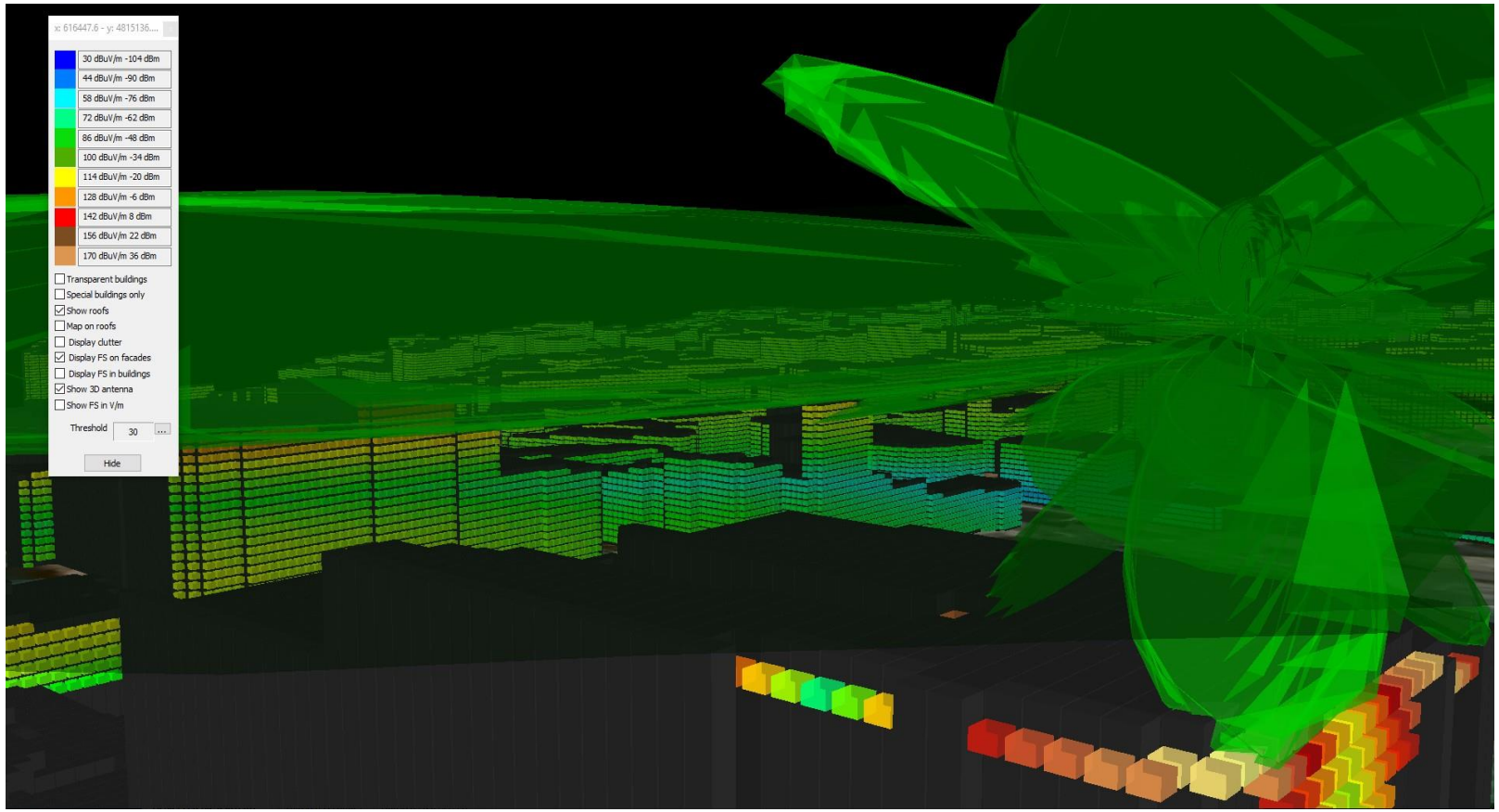
f = 22.4 GHz,
Pinput = 0.316 W,
area 1 m × 1 m,
EIRP = 0.657 kW,
occupational exposure limit: 137 V/m




see ITU-T 2016 Fig. 11-2

# Calculating far-field safety-distances around base stations using elevation ant. pattern

Ant. tilt 0 degrees;
also in azimuth antenna pattern is analysed;
typically in 3 sectors 5G,
there is azimuth overlap: 6dB attenuation in $\pm 60^0$ & 3dB $\pm 45^0$ around mainbeam



# Calculating Safety Distances; ITU-R 2011 HB

- In the frequency ranges, where the **electrical stimulation effects** are dominant, the calculation of the total exposure quotient is based on the field strengths directly.

- In the frequency ranges, where the **thermal effects** are dominant, the calculation of the total exposure quotient is based on the square of field strength values or on the power flux densities.

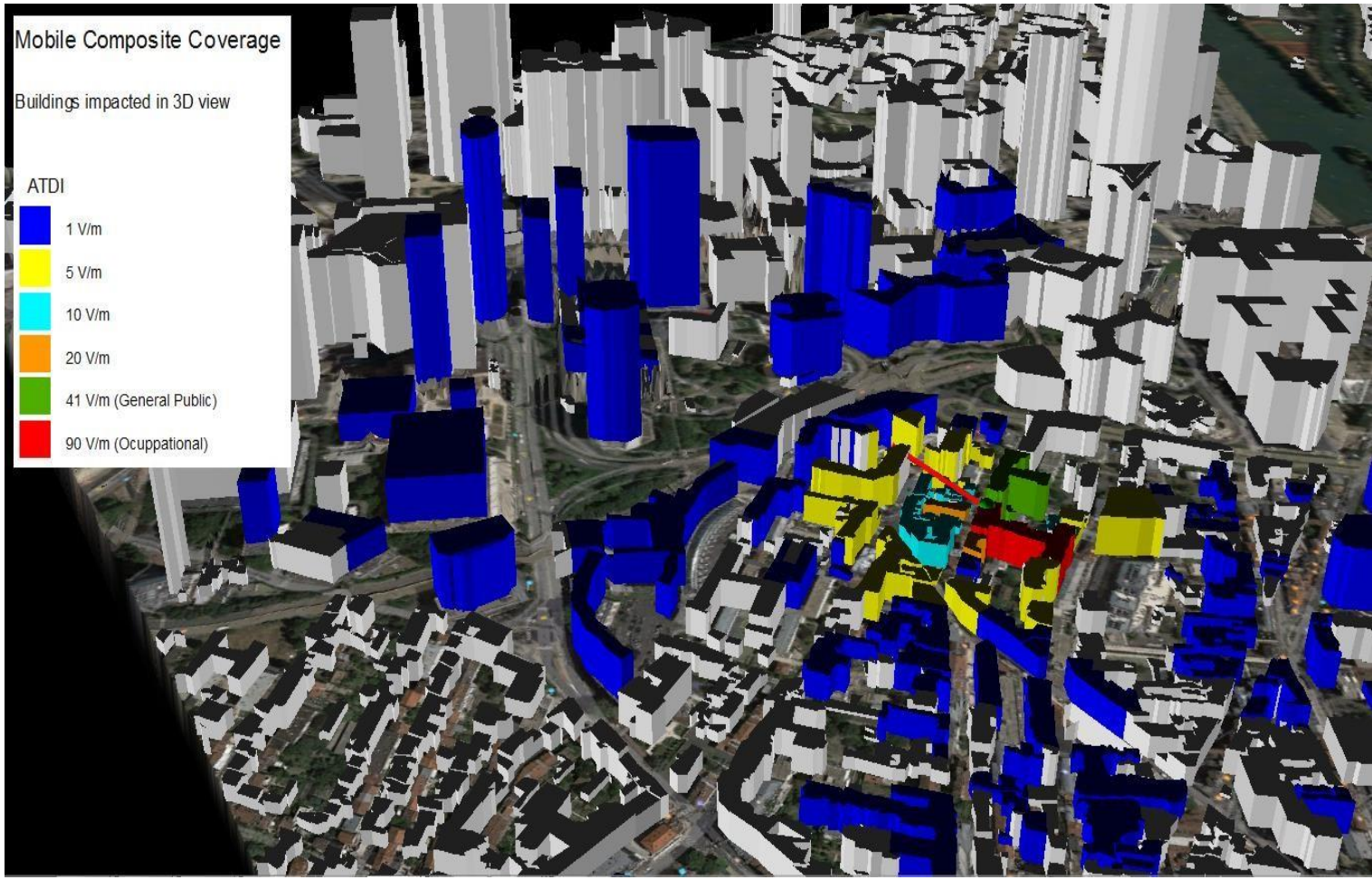
- In case there are spectral components situated in the common part of the two ranges (100 kHz-10 MHz), both types of total exposure quotients should be calculated and the value of both of them should be below one.

- **Measurements**
  - Electromagnetic fields can be sub-divided into two components: the electric field E (measured in V/m) and the magnetic field H (measured in A/m). The E-field and the H-field are mathematically interdependent in the far-field, that means only one component has to be measured. For example, in free space if the H-field is measured in this region, it can be used to calculate the magnitude of the E-field and power density S (W/m2):
  - In contrast, the H-field and E-field must be measured separately in the reactive near-field region and considered against the respective limits.

# Far-field 2-dimensions safety-distances, around FM Tx

# Far-field 3-dimensions cellular contours

Monaco

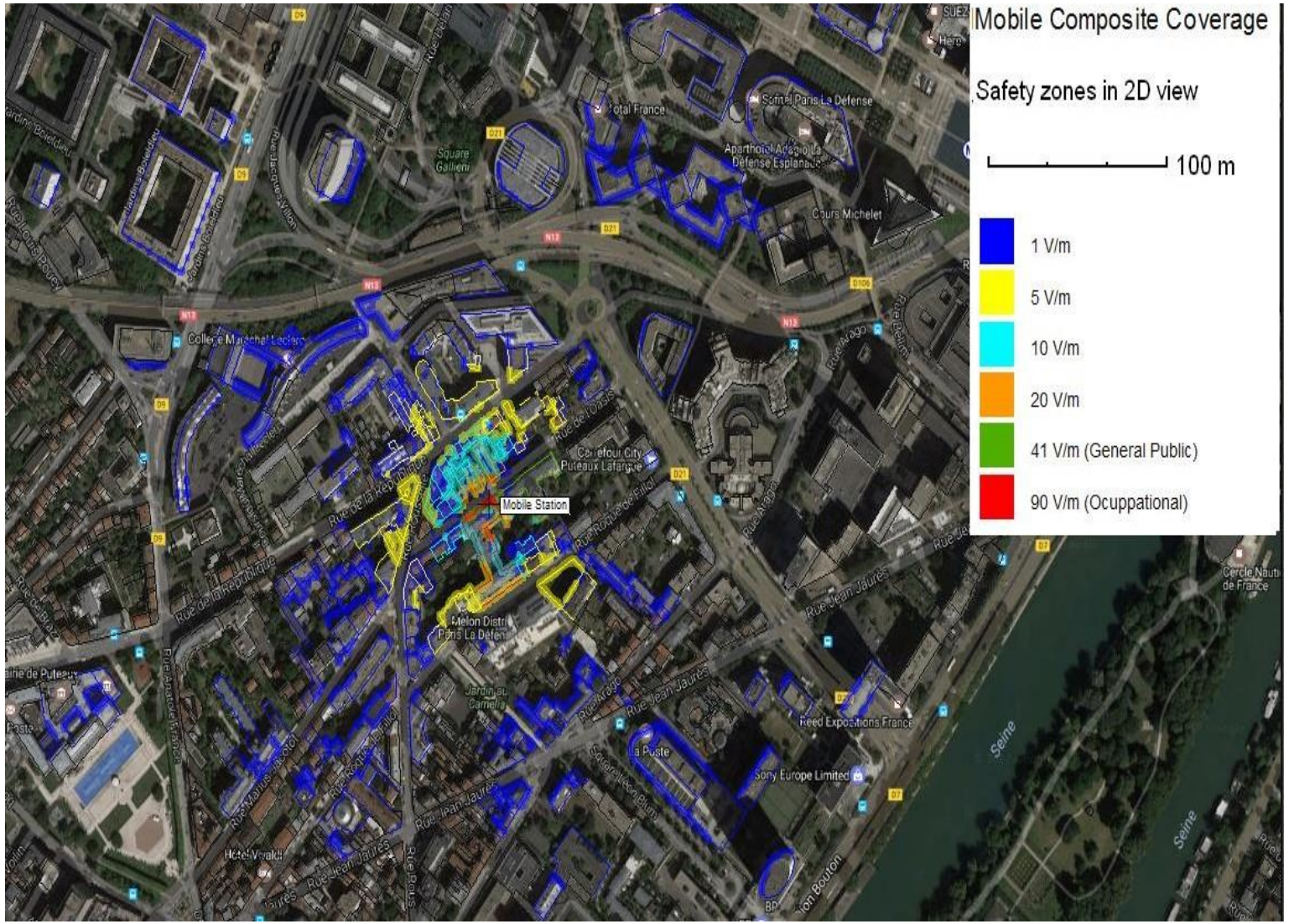



**Showing buildings impacted**

- RF=900 MHz,
- ICNIRP general-public reference-level 41 V/m & occupational; 3f 1/2 (MHz)= 90 V/M.
- Taking into account also wall attenuation;
- Tx 30 meters above roof;
- Rx mobile 1.5m

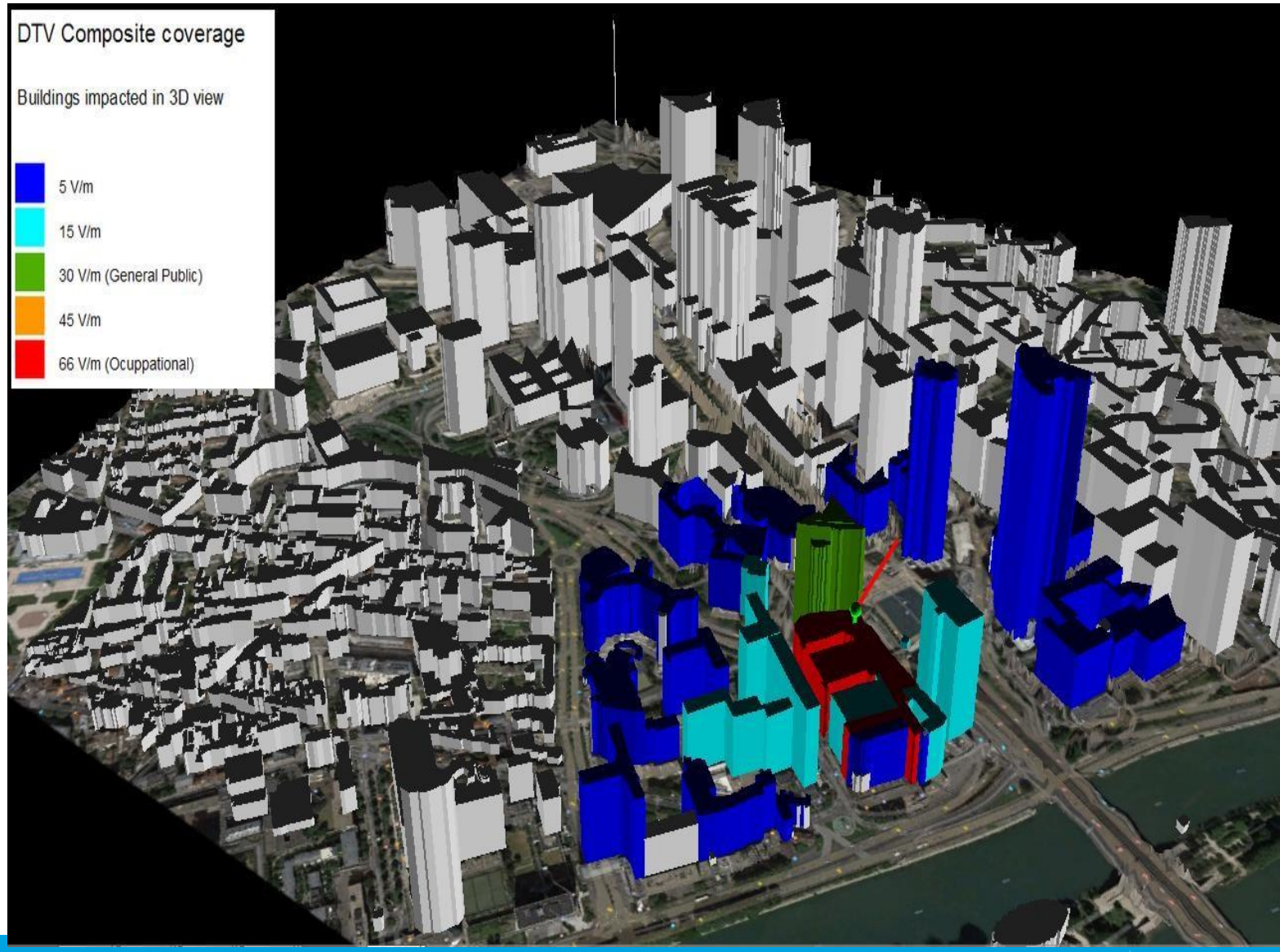
# Far-field 2-dimensions satellite view of cellular exposure-distances

Paris




Source ITU-R 2019 Fig 4

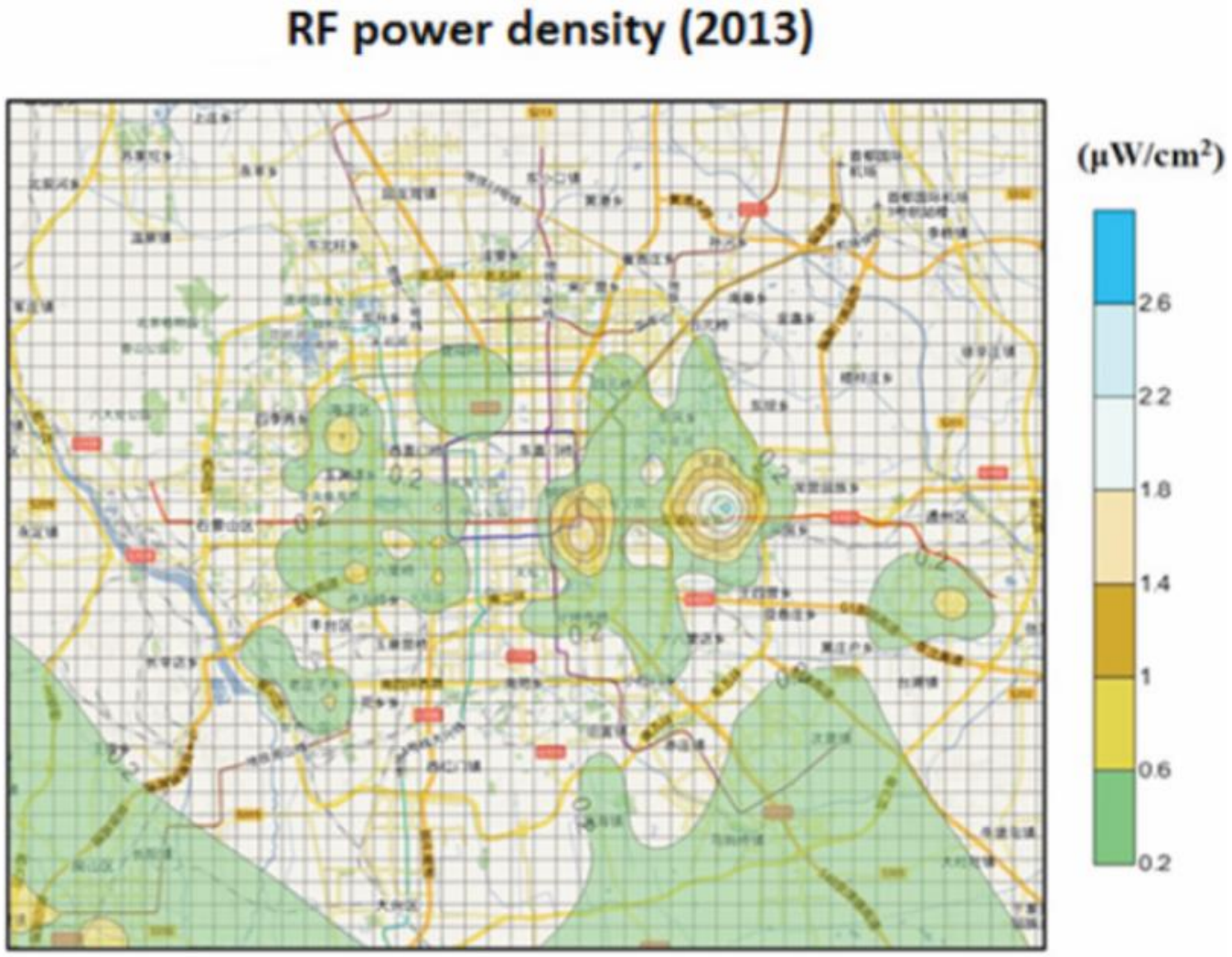
# Far-field 3-dimensions DTV general-public and occupational exposure-contours




Source ITU-R 2019 Fig 3

# The distribution of the electromagnetic environment in Beijing, China

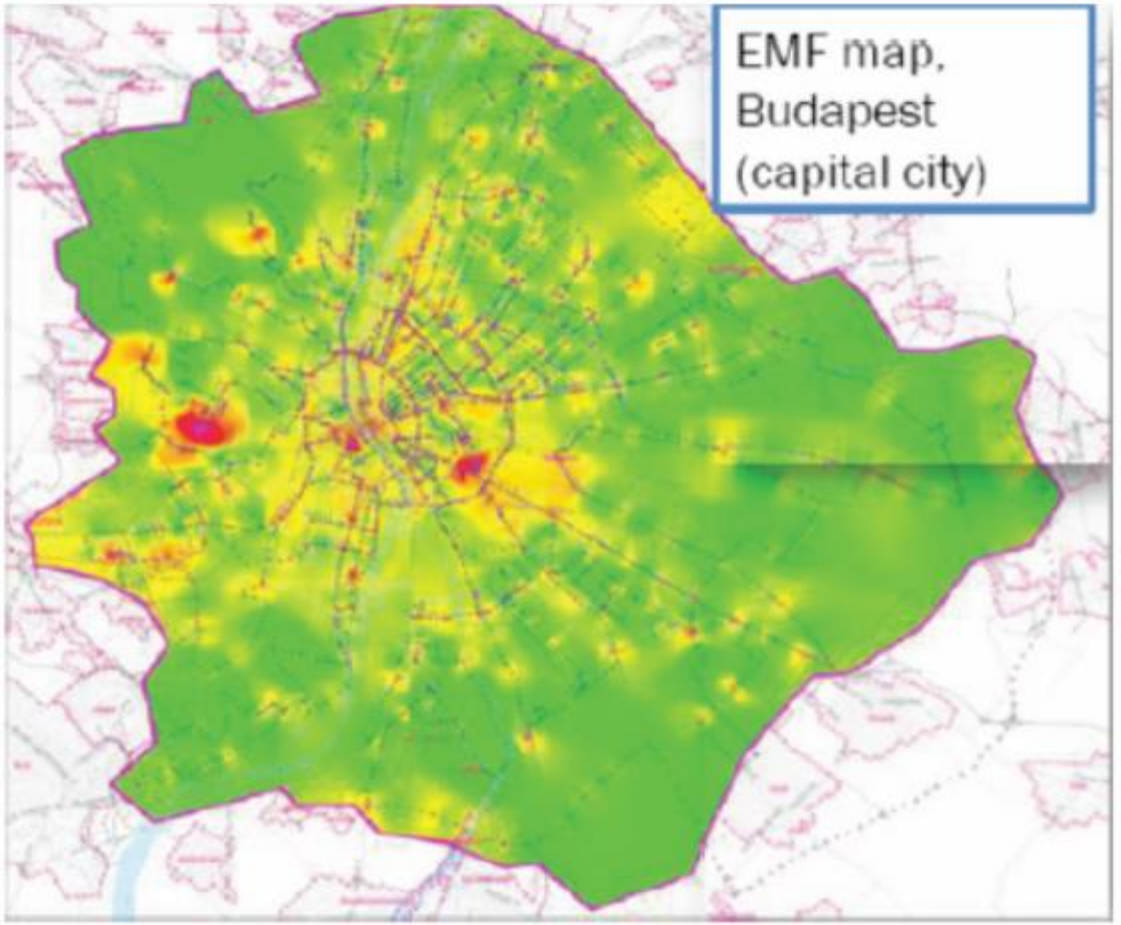
Safetytech implemented an electromagnetic environment investigation in Beijing downtown in 2013, divided the city to 352 grid point by 2km×2km, monitor each grid point center. The RF electromagnetic strength range from 0.2V/m to 6V/m, the average is 0.89V/m.




**Source**: BDT SG 2 Q7/2 report

# EMF Map
# Budapest , Hungary

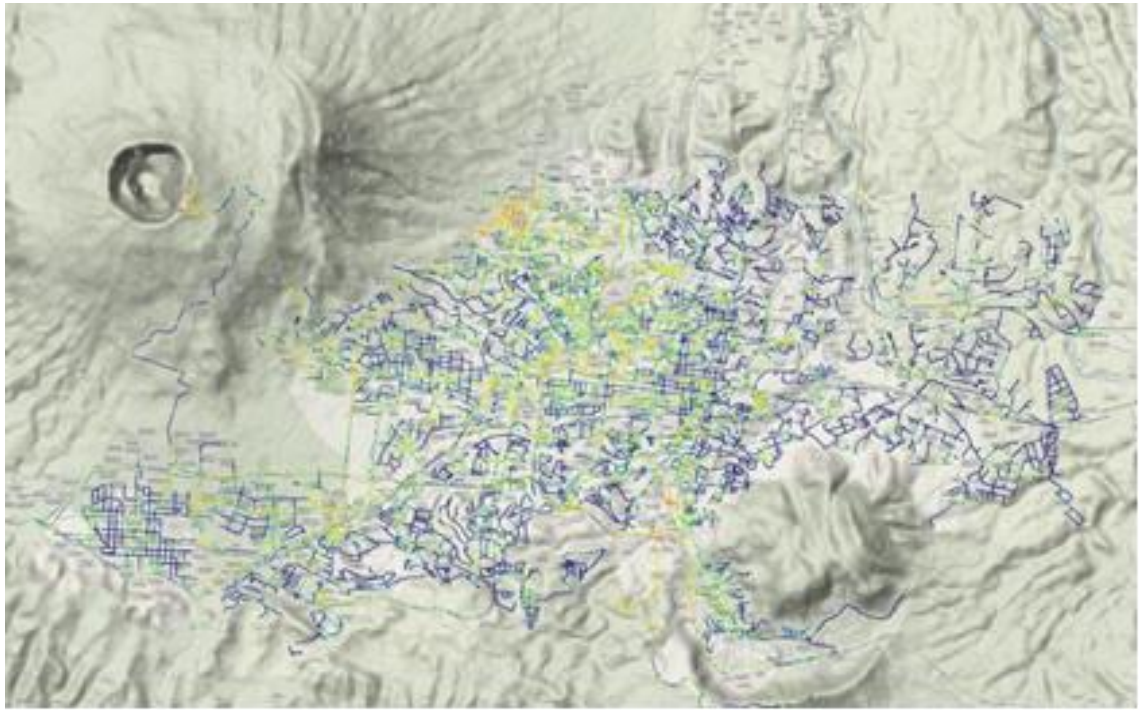
- Most cases the level of measured field is lower than 0.2V/M (green).
- High blocks of flats have lots of antennas, also some mobile base stations (yellow).
- The highest level of EMF field coming from **broadcast stations** (bigger red areas).
- Mobile base stations on lower building can cause higher field in small area (small red points).




**Source**: BDT SG 2 Q7/2 report

# NIR map of San Salvador, El Salvador

In this map you can see the levels of NIR that people can compare on a scale from blue to red, above which are outside the maximum limits specified by the WHO



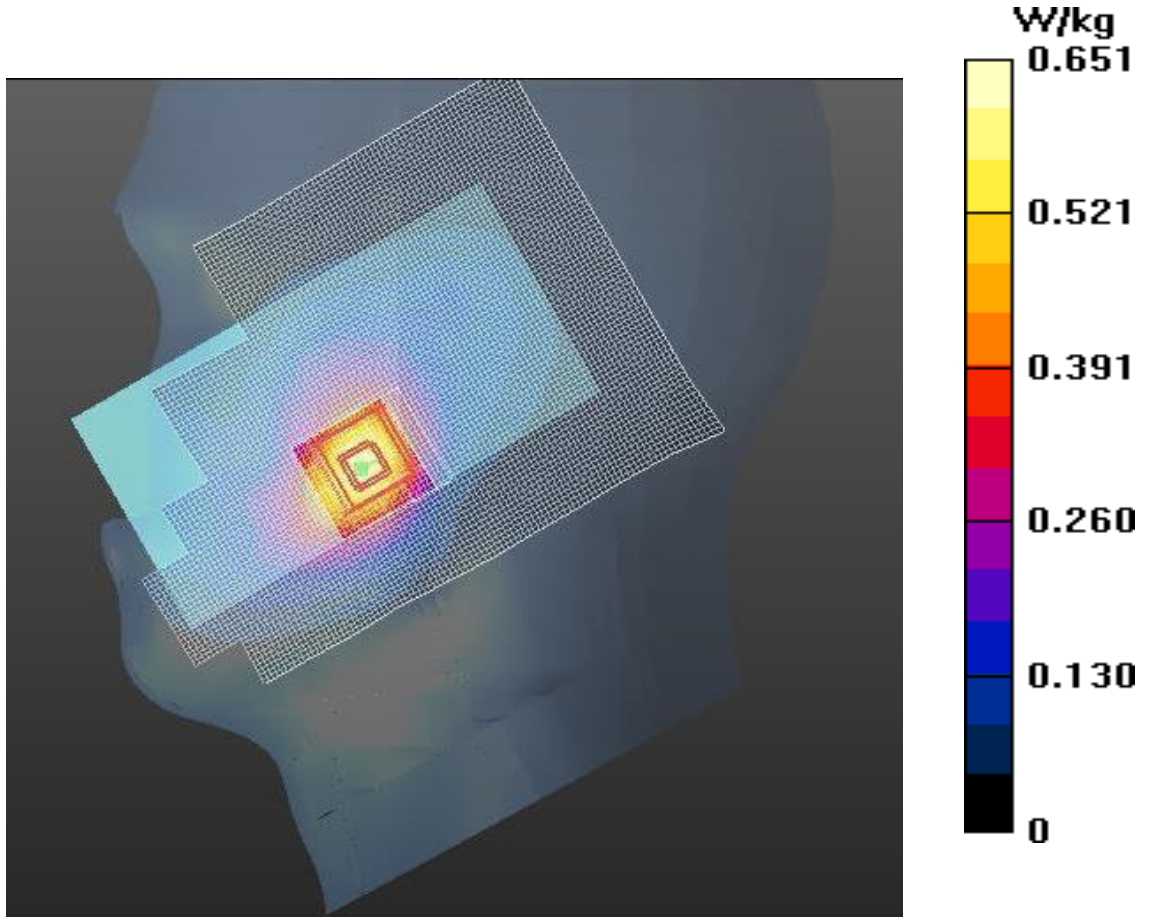
**Source**: BDT SG 1 Q23/1 report

# NIR map of Lomas de Zamora, Argentina

A small continuous monitoring system was deployed as a pilot, in order to achieve tranquility in various neighborhoods or in neighborhoods with high conflict due to NIR apprehension

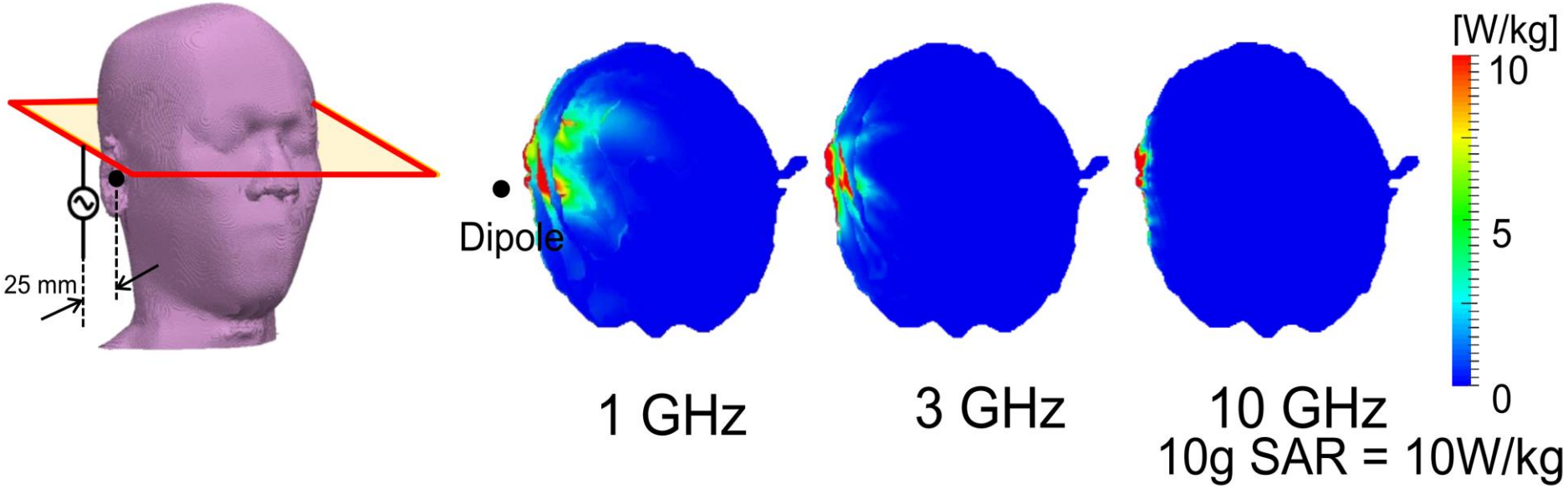

**Source**: BDT SG 1 Q23/1 report

# SAR real measurement for a commercial mobile phone




Source: Dr. Jafar Keshvari, Bio- electromagnetics Aalto University, Helsinki-Finland

# Measured power absorption in biological tissues; source, Akimasa **Hirata** in 5G higher RF



# **Public Narrative interventions:** Guidelines and Recommendations

# Why the wrong Impression?


## Mobile Phone Cooks Popcorn!

In a CNN news segment broadcast on July 9, 2008, CEO Abraham Glezerman of Cardo
Systems, a manufacturer of Bluetooth headsets, admitted that the whole thing had indeed been a marketing ploy.
"We sat down and said how can we create something that's funny, hilarious and causes people
to try and emulate it and eventually, of course, touching on our business," Glezerman tells CNN
correspondent Jason Carroll in the segment.

…

"The real thing is a mixture between a kitchen stove and digital editing," Glezerman says.
"You fried the popcorn separately somewhere else and then just dropped it in there, then digitally

Source: https://www.liveabout.com/cell-phone-popcorn-trick-revealed-3970601

"The real thing is a mixture between a kitchen stove and digital editing," Glezerman says

Source:
https://www.youtube.com/watch?v=V94shlqPlSI (~11 million views)
https://www.thoughtco.com/cell-phone-popcorn-trick-revealed-3970601

# Why the wrong Impression?

FAKE

The collective radiation of five cell phones was strong enough to pop a kernel of popcorn. Imagine what this can do to your head!

Source: https://www.youtube.com/watch?v=pqIZDIxJgXw

# Implications

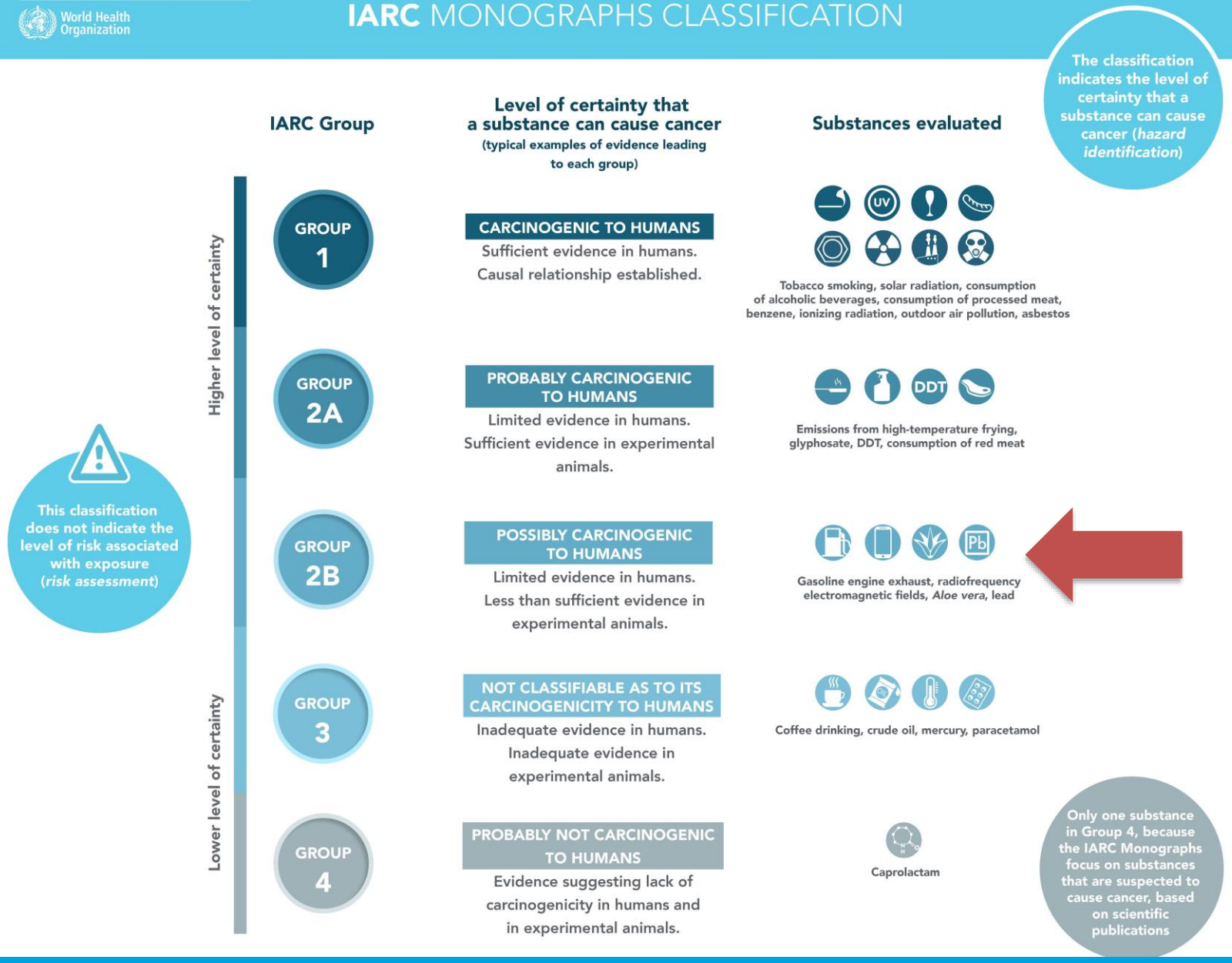
Compared to 4G, 5G, especially at higher frequencies, will more heavily rely on small cells, meaning that a greater number of 5G base stations will be installed. If not addressed, this factor alone may cause a number of socio-economic hazards including

Open Issue

- Misinformation
- Delays in installing base-stations
- Economic cost for society
- Environment, including EMF hazards to animals and plants

International Agency for Research on Cancer
World Health Organization

# IARC MONOGRAPHS CLASSIFICATION




**Group 1 : The agent is carcinogenic to humans. (e.g., Tobacco, Processed meat)**
There is *sufficient* evidence of carcinogenicity in humans.

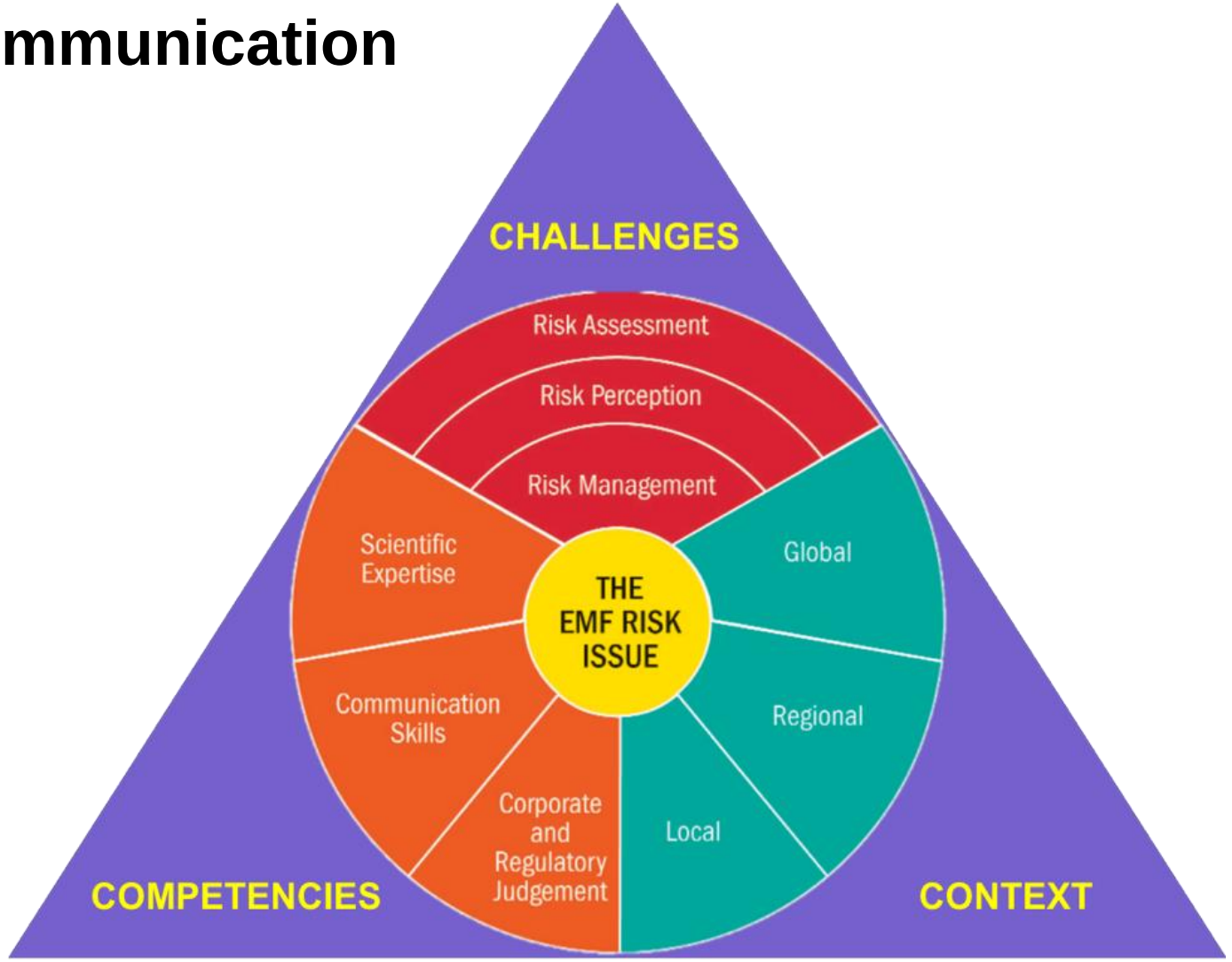
**Group 2A : The agent is probably carcinogenic to humans. (e.g., Red meat)**
There is *limited* evidence of carcinogenicity in humans and *sufficient* evidence in experimental animals.

**Group 2B: The agent is possibly carcinogenic to humans. (e.g., EMF, coffee, aloe vera, pickled vegetables)**
There is *limited* evidence of carcinogenicity in humans and *less than sufficient* evidence in experimental animals.

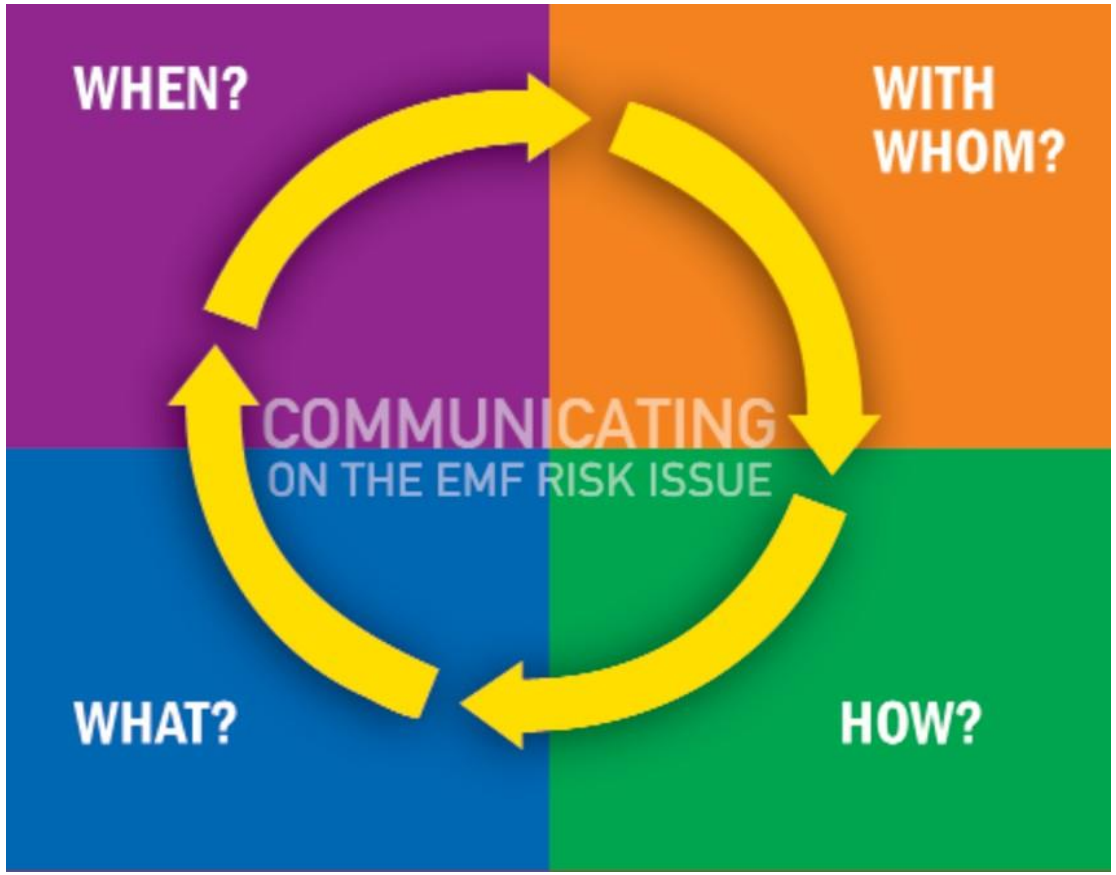
**Group 3 : The agent is not classifiable as to its carcinogenicity to humans.**
The evidence is *inadequate* in humans and *inadequate* or *limited* in experimental animals.

**Group 4 : The agent is probably not carcinogenic to humans.**
There is evidence *suggesting lack of* carcinogenicity in humans and in experimental animals.

# EMF Risk Communication



# EMF Risk Communication
# 3W 1H



# EMF Risk Communication 3W 1H Model 1/2

## When

**KEY QUESTIONS**

- When should you enter into a dialogue?
- Is there sufficient planning time?
- Can you quickly research who and what influences community opinions?
- When do you include the stakeholders? When do you plan the process, set the goals and outline the options? When are decisions made?

## Whom

**KEY QUESTIONS**

- Who will be most interested in this issue?
- What is known about the interests, fears, concerns, attitudes and motivation of the stakeholders?
- What authorities are responsible for determining and implementing policy?
- Are there organizations with whom to form effective partnerships?
- Who can provide advice or scientific expertise?

# EMF Risk Communication 3W 1H Model 2/2

## What

### KEY QUESTIONS

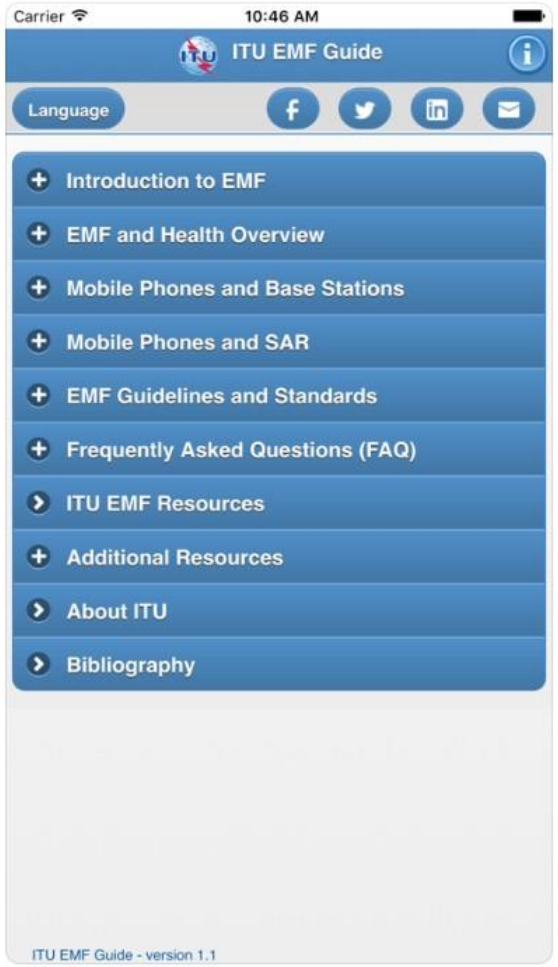
- Do the stakeholders have access to sufficient and impartial information about the technology?
- Is the message intelligible or does it contain a large amount of complex information?
- Are the messages of all key stakeholders being heard? i.e. is there an effective means for providing feedback?

## How

### KEY QUESTIONS

- What type of participation tool do you choose to address your audience?
- Where, when and under what circumstances does the discussion take place?
- What tone prevails?
- How formally is the situation handled?

# EMF Guide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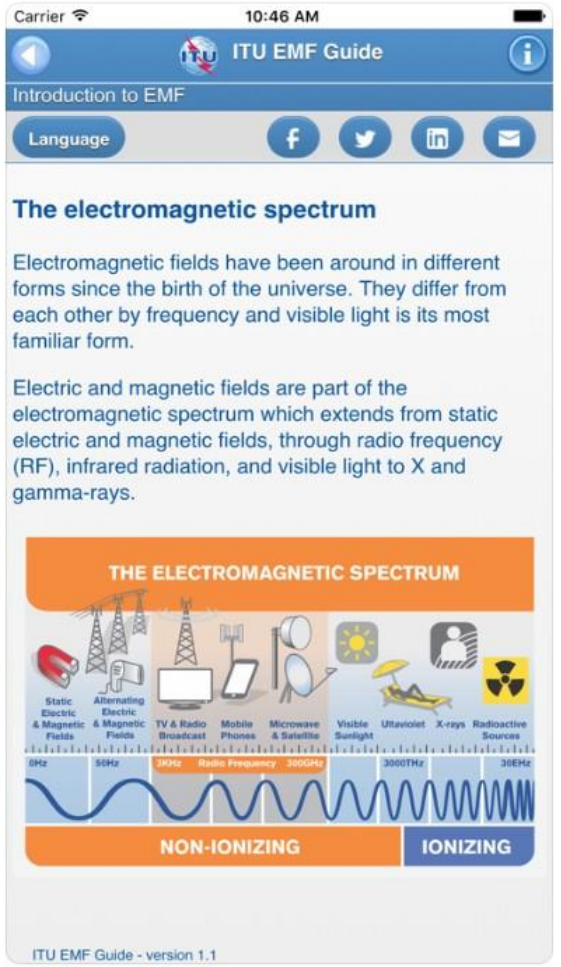
ITU EMF Guide
Language
Introduction to EMF
EMF and Health Overview
Mobile Phones and Base Stations
Mobile Phones and SAR
EMF Guidelines and Standards
Frequently Asked Questions (FAQ)
ITU EMF Resources
Additional Resources
About ITU
Bibliography
ITU EMF Guide - version 1.1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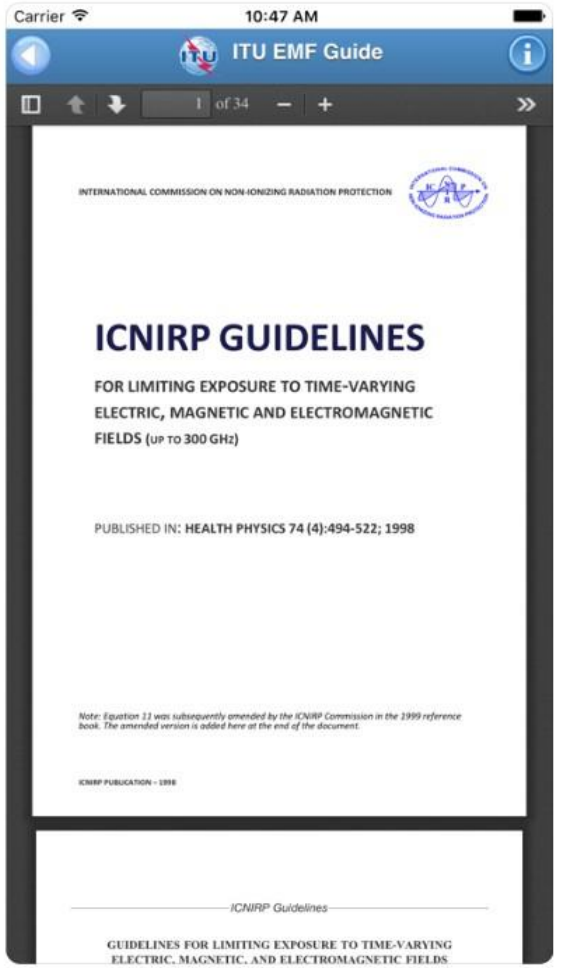
10:46 AM
ITU EMF Guide
Introduction to EMF
Language
The electromagnetic spectrum
Electromagnetic fields have been around in different forms since the birth of the universe. They differ from each other by frequency and visible light is its most familiar form.
Electric and magnetic fields are part of the electromagnetic spectrum which extends from static electric and magnetic fields, through radio frequency (RF), infrared radiation, and visible light to X and gamma-rays.
THE ELECTROMAGNETIC SPECTRUM
NON-IONIZING
IONIZING
ITU EMF Guide - version 1.1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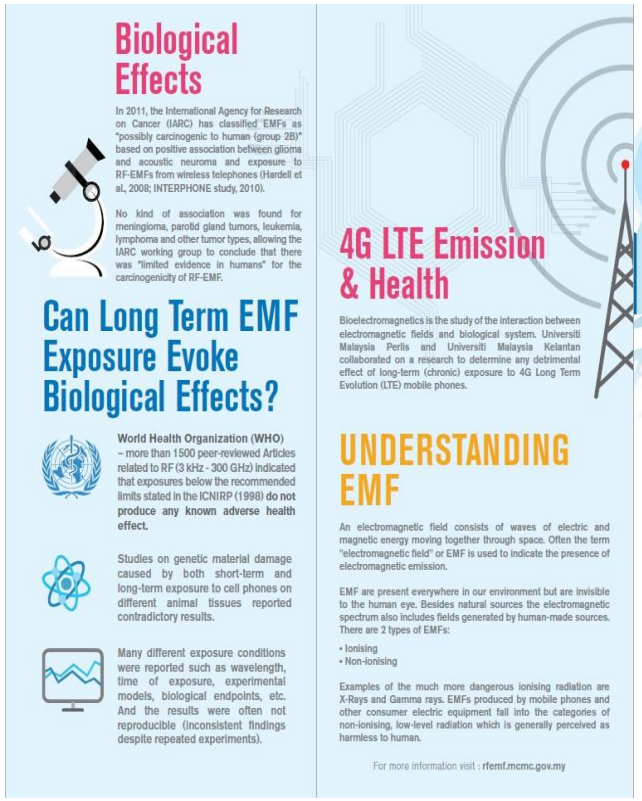
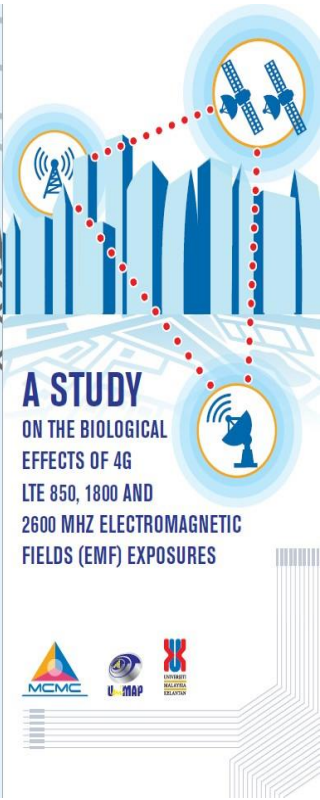
ITU EMF Guide
INTERNATIONAL COMMISSION ON NON-IONIZING RADIATION PROTECTION
ICNIRP GUIDELINES
FOR LIMITING EXPOSURE TO TIME-VARYING ELECTRIC, MAGNETIC AND ELECTROMAGNETIC FIELDS (UP TO 300 GHz)
PUBLISHED IN: HEALTH PHYSICS 74 (4):494-522; 1998
ICNIRP Guidelines
GUIDELINES FOR LIMITING EXPOSURE TO TIME-VARYING ELECTRIC, MAGNETIC, AND ELECTROMAGNETIC FIELDS

# Information Brochure





# Awareness Seminars

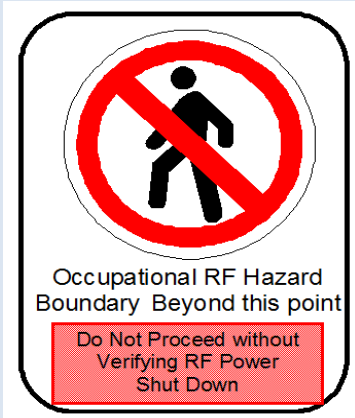
## Targeted Audience from

- Government agencies and regulator
- State government agencies and local councils
- Industry players
- General public

MUST be Free to participate

Work very well if you involve Academia

# RF Signs for guidance

| Sign | Guidance on use | Example - Australia | Example - USA |
|---|---|---|---|
| **Notice** | Used to alert persons to the potential of exposures exceeding the reference levels for the public.<br>Note: In some countries, these signs are called Notices or Caution Signs |  |  |
| **Caution** | Used to alert persons to the possibility of exposures exceeding the reference levels for workers.<br>Note: In some countries, these signs are called Caution Signs or Warning Signs |  |  |

# RF Signs for guidance

| Sign | Guidance on use | Example - Australia | Example - USA |
|---|---|---|---|
| **Warning** | Used to advise persons of potential exposures that may exceed the reference levels for workers by a factor of 10 (the safety factor in the (ICNIRP, 1998) guidelines.<br>Note: Not used in all countries. | Not used in Australia |  |
| **Danger** | Normally only used for situations in which immediate and serious injury will occur such as in the case of RF burns and/or RF electrical shocks. |  |  |

# Policies Interventions: Administrations and Regulator (1/2)

- **Prioritize the alternative**: cable and satellite telecommunications, in order to reduce off-air TV, fixed wireless access emissions, wireless internet router and broadband applications;

- **Promote cellular sites' co-location** passive (same site, mast and antenna) and even active sharing (same transceivers and frequencies) among operators, in order to reduce the number of the cellular base stations and in general the human exposure;

- **Do not limit construction of masts** near sensitive places, as the individual exposure from the handsets increases, with fewer base station antenna, due to handset power growth;

- **Inform the public transparently** about existing and expected exposure values, by performing simulations. For the cell phones: provide good visible publication of the SAR values;

# Policies Interventions: Administrations and Regulator 2/2

- **Theoretically assess base station** to assure that general public exposure is lower than ICNIRP 1998 reference levels; measure upon request; try to software monitor the exposure and emitted power 24 hour a day 365 days a year; and

# Main precautionary measures that can be taken are:

- ✓ avoid prolonged exposure to electromagnetic waves;
- ✓ favour areas with good cellular reception;
- ✓ avoid excessively long conversations with the telephone next to one's ear;
- ✓ use hands-free kit;
- ✓ use text messages (SMS) for communication;
- ✓ choosing a mobile phone with a low SAR;
- ✓ do not have wireless devices nearby when sleeping;
- ✓ limit the time children spend on wireless devices (mobile telephones, tablets, game consoles, etc.);
- ✓ do not give mobile phones to children under the age of 10;
- ✓ limit the amount of time you have wireless devices on your person;
- ✓ recharge mobile phones at a distance from you.

# Mitigation techniques to decrease the radiation level (1/2)

- **Avoid** wireless communications if the transmitter & receiver stations are fixed
- **Avoid** WiFi routers based on cellular infrastructure (Use Satellite and Cable TV)
- **Maximize** sharing, including active frequencies sharing among cellular operators
- **Incentivize** the RF to operators in order to decrease sites
- **Restrict access** to areas where the exposure limits are exceeded. Physical barriers, lockout procedures and adequate signs are essential; workers can use protective clothing (ITU-T 2004 K.52)

# Mitigation techniques to decrease the radiation level (2/2)

- **Increase, if possible, the antenna height**. The distances to all points of investigation are increased and the radiation level is reduced. Moreover, additional attenuation to the radiation is achieved due to the increase of elevation angle and decrease of transmitting antenna sidelobe (ITU-T 2007 K.70 p.22)

- **Minimize exposure to the min. needed** to maintain the quality of the service, as quality criterion. Decrease the Tx power & consequently decrease linearly the power density in all the observation points. As it reduces the coverage area, it is used only if other methods cannot be applied (2007 K.70 p.22)

- **Increase the antenna gain** (mainly by reducing the elevation beam width), and consequently decrease the radiation in the direction accessible to people. The vertical beam width may be used to reduce the radiation level in close proximity to the antenna. Moreover, the same value of the EIRP can be achieved by a low power transmitter feeding high gain antenna or by high power transmitter feeding low gain antenna. As far as the protection against radiation is concerned, a much better choice is to use the low power transmitter feeding the high gain antenna.

(ITU-T007 K.70 p.22)

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## THANK YOU