7 June 2017

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Human Radio Frequency Exposure Limits International, Regional and National

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Outlines

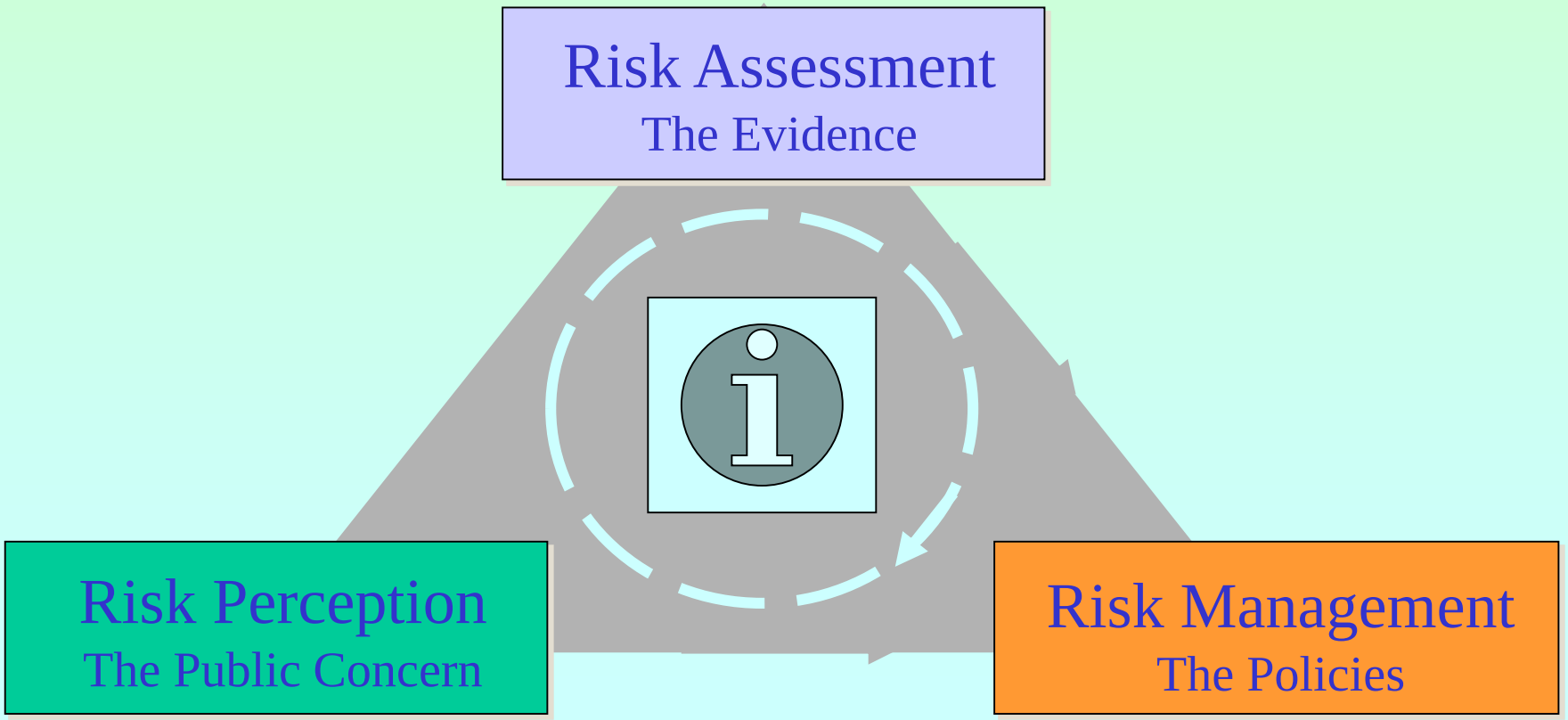
- Risk Assessment
- ITU-R, D & T are most active to regulate and standardise the radio aspects of the EMF. ATDI contributes to all ITU Sectors
- Exposure from base stations: ICNIRP levels
- Representative general population/uncontrolled exposure reference levels base stations and handsets/notebooks (+capsules, implants, chargers)
- Country specific RF limit information
- ICNIRP vs. N. America and Japan reference levels
- Summary

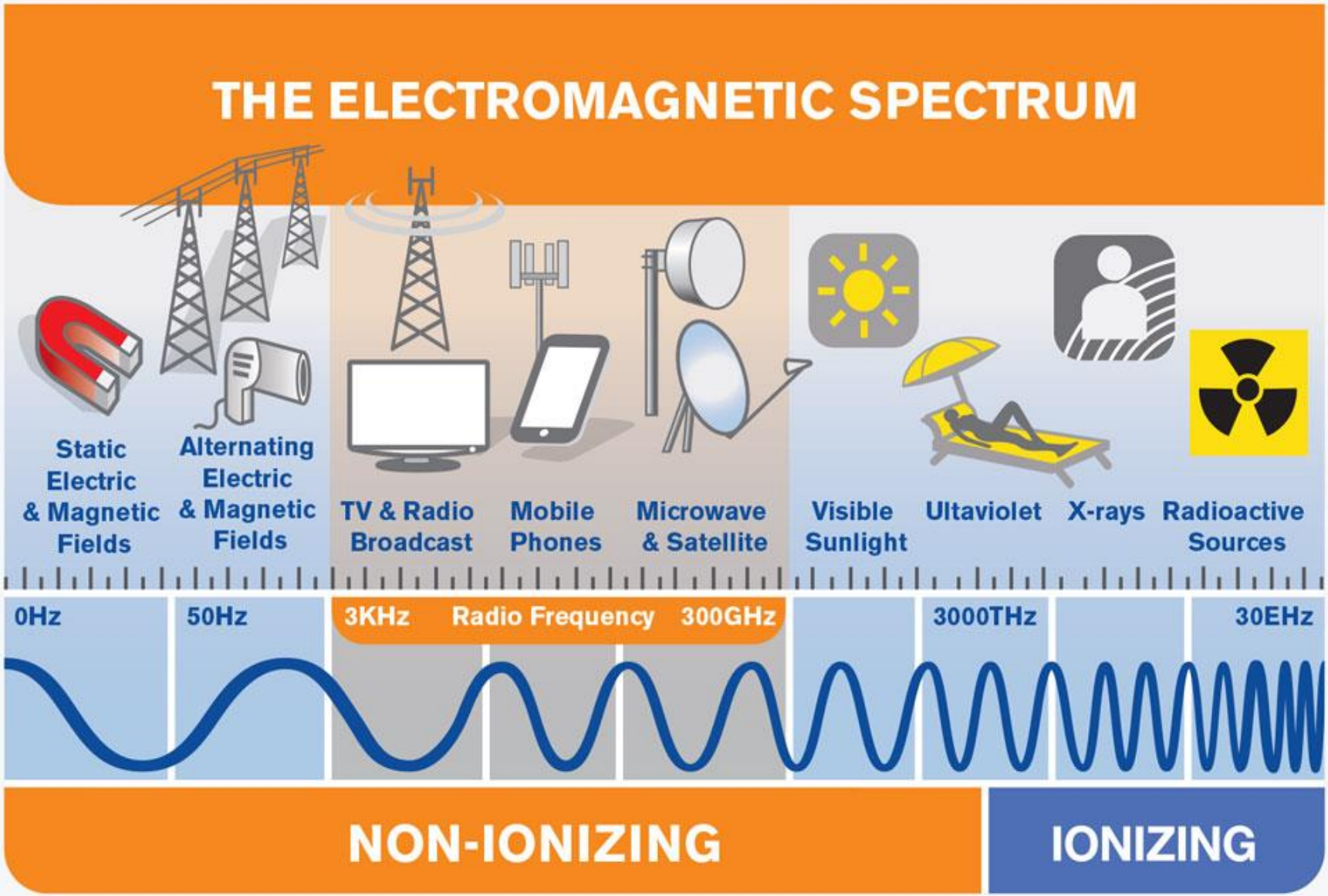
World Health Organization

Dr E. van Deventer; Department of Public Health and Environment Geneva, Switzerland;
ITU-D Q 7/2 22 Apr 16

Electromagnetic Radiofrequency Fields; National Management and Regulatory Approaches

- **Mobile phone use is ubiquitous with an estimated 4.6 billion subscriptions globally**
- **To date, no adverse health effects have been established from RF fields exposures**
- **Studies are on-going to assess potential long-term effects of wireless technologies**



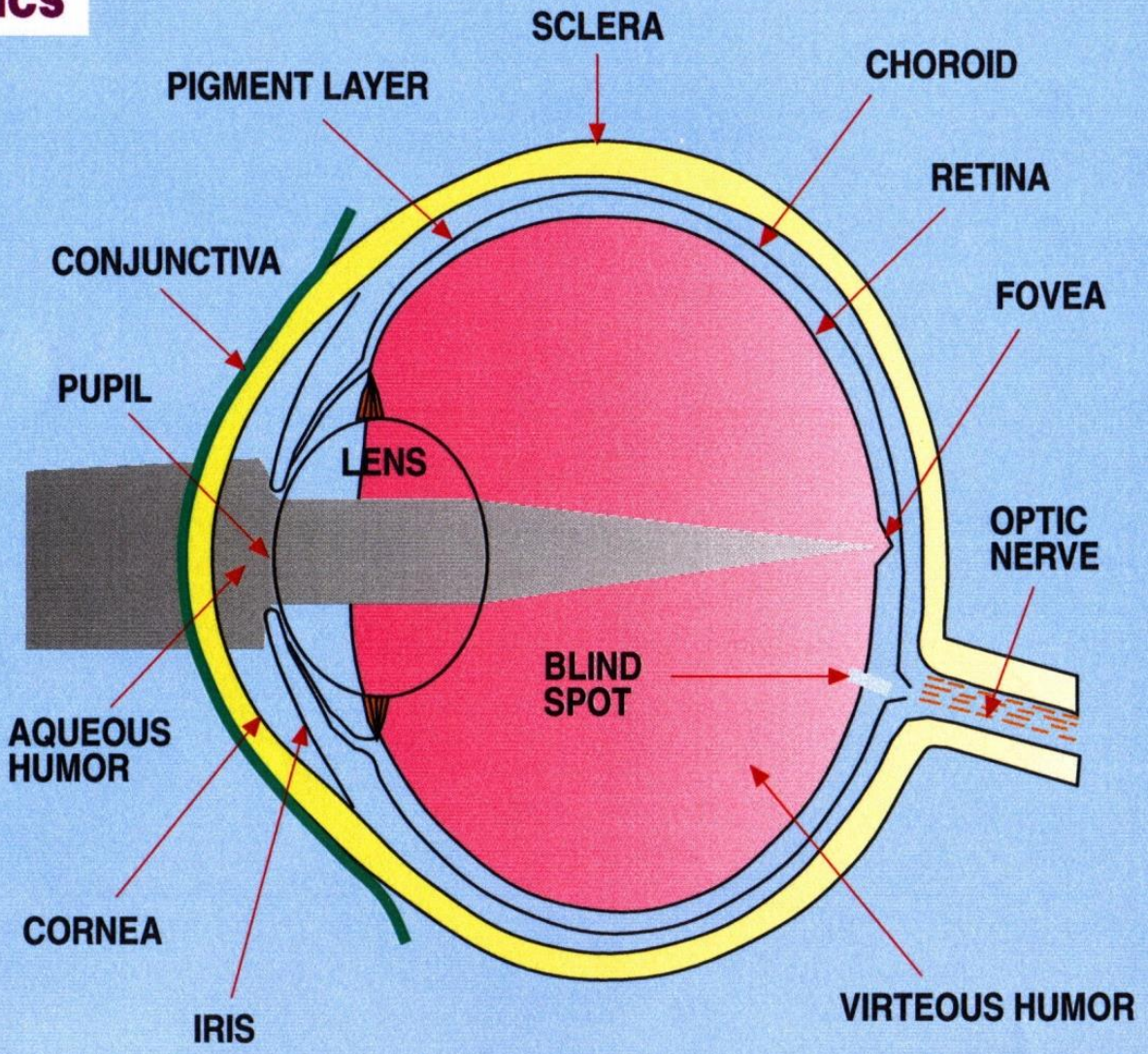


Source: ITU-T Report 2014 *EMF Considerations in* ***Smart Sustainable Cities***

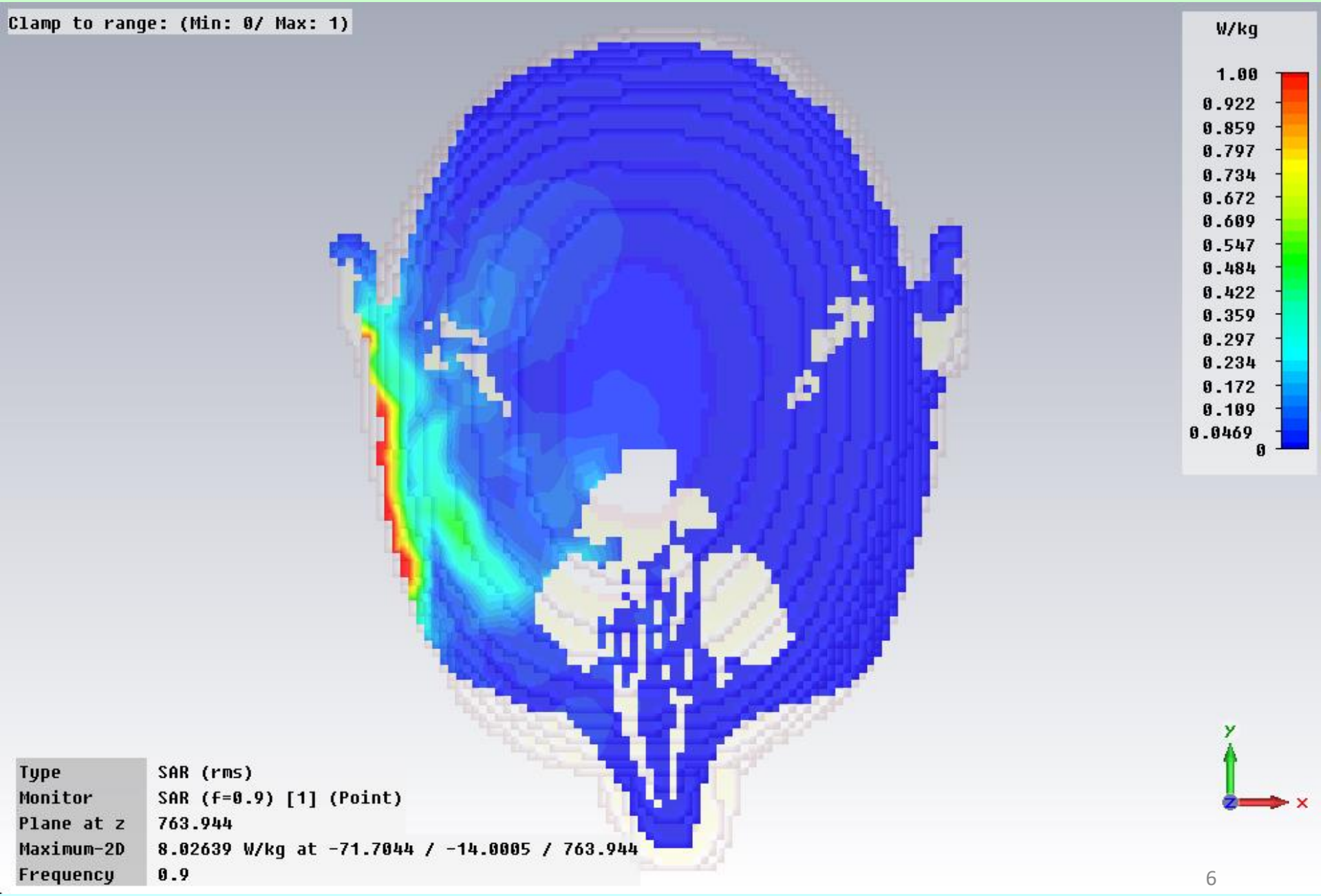
The Human Eye (Moshe Netzer)

SUSCEPTIBILITY CHRACTERISTICS

- POOR BLOOD CIRCULATION
- LENSE OPACITY
- CORNEA DAMAGE
- RETINA RAPTURE

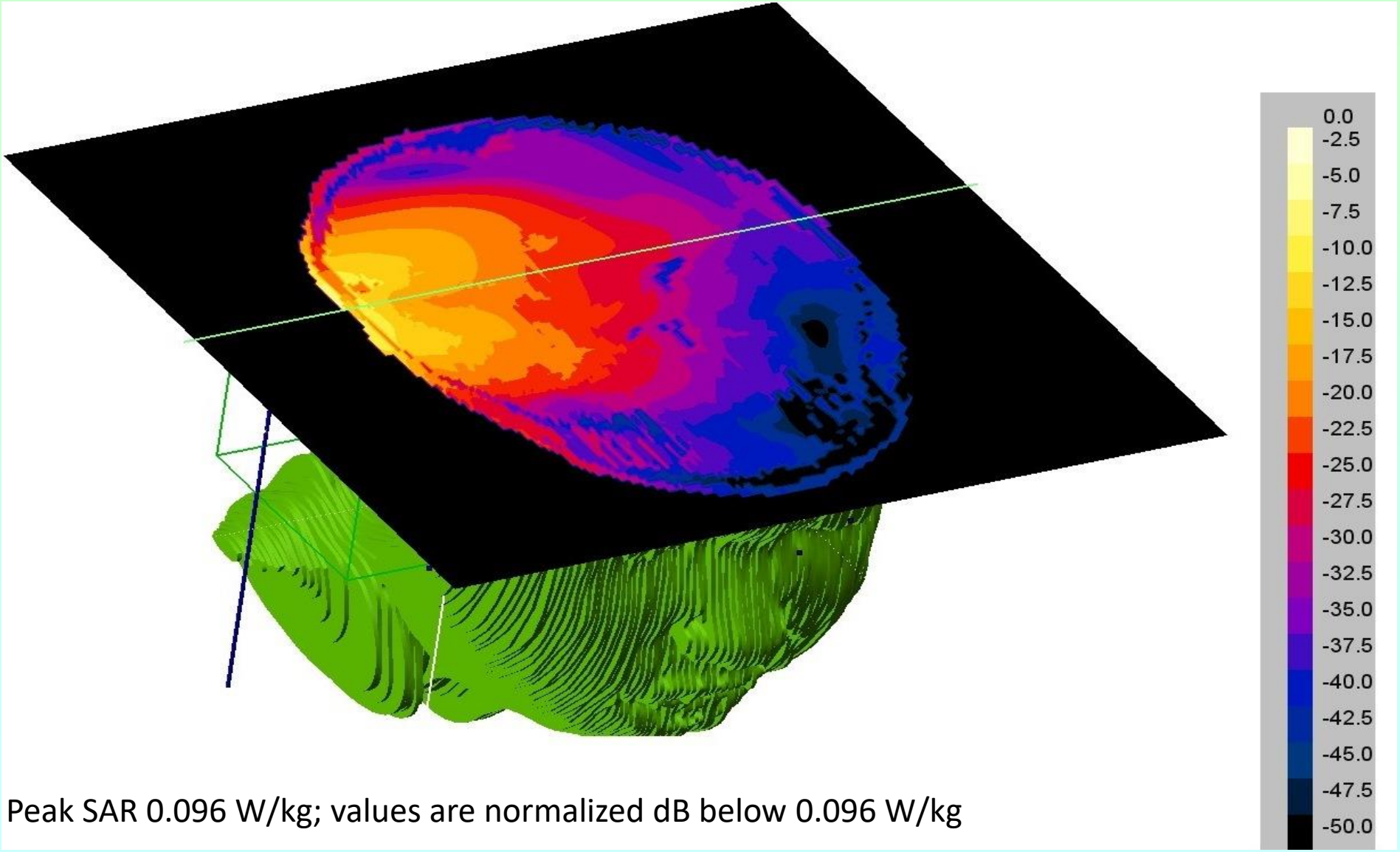


SAR phantom simulation (Stefan Chulski & Stav Revich from HIT)



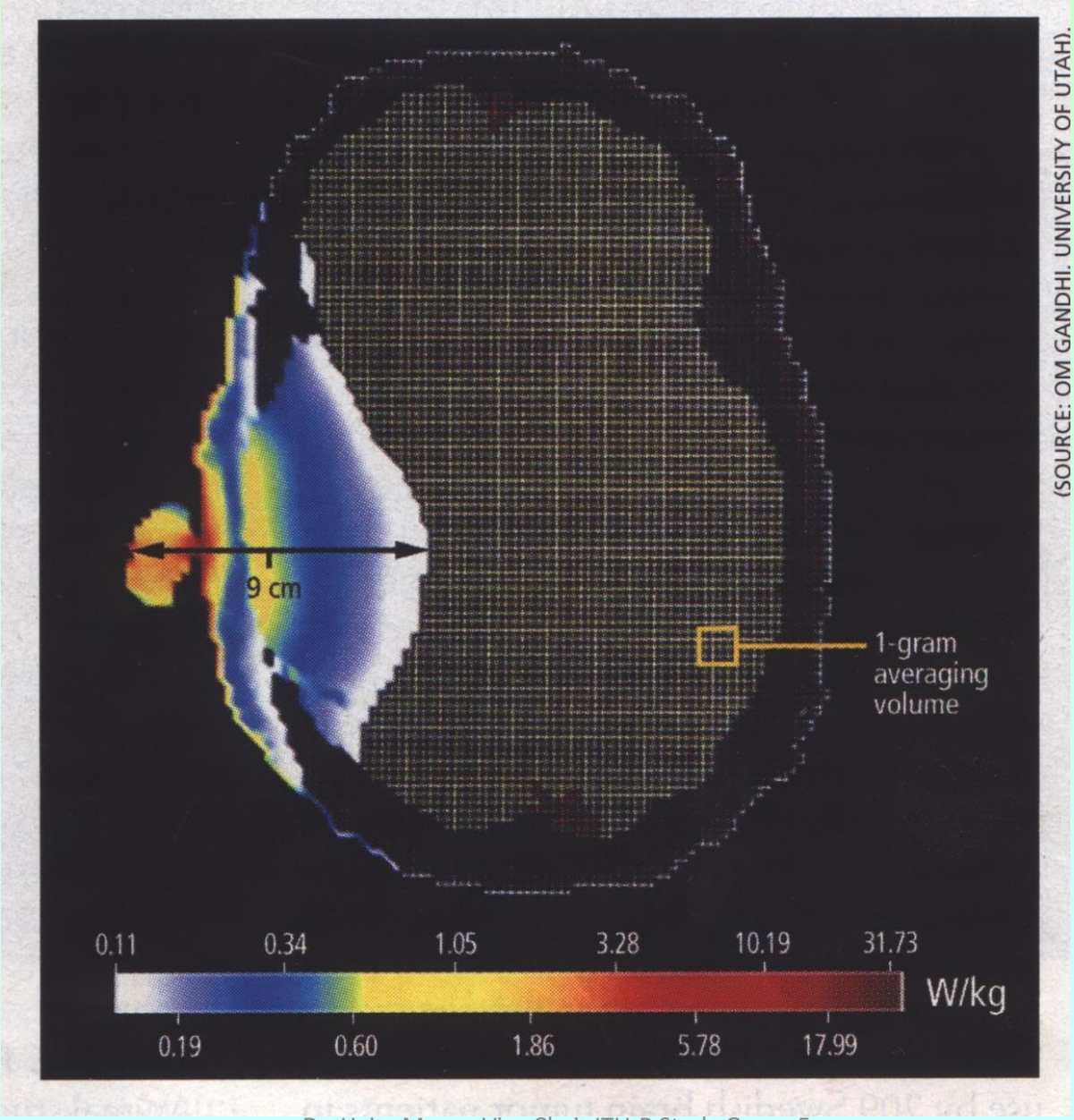
Numerical simulation of SAR; for a three years child

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



Peak SAR 0.096 W/kg; values are normalized dB below 0.096 W/kg

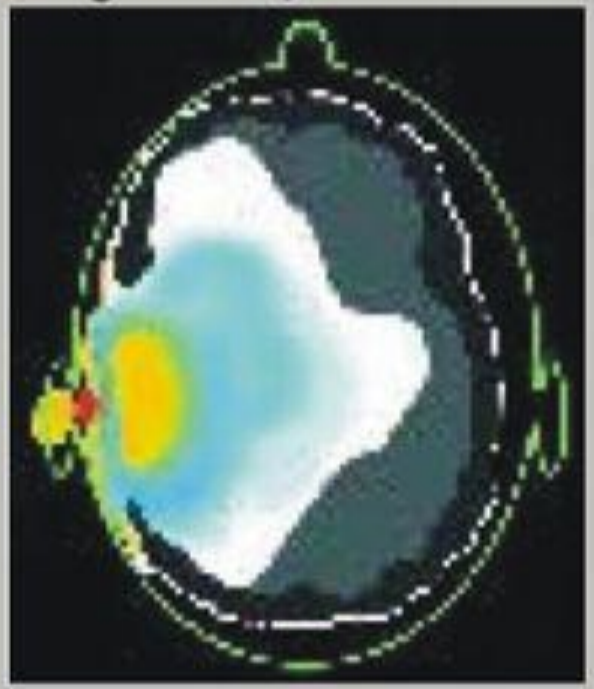
Typical SAR from a Cell Phone (Moshe Netzer)



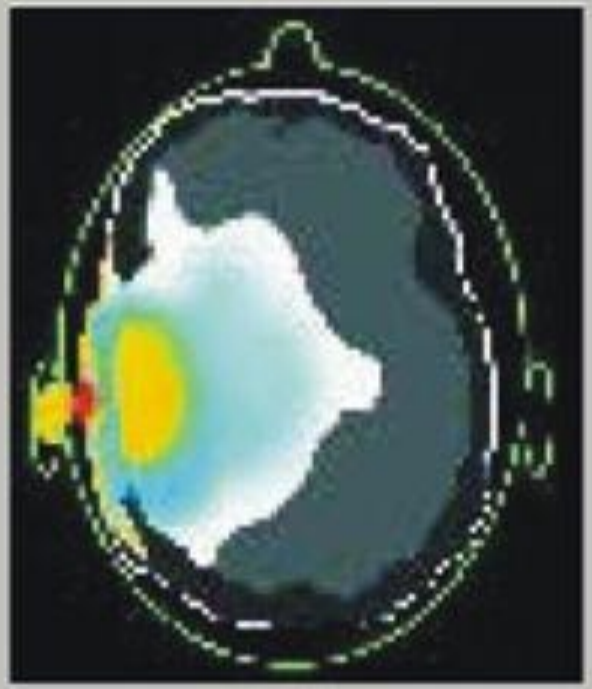
SAR overexposure in the brain

Gandhi O.P., Lazzi G., Furse C.M. (1996 vol.44, p1884-1897) : Absorption des rayonnements électromagnétiques dans la tête et le cou humain pour les téléphones mobiles de 835MHz /1900MHz

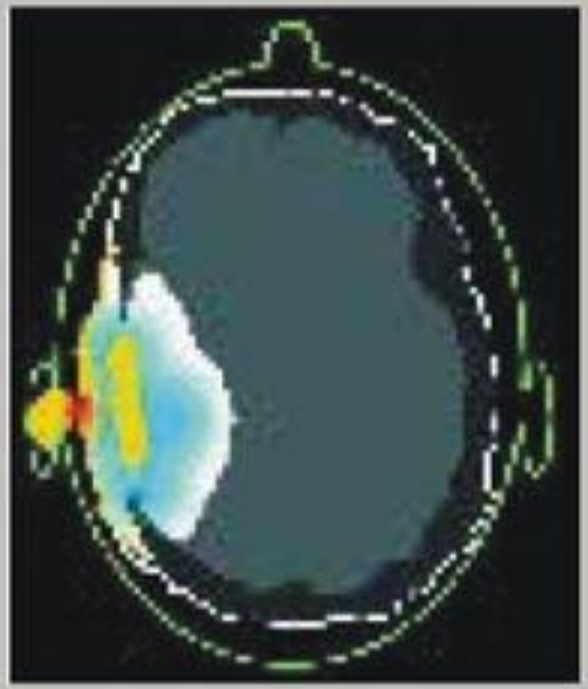
Degré de pénétration des Radiations du Portable dans le Cerveau



Enfant de 5 ans
Taux d'absorption: 4,49W/kg



Enfant de 10 ans
Taux d'absorption: 3,21W/kg

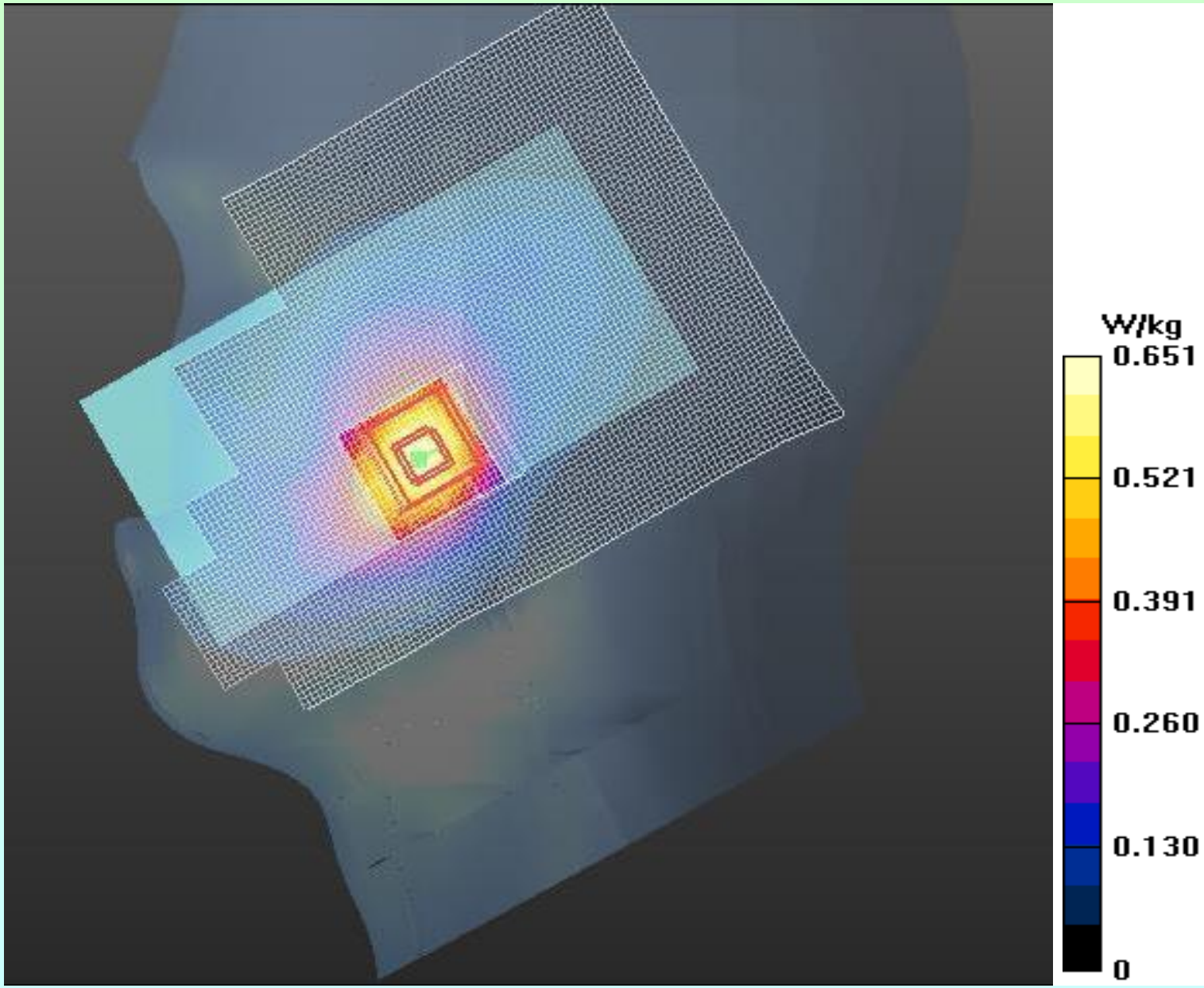


Adulte
Taux d'absorption: 2,93W/kg

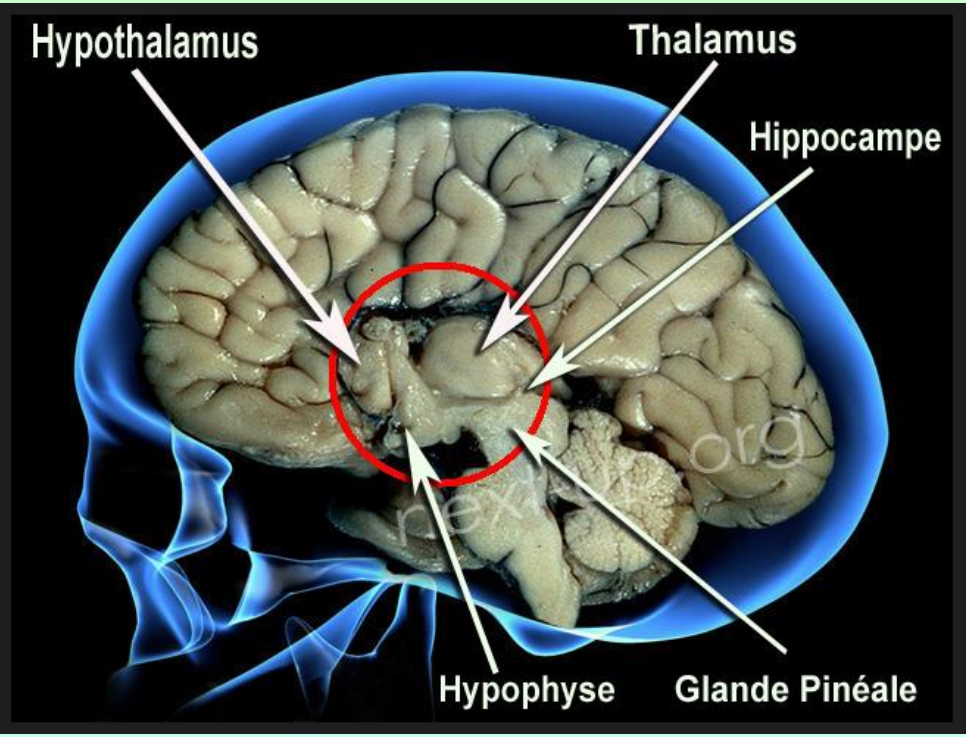
Pour un taux d'absorption de 2,93 W/kg de puissance absorbée par un adulte, cette même puissance produira un Taux d'absorption de 3,21 W/kg pour un enfant de 10 ans et un Taux d'absorption de 4,49 W/Kg pour un enfant de 5ans.

SAR real measurement for a commercial mobile phone

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



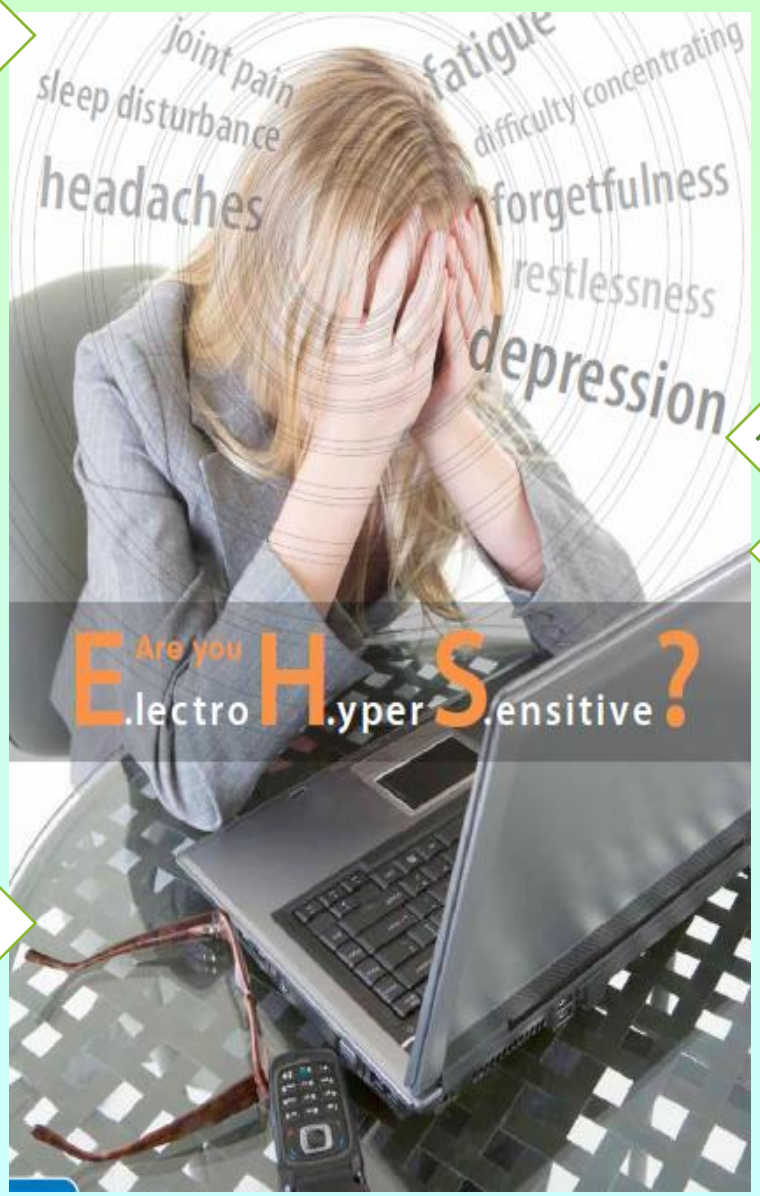
Brain is Exposed to Cellphone Radiation (Dr. Shalita)



Electromagnetic Hyper-Sensitivity; electro-phobia

Subjective phobia, phantom risk (?!)

Precautionary Principle: billions of cellular users phones and millions of base-stations worldwide



Type I error imposes regulatory restrictions on factors that turn out to be harmless.

Type II error : acceptance of a null hypothesis that turns out to be false

There is no evidence of causality between pains and RF exposure

Measurement of Radiation (partly Dr. Zamir Shalita, BS.1698)

Questions to be raised

Monitoring of human exposure around the world reveals that the levels are very low, relative to ICNIRP reference levels:

- 2001 to 2004 (WHO 2007:30), UK conducted radio surveys at 289 schools with base stations on or near them. The highest levels measured anywhere were **3.5×10^{-3}** (= 12.2×10^{-6} of the power density), with the 90% of the schools having a highest compliance factor below 2.9×10^{-4} (**8.4×10^{-8}** power density) – which are very low values indeed.
- See also IARC 2013:58, fig. 1.11 specifies a cumulative distribution of exposure quotients corresponding to 3321 spot measurements made by OFCOM at 499 sites where public concern had been expressed about nearby base stations; the quotient values are median 8.1×10^{-6} of ICNIRP power density, ranging from the **5th percentile 3.0×10^{-8} to 95th percentile 2.5×10^{-4}**.
- Two hundred randomly selected people in urban, sub-urban, and rural subgroups have measured on 2005–2006 in France (Viel et al. 2009; see also IARC 2013:114) for 24 hours a day, 184 daily measurements. At the GSM 900/1800 bands most of the time, the recorded field strength was below detection level (**0.05 V/m); 0.05 V/m is 3.63%** of the ICNIRP level at 900 MHz. 12.3% of measurements at the FM band indicate field strength above the detection threshold; the mean field strength was 0.17 V/m (Viel et al. 2009:552), the maximum field strength was always lower than 1.5 V/m. ANFR 2007 reveals that at 2004-2007, the average measurements are less than 2% of the field strength limit (less than 0.04 % of power density); more than 75% of the measurements were less than 2% of the field strength limit, regardless of the frequency band considered**.**

So: **Why do we need to make so many measurements?**

May be ICNIRP reference levels are too high?

What is the minimal Tx power (not from handset) to measure and approve RF hazards?

Hillel (ex) Radio Antenna: Closed due to hypersensitivity

Yehuda Halevi, TelAviv; Israel

Base Station Antenna Pattern: Azimuth and Elevation (Dr. Zamir Shalita)

ITU Activities :Plenipotentiary (PP) Conference in 2014

PP- 14 Resolution 176 on "Human exposure to and measurement of electromagnetic fields"

- *resolves to instruct the Directors of the three Bureaux* "to collect and disseminate information concerning exposure to EMF, including on EMF measurement methodologies, in order to assist national administrations, particularly in developing countries, to develop appropriate national regulations"
- *invites Member States* "to take the appropriate measures to ascertain compliance with guidelines produced by ITU and other relevant international organizations with respect to exposure to EMF"

ITU World Telecommunications Development Conference (WTDC)-14

WTDC-14 approved **Resolution 62** on "Measurement concerns related to human exposure to electromagnetic fields"

ITU-D Study Group 2 Question 7/2 on "Strategies and policies concerning human exposure to electromagnetic fields"

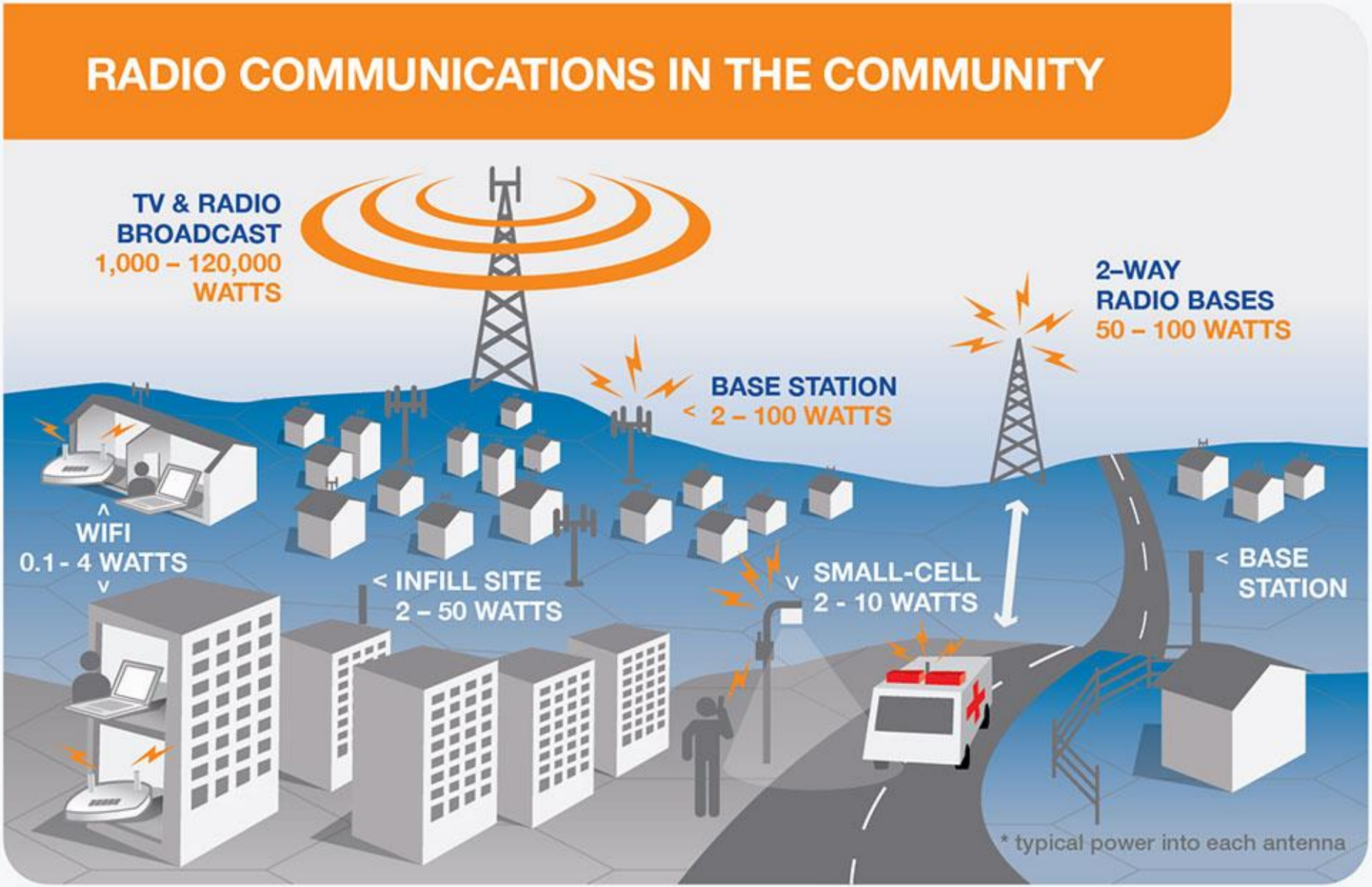
Items to be studied:

- "Compilation and analysis of the regulatory policies concerning human exposure to electromagnetic fields that are being considered or implemented for authorizing the installation of radiocommunication sites and powerline telecommunication systems"
- "Description of the strategies or methods for raising the awareness of population and increasing information to populations regarding the effects of electromagnetic fields due to radiocommunication systems"
- Proposed guidelines and best practices on this matter"
- New item included in Resolution 62, "effect on humans of EMF from handheld devices"

ITU World Telecommunications Standardisation Assembly (WTSA)-16

WTSA-16 agreed on the following:

- Revision of Resolution 72 on “Measurement and assessment concerns related to human exposure to electromagnetic fields”
- ITU-T Study Group 5 Question 3/5 on “Human exposure to electromagnetic fields (EMFs) from information and communication technologies (ICTs)”



Source: ITU-T Report 2014 *EMF Considerations in Smart Sustainable Cities*

ITU-T SG5 activity on Q 3/5; K-series Recommendations Recommendations

K.52: *Guidance on complying with limits for human exposure to emf*

K.61: Guidance on measurement and numerical prediction of electromagnetic fields for compliance with human exposure limits for telecommunication installations

K.70: *Mitigation techniques to limit human exposure to EMFs in the vicinity of stations*

K.83: *Monitoring of electromagnetic field levels*

K.90: *Evaluation techniques and working procedures for compliance with exposure limits of network operator personnel to power-frequencies*

K.91: *Guidance for assessment, evaluation and monitoring of human exposure to radio frequency electromagnetic fields*

K.100: *Measurement of RF EMF to determine compliance with human exposure limits*

K.113: *Generation of radiofrequency electromagnetic field level maps*

K.121: *Guidance on the environmental management for compliance with RF EMF limits for base stations*

K.122: *Exposure levels in close proximity of radiocommunication antennas*

Recommendation ITU-T K.BPrac

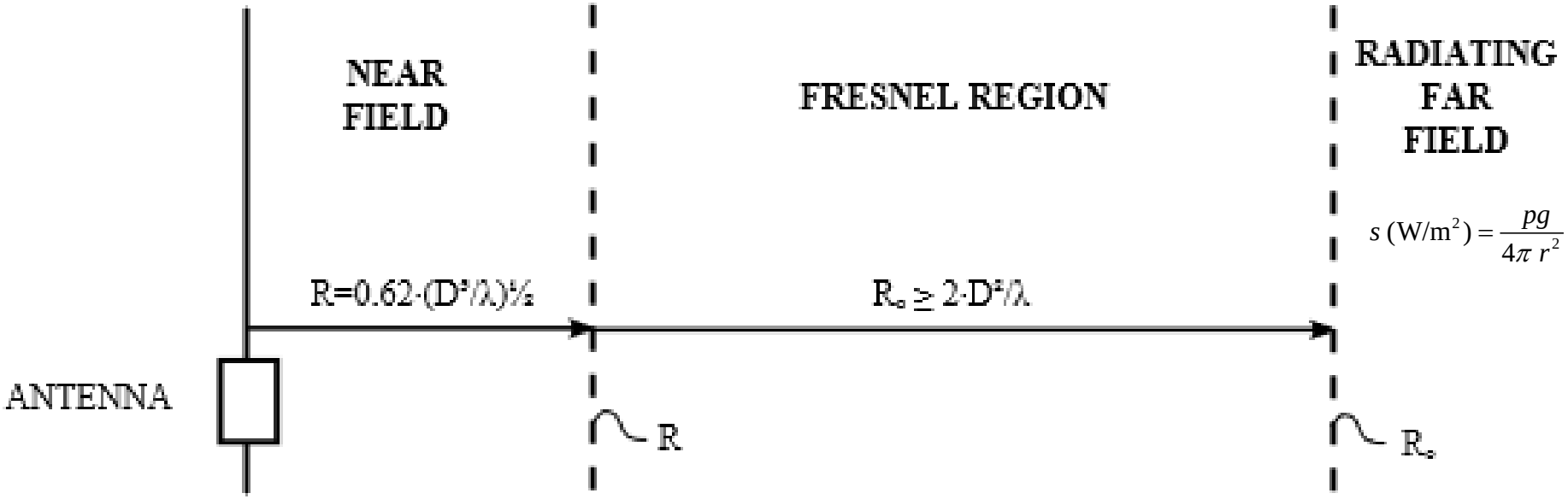
ITU-R Study Group 1

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?

ATDI & Rohde Schwartz propose a new Draft Report to ITU-R Working Party 1C, June 2017 meeting

Various radiation zones of Wikipedia



If $X >= 2D^2/\lambda$, **far-field** region

If $2D^2/\lambda > X > \lambda/2\prod$ **radiating** near-field region

If $\lambda/2\prod > X$ **reactive** near-field region

ICNIRP- Established Effects of EMF (Paolo_Vecchia)

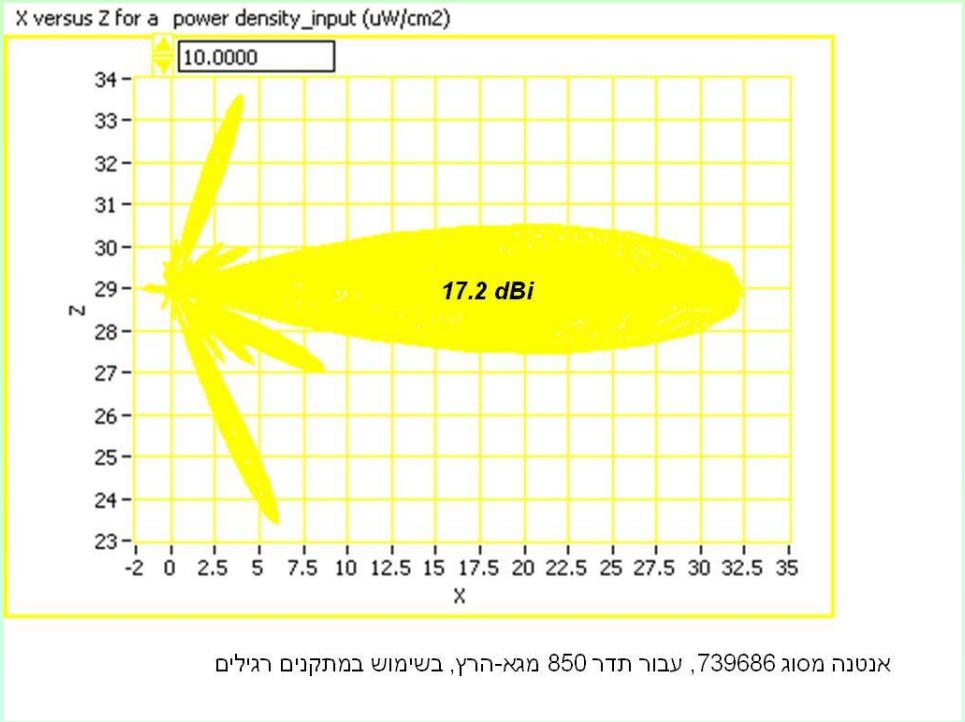
- All effects of EMF that have been established so far are acute in nature

- ELF
- Stimulation of electrically excitable tissues

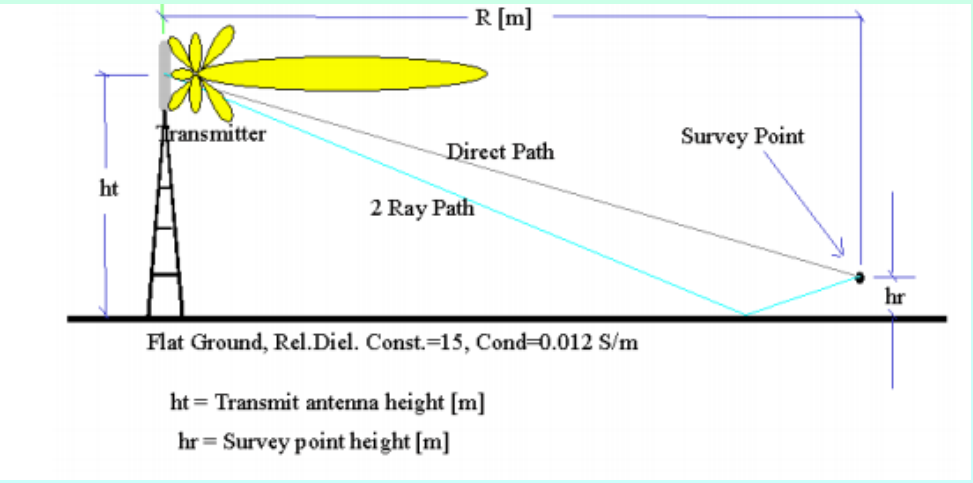
- RF
- Increase of body temperature (general or local)

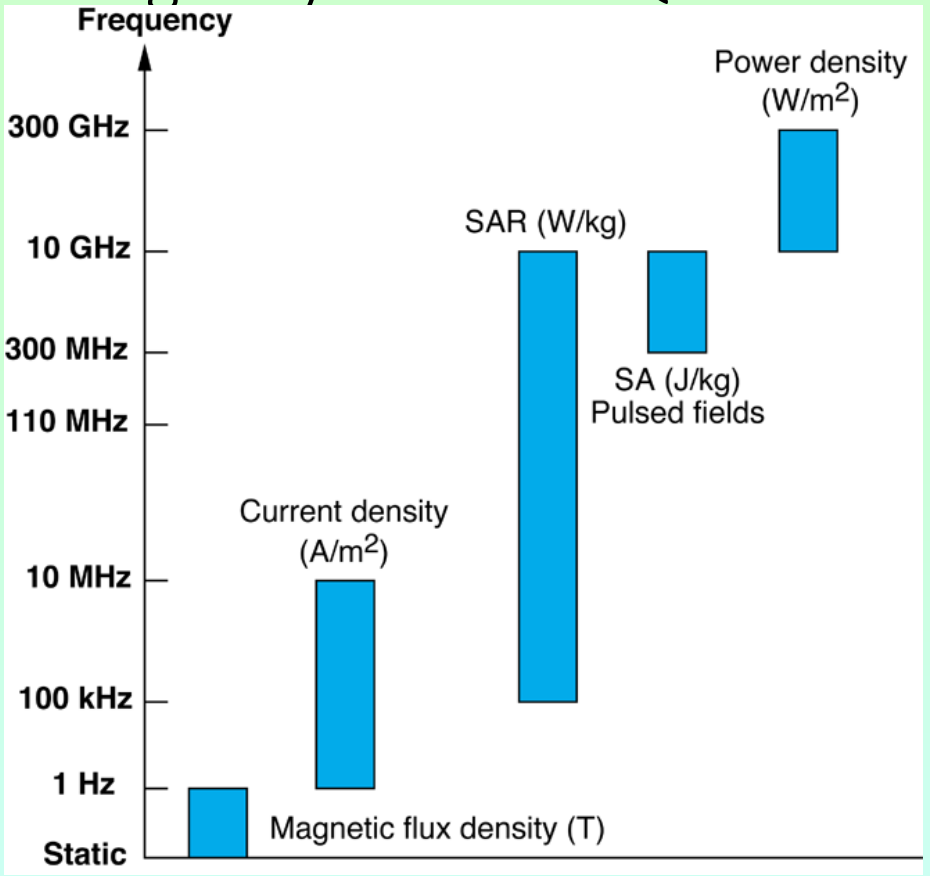
Such acute effects occur above given exposure thresholds

Biologically Effective Quantities



אנטנה מסוג 739686, עבור תדר 850 מגא-הרץ, בשימוש במתקנים רגילים





SA: Specific Absorption

Physical Quantities and Units

Quantity	Symbol	Unit	Symbol
Frequency	*f*	Hertz	Hz
Electric field strength	*e*	Volt per metre	V/m
Power	*p*	Watts	W
Power density or power flux density	*s*	Watt per square metre	W/m^2
		mWatt per square cm	mW/cm^2
Specific Absorption Rate	*SAR*	Watt per kilogram	W/kg
		mWatt per gram	mW/g

EXPOSURE LIMITS: BASE STATIONS

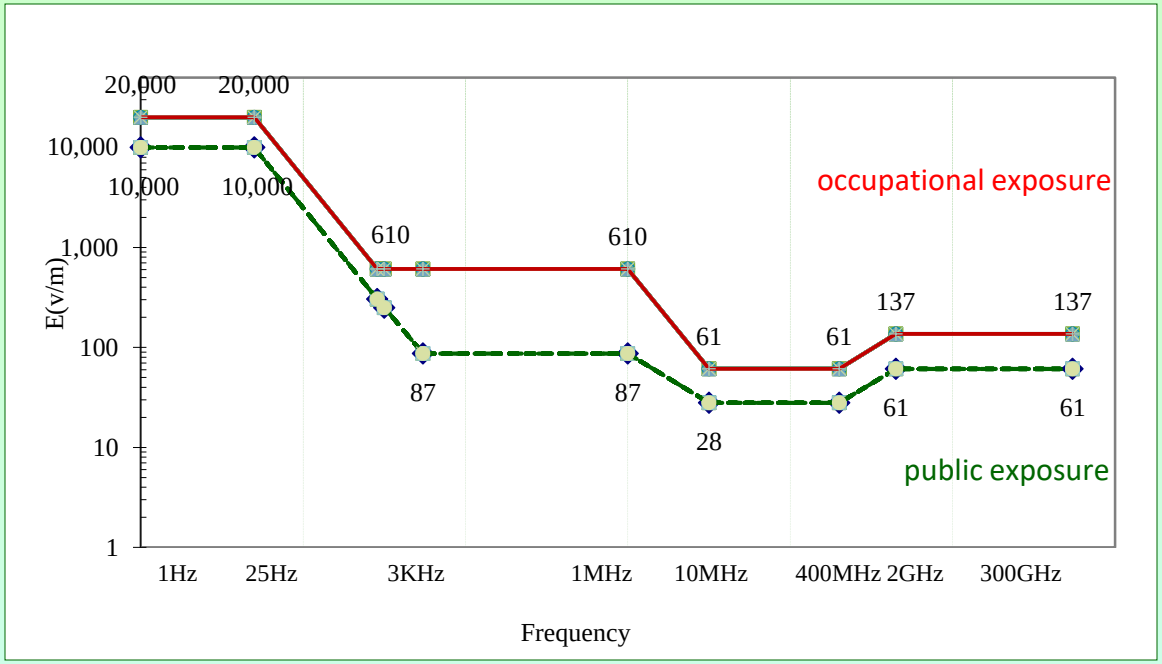
- 1998 guidance includes heating effects for RF above 100 kHz; ICNIRP 2010 guidance includes consideration of nervous system effects only
- In 100 kHz to 10 MHz, protection against **nervous system effects** is independent of RF; by contrast, when heating is taken into account, reference level reduces 0.1 to 10 MHz
- In order to ensure protection against both nervous system and heating effects, use whichever of field-strength limit is the lower

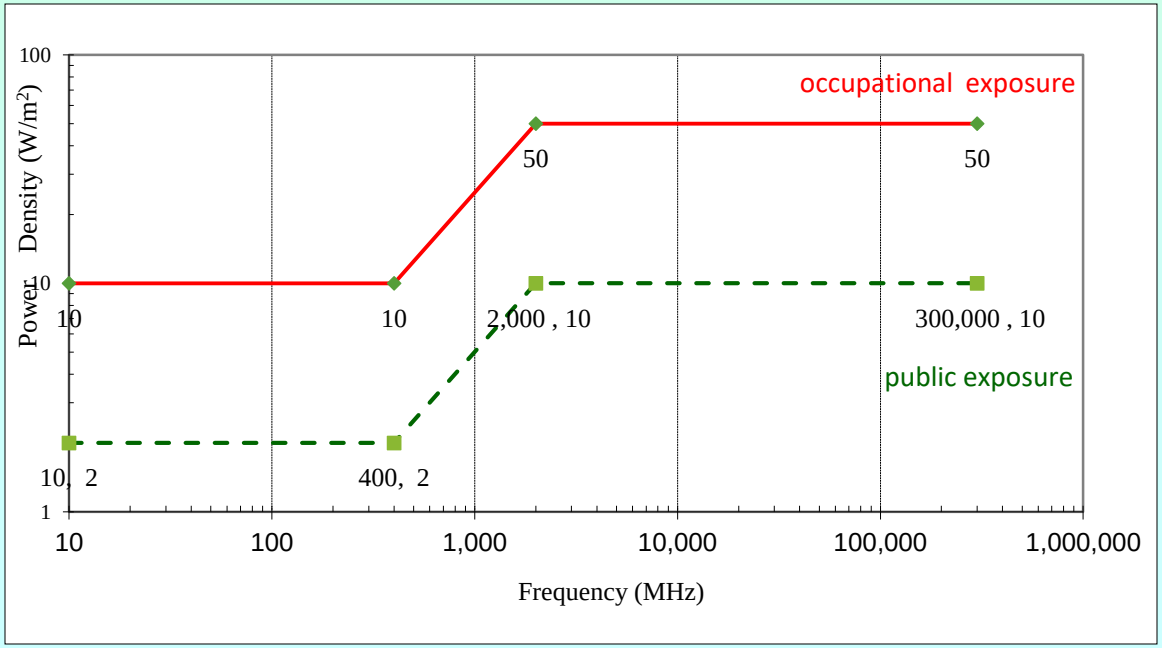
ICNIRP 1998 p.511 reference levels for occupational & general public exposure- table7

Frequency range	Electric field strength (V/m)		Equivalent plane wave power density S_{eq} (W/m^2)	
	general public	occupational	general public	occupational
1-25 Hz	10,000	20,000	-	
0.025- 0.82 KHz	250/f(KHz)	500/f(KHz)		
0.82 -3 KHz	250/f(KHz)	610	-	
3-1000 KHz	87	610		
1-10 MHz	$87/f^{1/2}$ (MHz)	610/f (MHz)	-	
10-400 MHz	28	61	2	10
400-2000 MHz	$1.375f^{1/2}$ (MHz)	$3f^{1/2}$ (MHz)	f/200	f/40
2-300 GHz	61	137	10	50

General public exposure Power Density is 5 times lower than occupational exposure

ICNIRP 1998 p.511 reference levels for occupational & general public exposure- graphs





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ICNIRP, US FCC §1.1310 (& Japan) & Canada SC6 (W/m^2)

RF	ICNIICIP	USA	Canada
20 (MHz)	2	$1800/f^2$ =4.5	2
30 (MHz)	2		$8.944 / f^{0.5}$ =1.63
48 (MHz)			1.291
300 (MHz)	2		
500 (MHz)	f/200 =2.5	f/150 =3.3	$0.02619\ f^{0.6834}$ =1.83
570 (MHz)	f/200 =2.8	f/150 =3.8	$0.02619x\ f^{0.6834}$ =2
1,000 (MHz)	f/200 =5	f/150 =6.7	$0.02619x\ f^{0.6834}$ =2.9
1,500 (MHz)	f/200 =7.5	10	$0.02619x\ f^{0.6834}$ =3.9
3,000 (MHz)	10 W/m^2		$0.02619x\ f^{0.6834}$ =6.2
6,000 (MHz)	10 W/m^2		

Representative general population/uncontrolled exposure reference levels

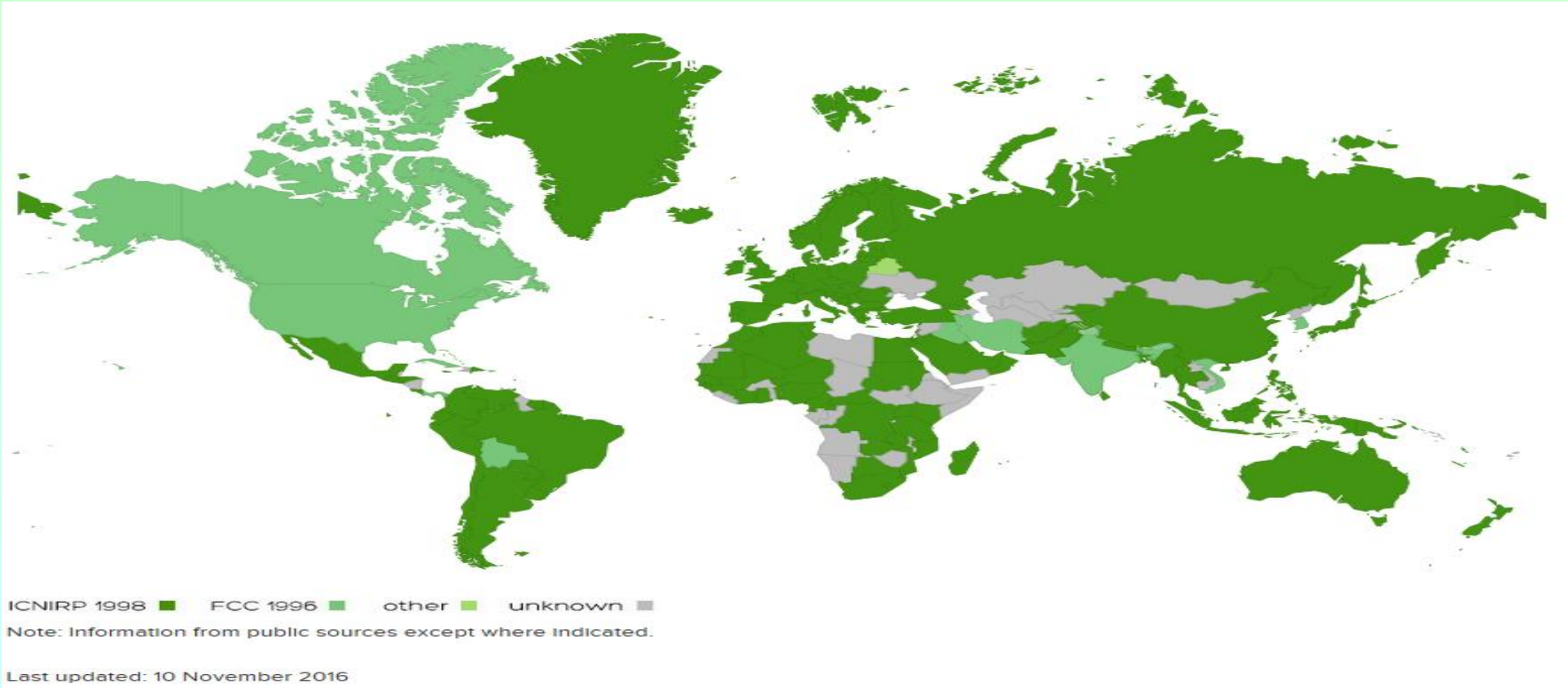
	PD 1,000 MHz (W/m^2) Far-Field	SAR (W/kg) Near-Field
USA	$f/150$ =6.67; 133/%	1.6[a], averaged over 1g tissue
Japan		2.0 , over 10 g
ICNIRP1998; ANSI/ IEEE 2005; AUS; NZL; 1999/519/EC	$f/200$ =5; 100%	
Korea		
Canada	$0.02619f^{0.6834}$ =2.94; 59%	1.6[a], averaged over 1g tissue
China	0.4; 8%	2.0 , over 10 g

[a:] See U.S. CFR 47 FCC §2.1093 and Canada Safety Code 6

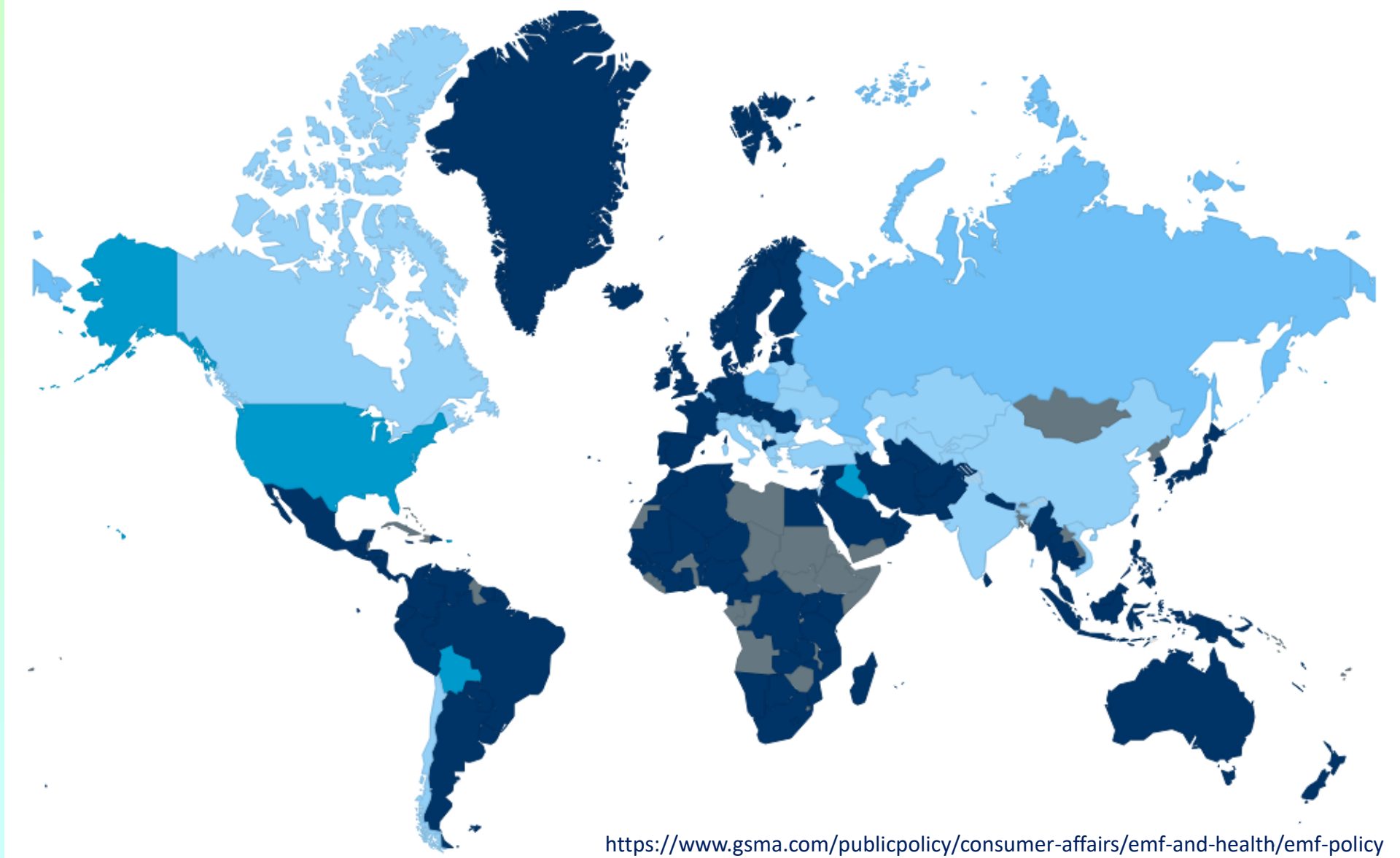
Public RF limits – mobile devices

ICNIRP 1998 - 150
FCC 1996 - 19
Other - 2

GSMA



http://www.gsma.com/publicpolicy/consumer-affairs/emf-and-health/emf-policy



https://www.gsma.com/publicpolicy/consumer-affairs/emf-and-health/emf-policy

125 countries apply ICNIRP, 11 follow the FCC 1996 limits, and 36 have other limits. differences between Other values and their application

GSMA origin; May 2017

country specific RF limit information

FCC 2016 Limits for Maximum Permissible Exposure (MPE)

Reassessment of RF Exposure Limits & Policies, and Proposed Changes in the Rules Regarding Human Exposure to RF Fields

Frequency range (MHz)	*electric field strength (V/m)*	*magnetic field strength (A/m)*	*power density (**mW/cm²**)*	*averaging time (minutes)*
(A) limits for occupational/controlled exposure				
0.3 – 3.0	614	1.63	100 *	6
3.0 – 30	1,842/*f*	4.89/*f*	900/*f*² *	6
30 – 300	61.4	0.163	1.0	6
300 – 1,500	–	–	*f*/300	6
1,500 – 100,000	–	–	5	6
(B) limits for general population/uncontrolled exposure				
0.3 – 1.34	614	1.63	100 *	30
1.34 – 30	824/*f*	2.19/*f*	180/*f*² *	30
30 – 300	**27.5**	0.073	0.2	30
300 – 1,500	–	–	***f*/1,500**	30
1,500 – 100,000	–	–	**1.0**	30

[1] FCC uses different units than ICNIRP 1998 for power density: mW/cm^2 and not W/m^2; $W/m^2 = 0.1\ mW/cm^2$

ICNIRP vs. N. America and Japan reference levels

ICNIRP 1998, EC (1999/519) and IEEE reference levels for public

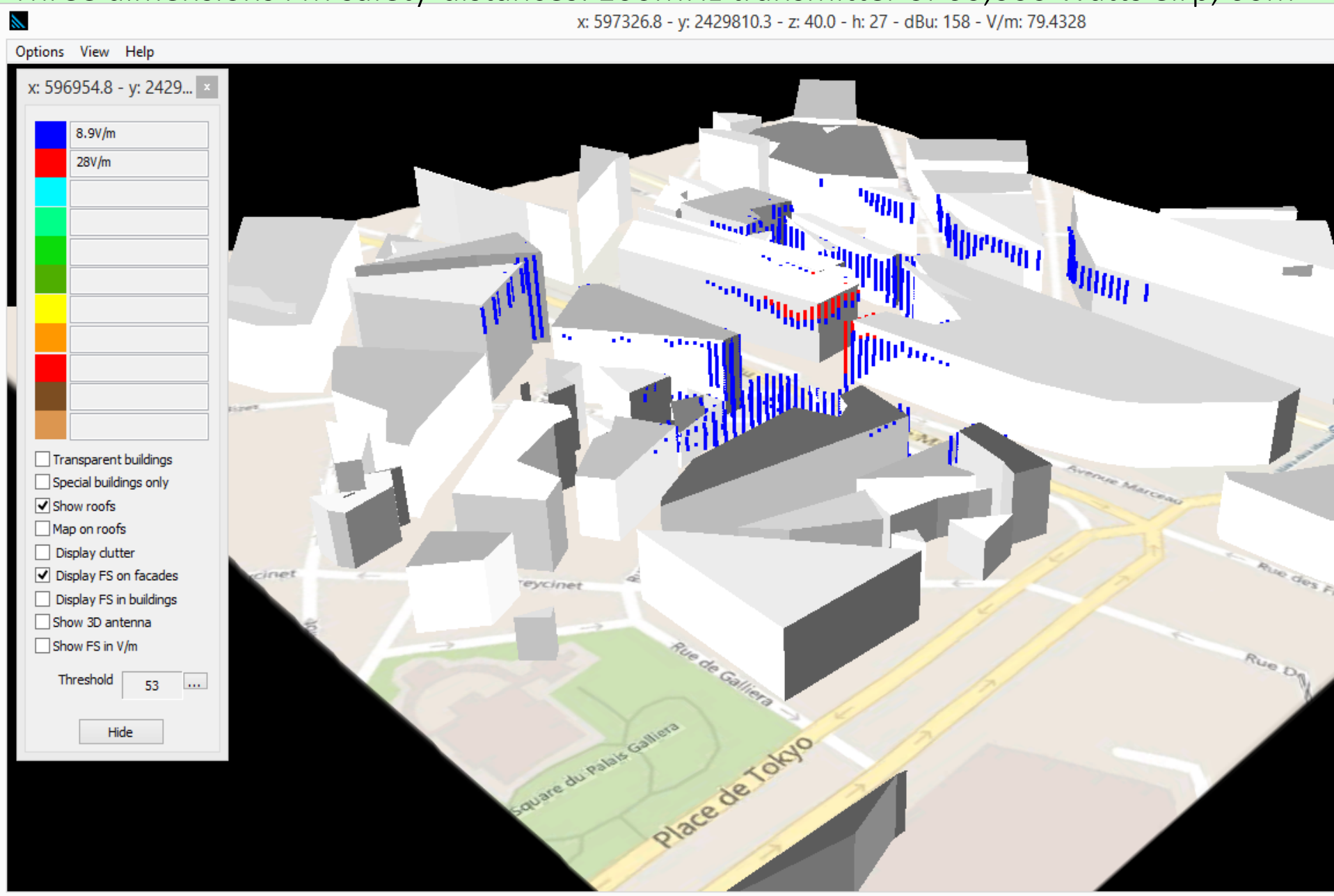
Frequency range	electric field strength (V/m)	equivalent plane wave power density S_{eq} (W/m^2)
10–400 MHz	28	2
400-2000 MHz	$1.375f^{1/2}$	***f*/200**
2-300 GHz	61	10

USA and Japan Maximum Permissible Exposure for general population/uncontrolled

RF (MHz)	electric Field (*E*) (V/m)	power Density (*S*) (mW/cm^2)
30-300	27.5	0.2
300-1500	--	***f*/1,500**
1,500-100,000	--	1

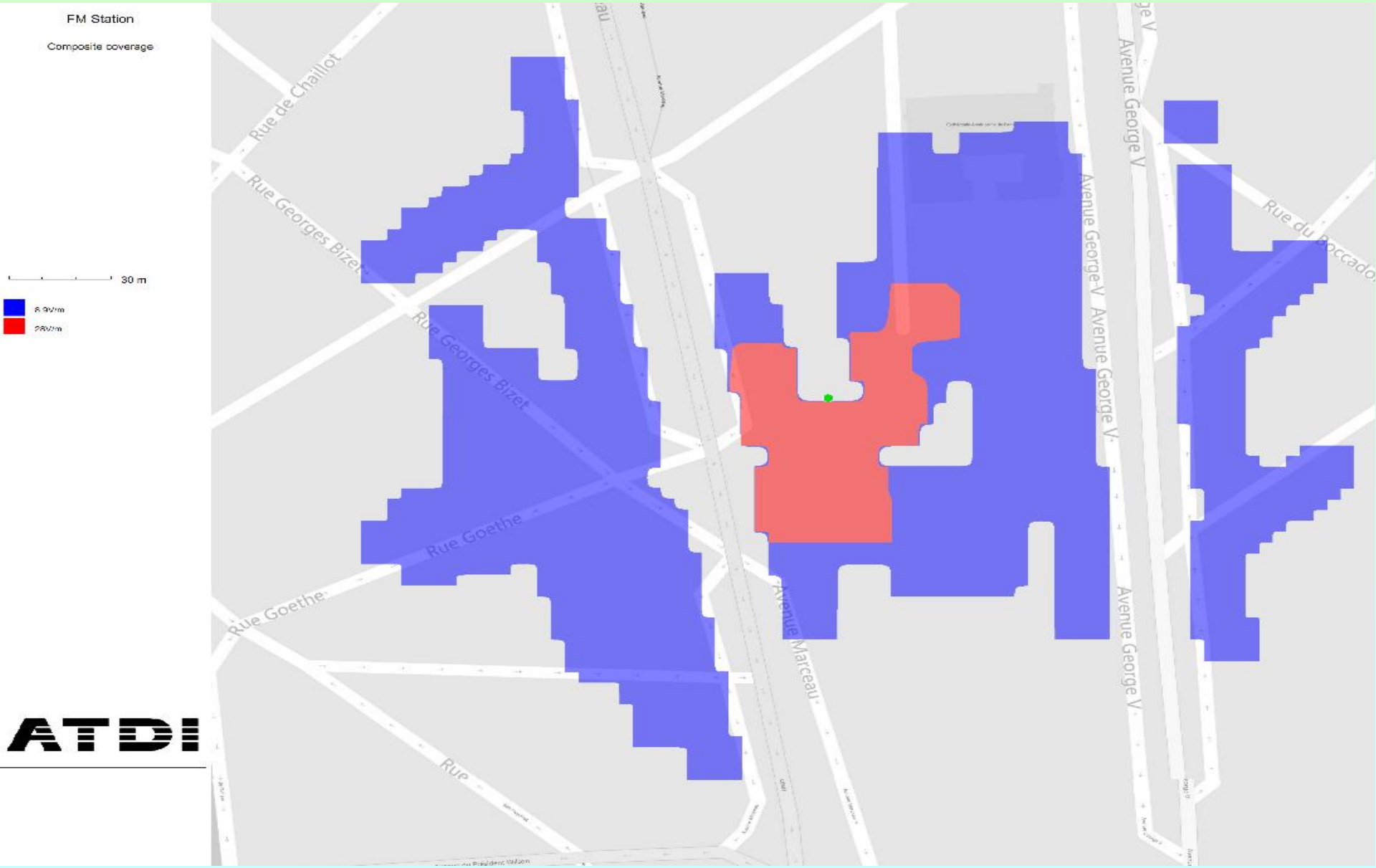
[1] FCC uses different units than ICNIRP for power density: mW/cm^2 and not W/m^2; $W/m^2 = 0.1\ mW/cm^2$

Three dimensions FM safety-distances: 100MHz transmitter of 60,000 Watts eirp, 60m

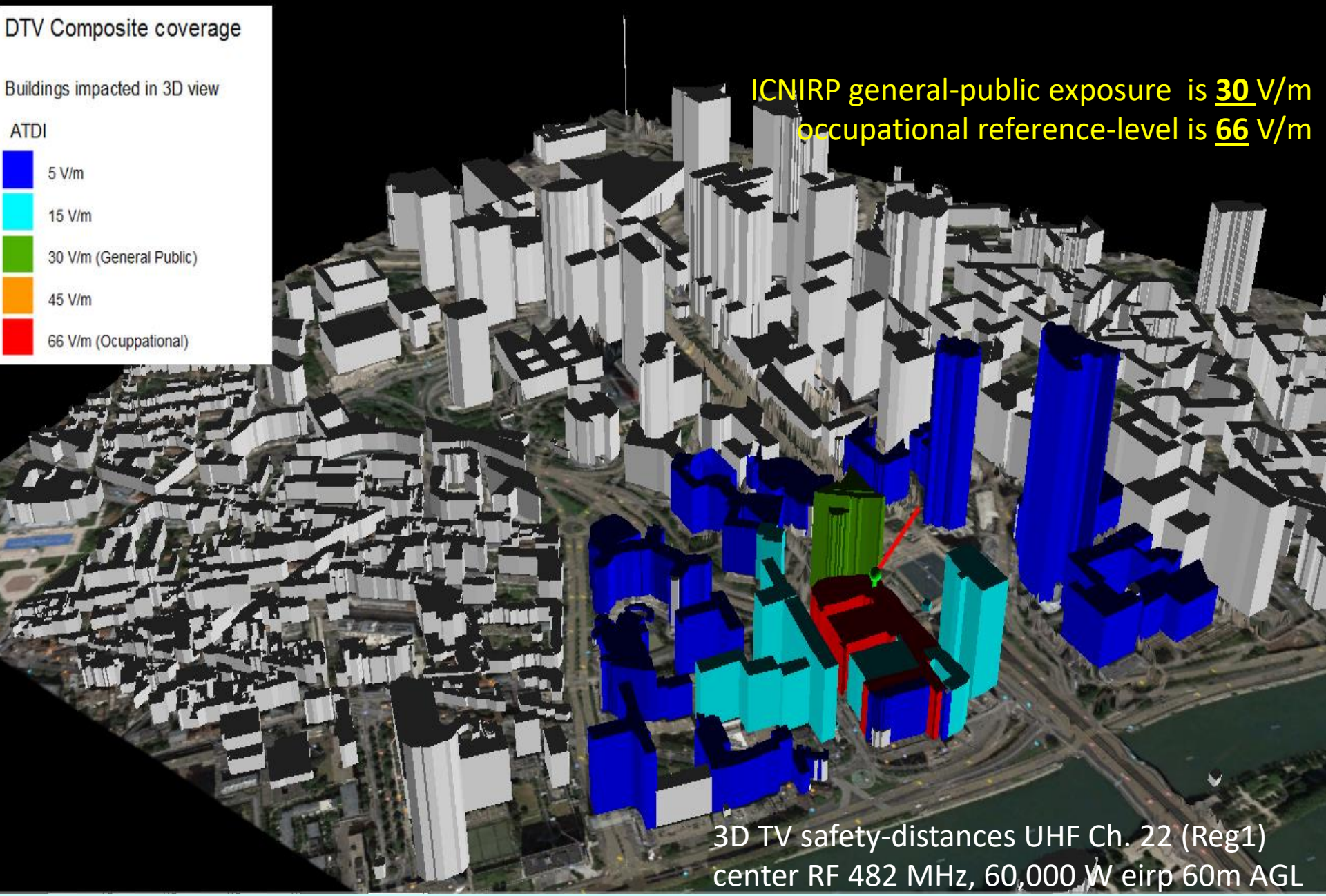


See ATDI's contribution: ITU-R Doc 6/395 6July15Fig2 and SG2RGQ/246-E 8 Jan17fig3

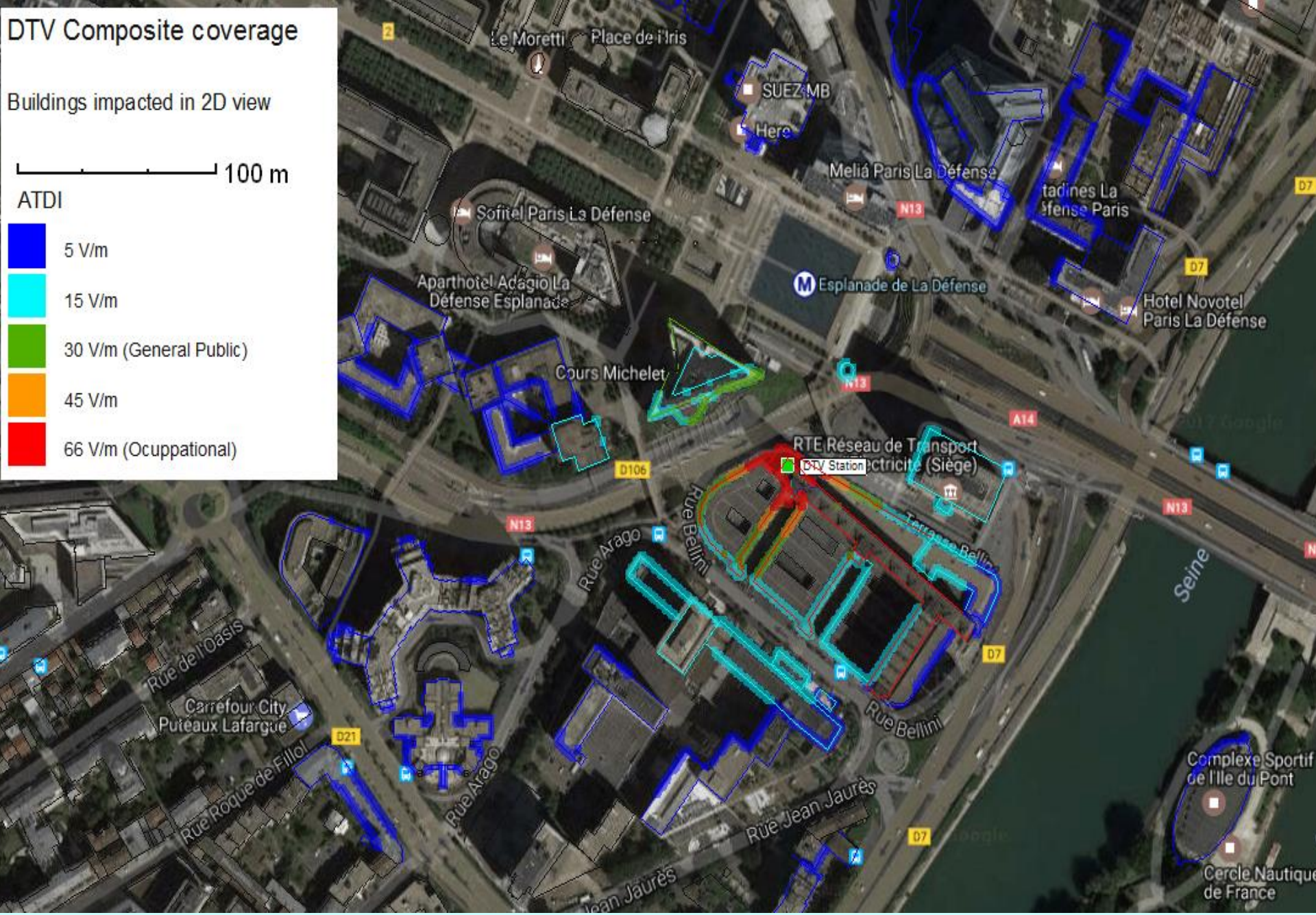
2D FM safety-distances: 100 MHz transmitter of 60,000 Watts eirp, 60m



See ITU-RDoc 6/395 6July15Fig.3&SG2RGQ/246-E 8Jan17fig4



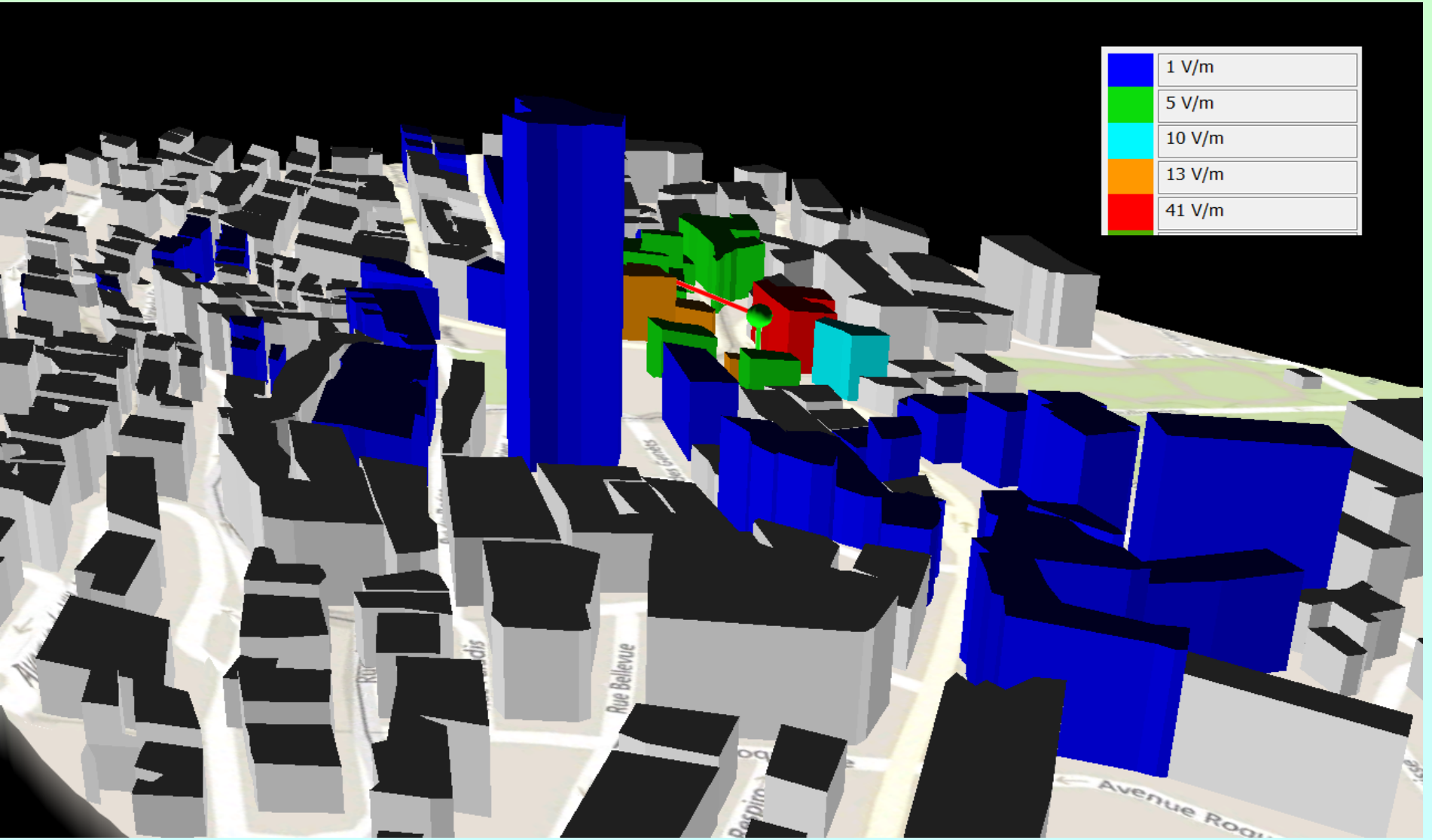
ATDI's 1C/77 contribution to ITU-R WP1C June 17



2D safety-distances UHF Ch. 22 center RF 482 MHz, 60 kW eirp 60m AGL; 2D Satellite view

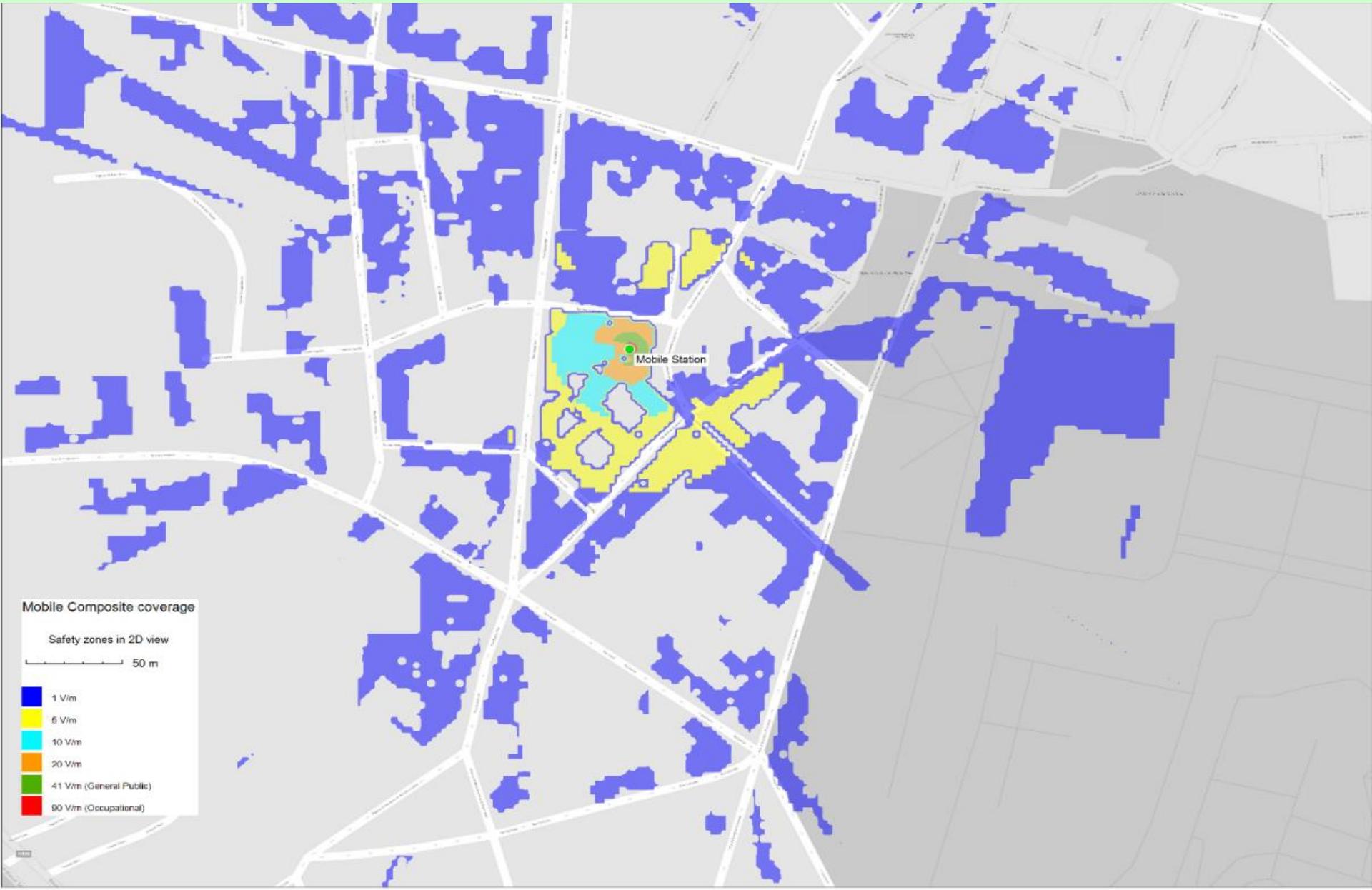
Three dimensions cellular safety-distances showing buildings impacted

For max. downlink power of 100 W, ant gain (including losses) 17 dBi, eirp is 5 kW; the free-space outdoor propagation loss safety-contours are 9.5 m for 41 V/m and 30 m for 13 V/M



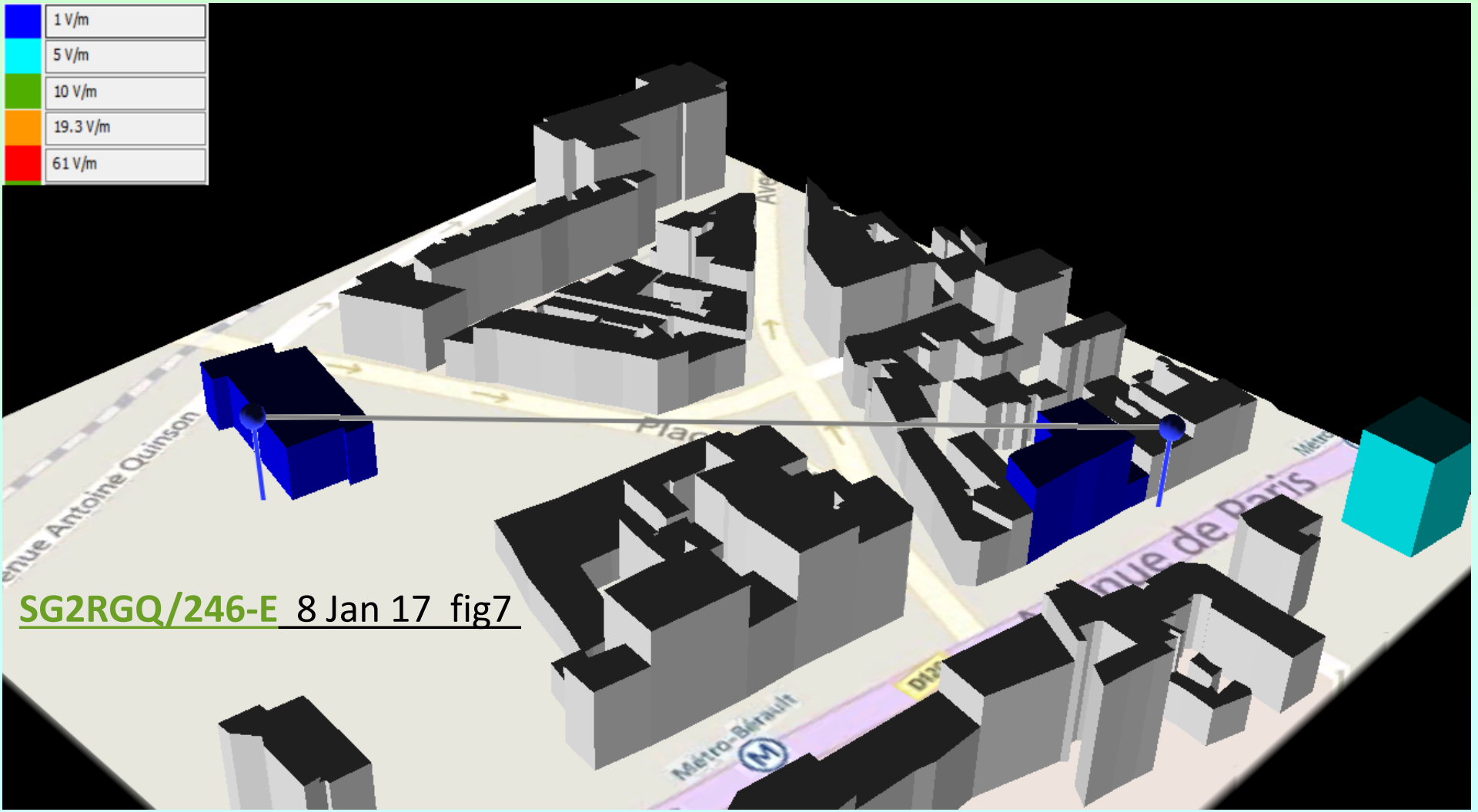
Contribution of ATDI: ITU-D SG2RGQ/246-E; **8 Jan17** fig5

Two dimensions cellular safety-distances



See ATDI contribution ITU-D Doc 5D/007 and 5A/008; p. 4; & **SG2RGQ/246-E** 8Jan17fig6

P2P 3 dimensions exposure, using ITU-R F.699 antenna patterns; 40 kW eirp



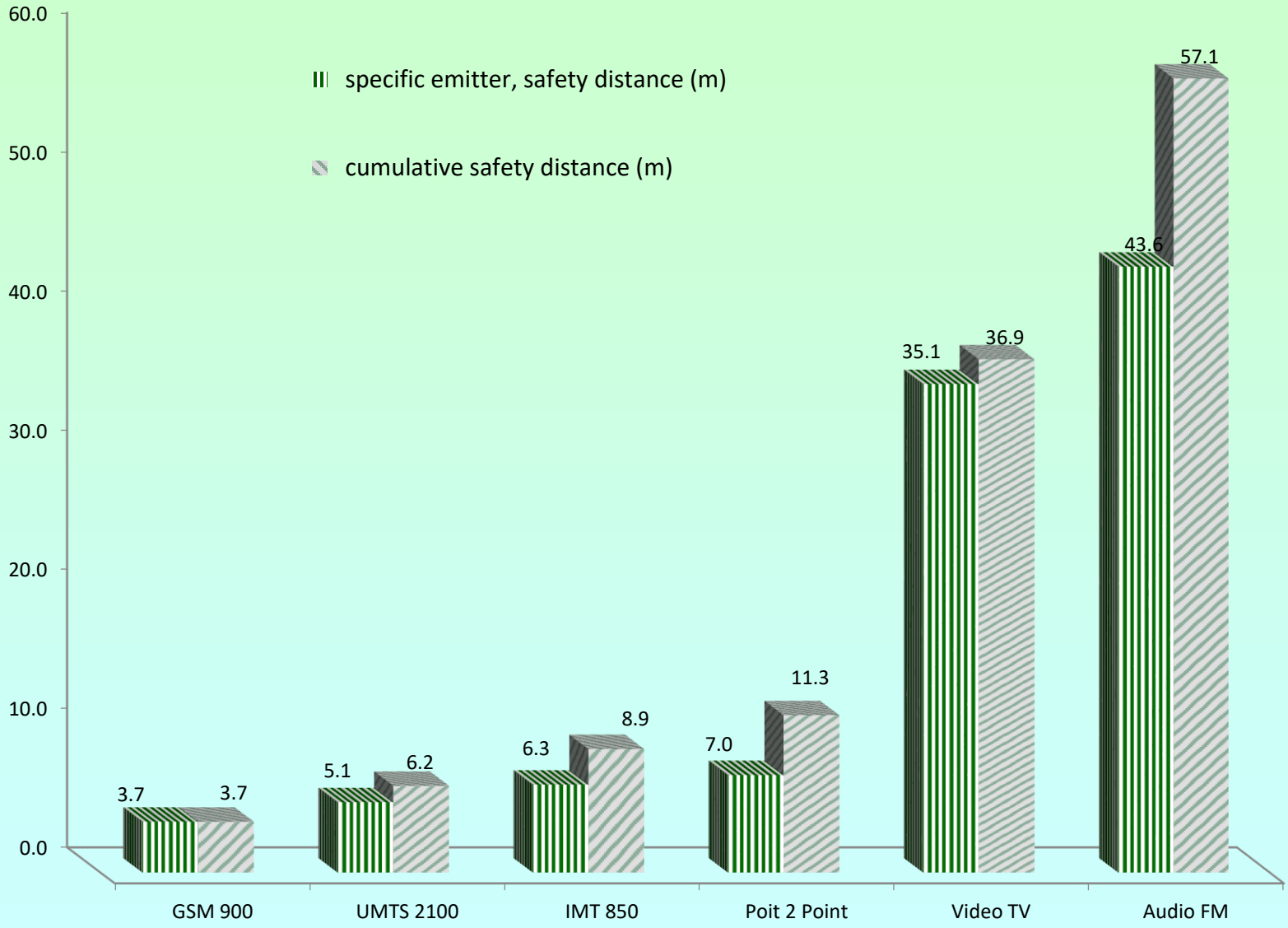
SG2RGQ/246-E 8 Jan 17 fig7

Worst-case horizontal safety-distances & cumulative exposure; co-located site

Transmission System	GSM 900	UMTS 2100	IMT 850	point-to-point	Video TV	Audio FM
Frequency (MHz)	891	2100	800	514	514	100
ICNIRP limit, power density (W/m^2)	4.75	10.00	4.00	2.57	2.57	2.00
Antenna Gain (dBi)	16	18	18	23	17	10
Antenna elevation model or real pattern	742 265	TBXLHA	80010302_0824	ITU-R F.1336	ITU-R F.699	ITU-R F.699
Ant. Altitude above ground level (m)	32	45	15	25	60	60
Cable Loss (dB)	0	1	1	1	1	1
Power (Watt)	20	64	40	10	1,000	6,000
EIRP (Watt)	800	3,210	2,000	1,580	39,810	47,660
Specific safety distance (m)	3.7	5.1	6.3	7.0	35.1	43.6
Cumulative safety distance (m)	3.7	6.3	8.9	11.3	36.9	57.1
ICNIRP limit, field strength (V/m)	41.30	61.00	38.89	31.17	31.17	28.00
Specific field strength at 50m, ICNIRP ratio	0.08	0.10	0.13	0.14	0.70	0.85
Cumulative field strength ratio	0.08	0.13	0.18	0.23	0.74	1.13

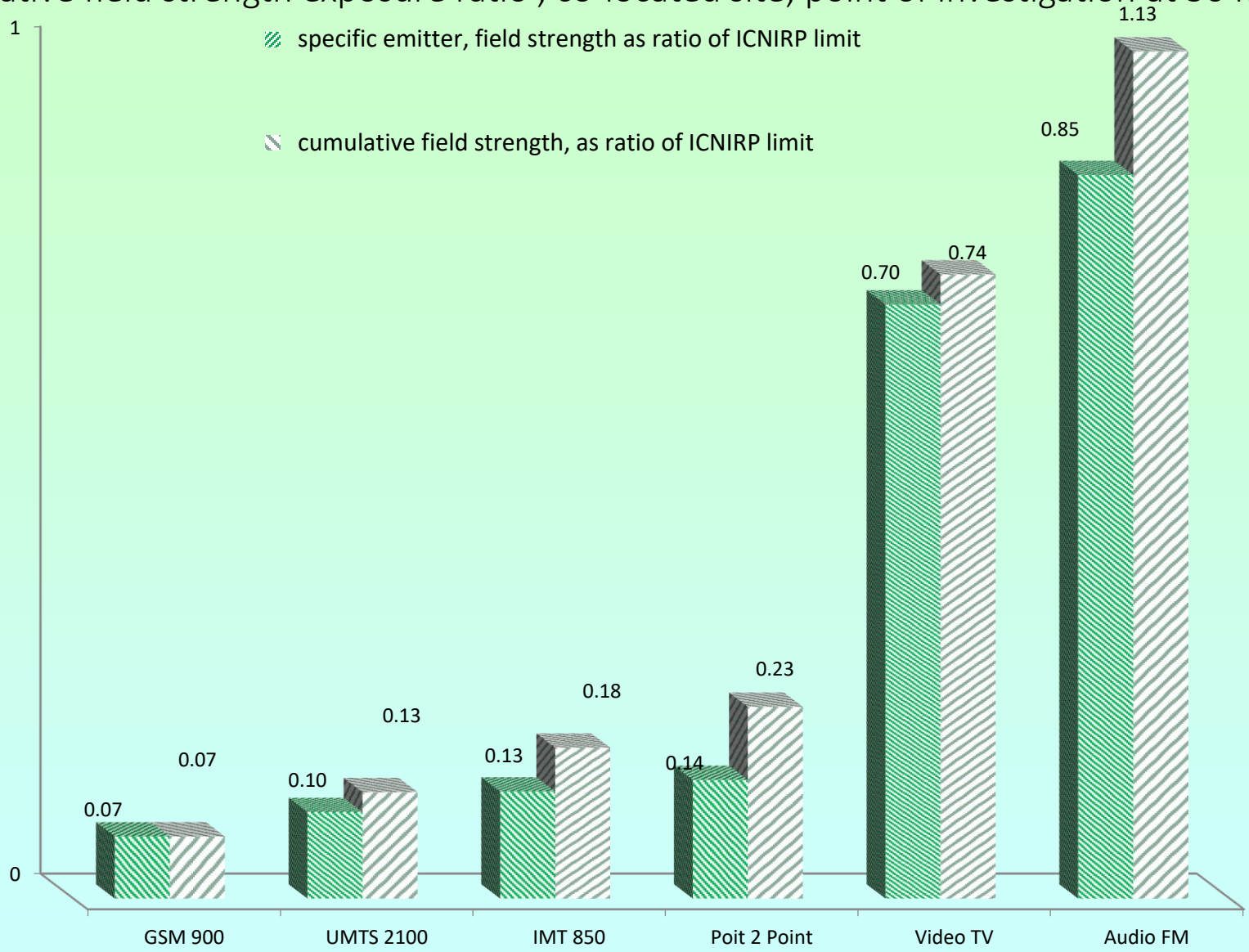
calculated by author

Cumulative horizontal safety-distance, co-located site; y axis (m)



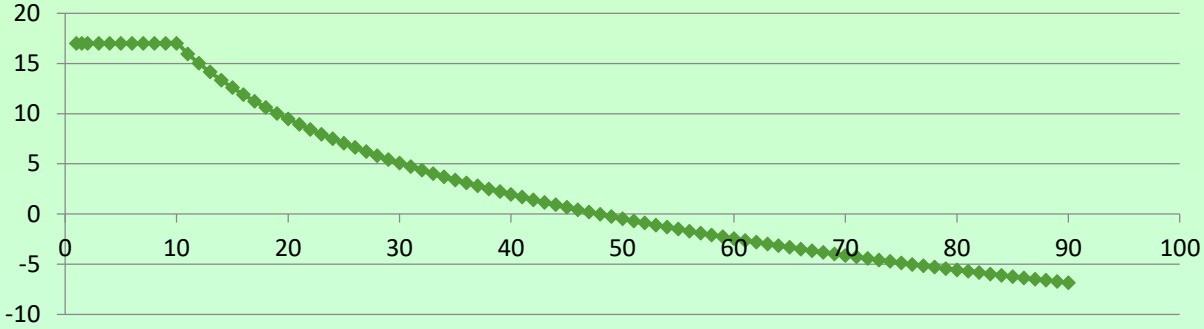
calculated by author, mazar@ties.itu.int

Cumulative field strength exposure ratio , co-located site; point of investigation at 50 meter

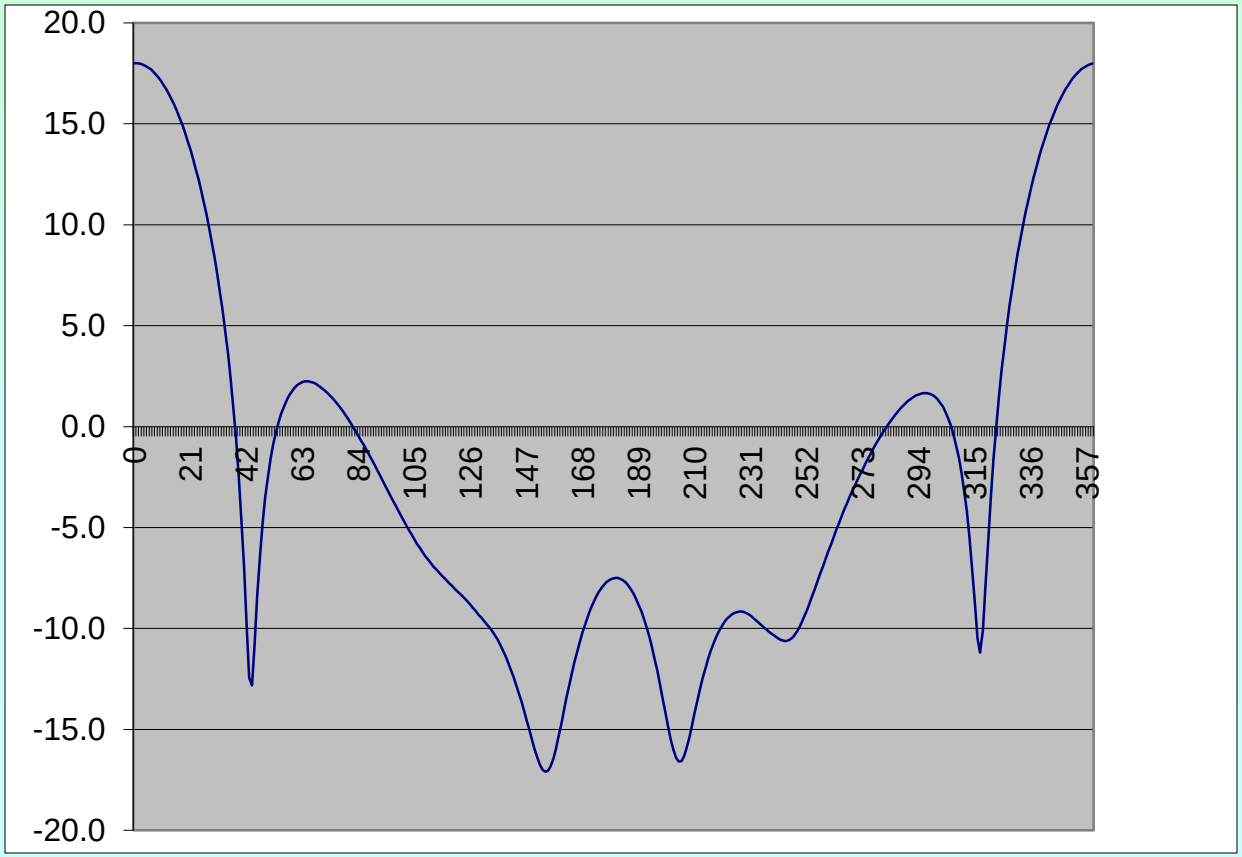


calculated by author

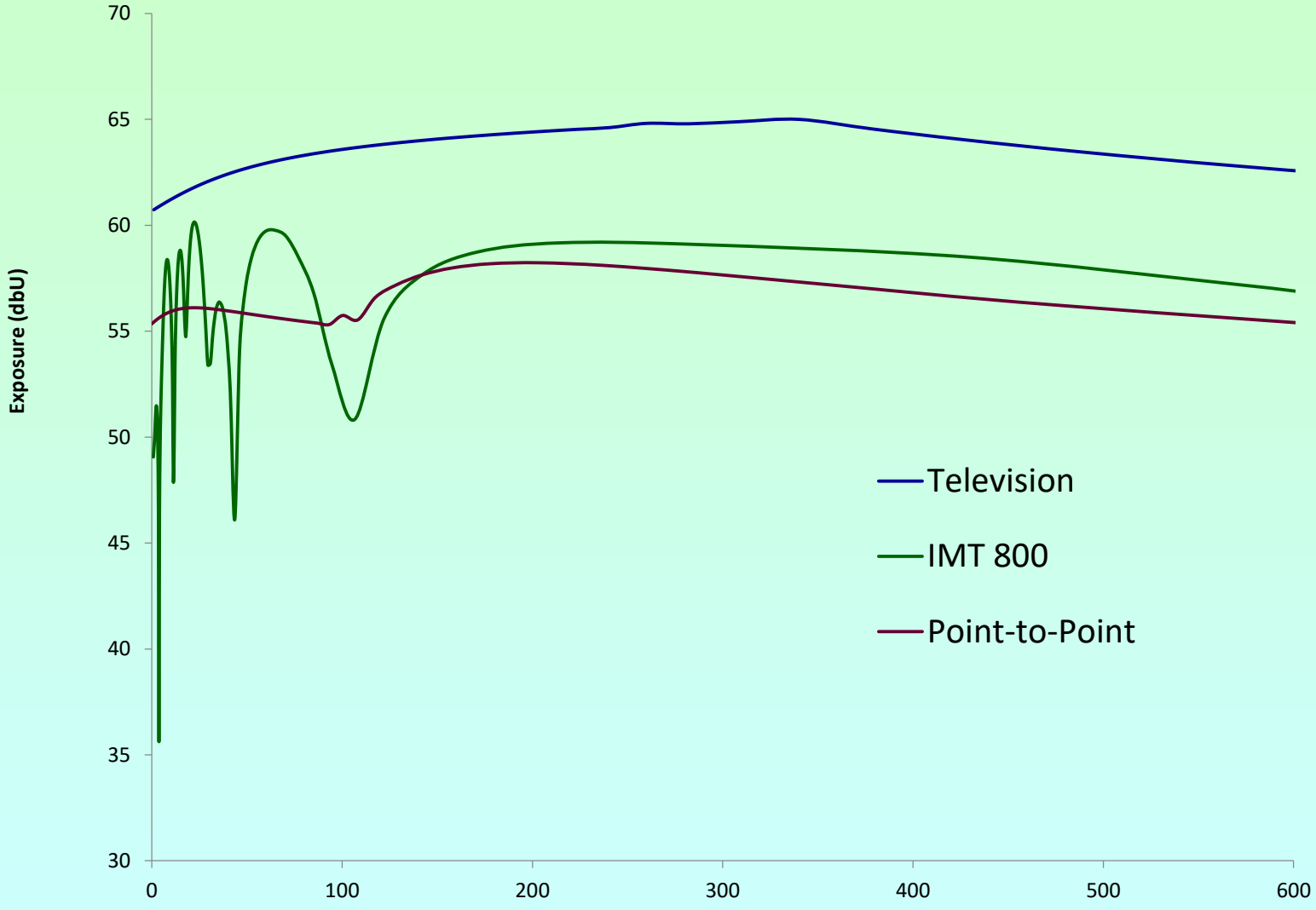
Vertical pattern of TV antenna 17 dBi calculated by ITU-R Rec. F.699



Vertical pattern of 80010302_0824_X_CO_M45_00T; Anatel



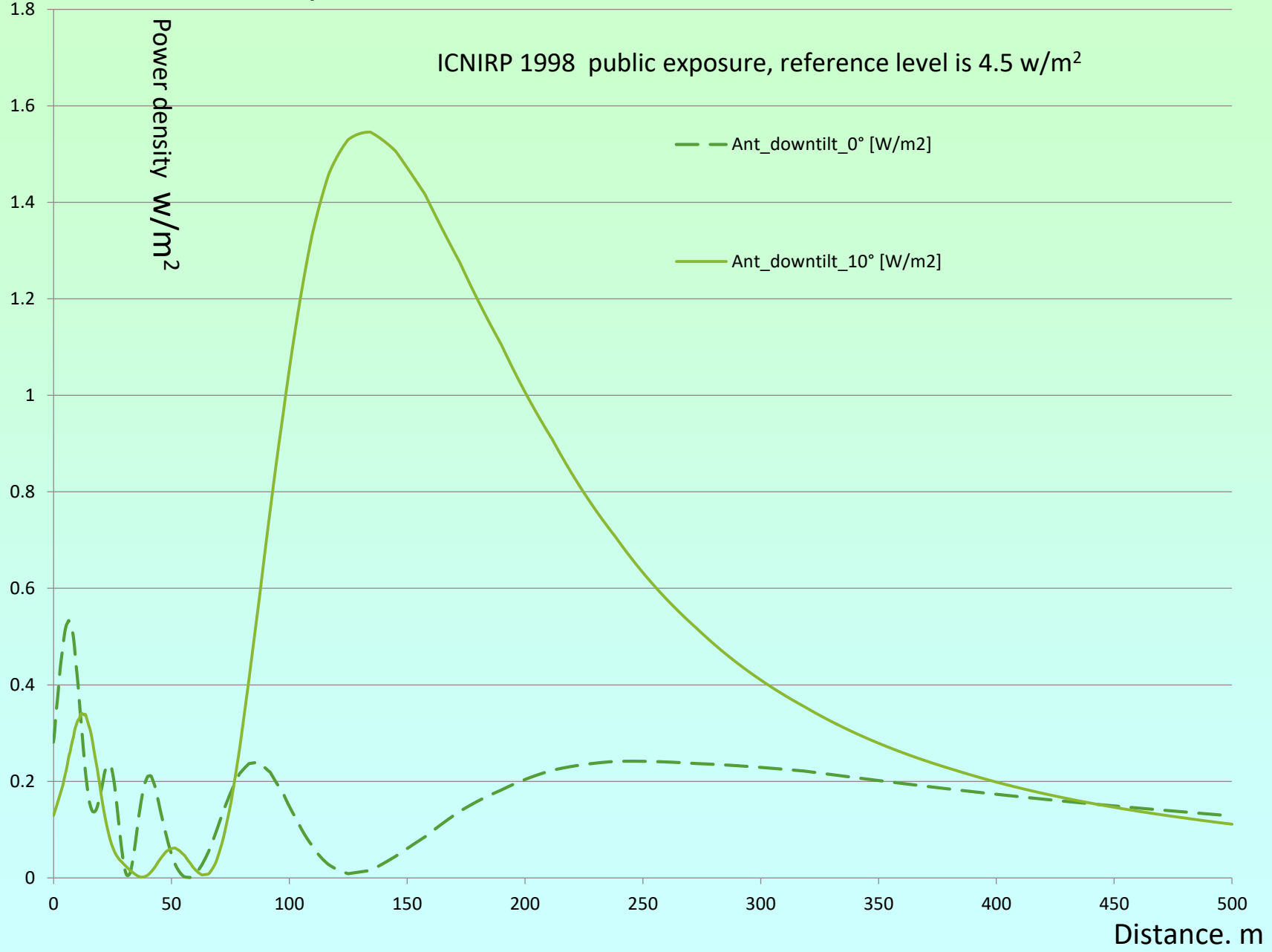
Field Strength (dBµV/m) vs. distance (m), co-located site TV, IMT 850 & Point 2 Point



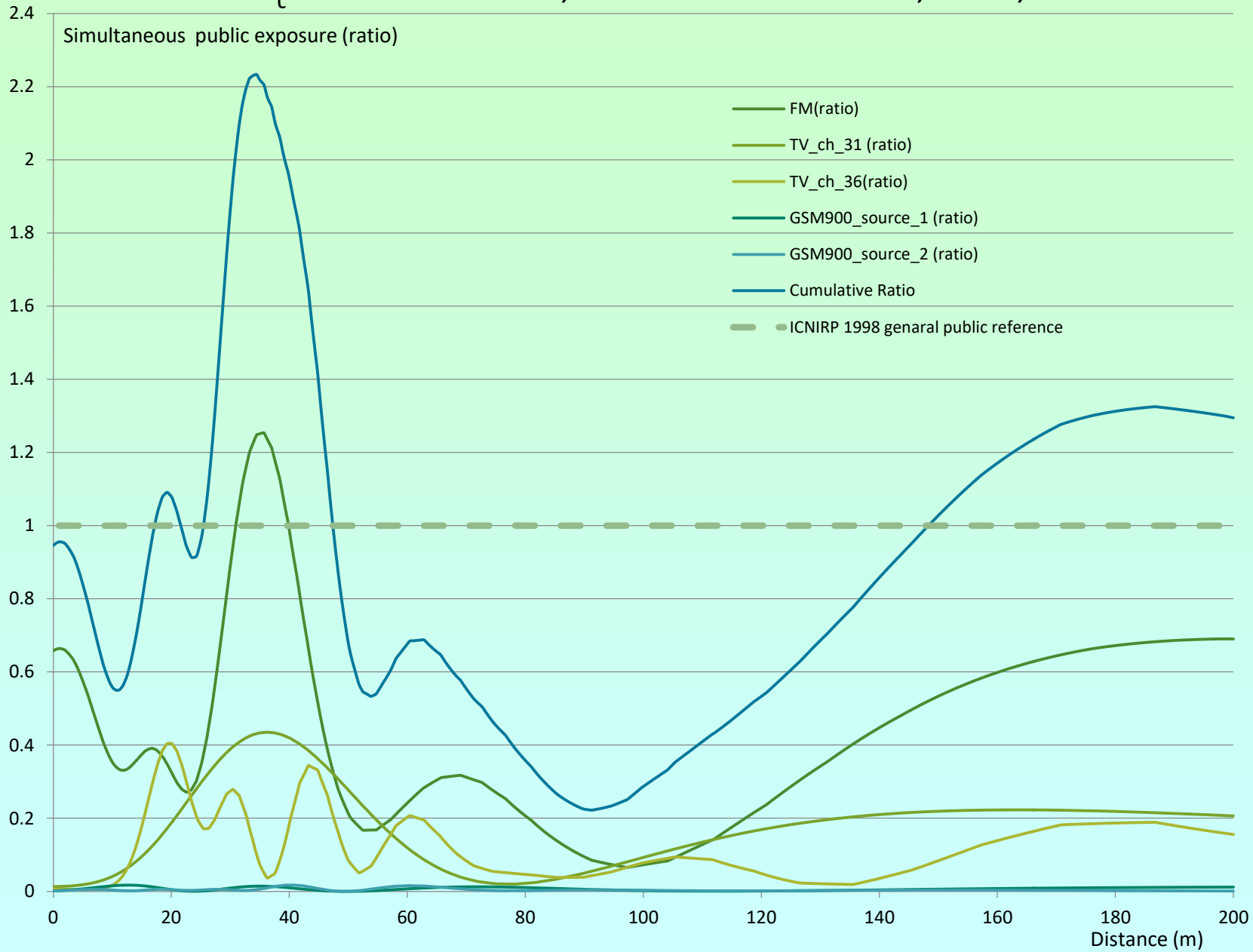
see where is the max exposure

calculated by author

Power density vs. horizontal distance, for 2 down-tilts

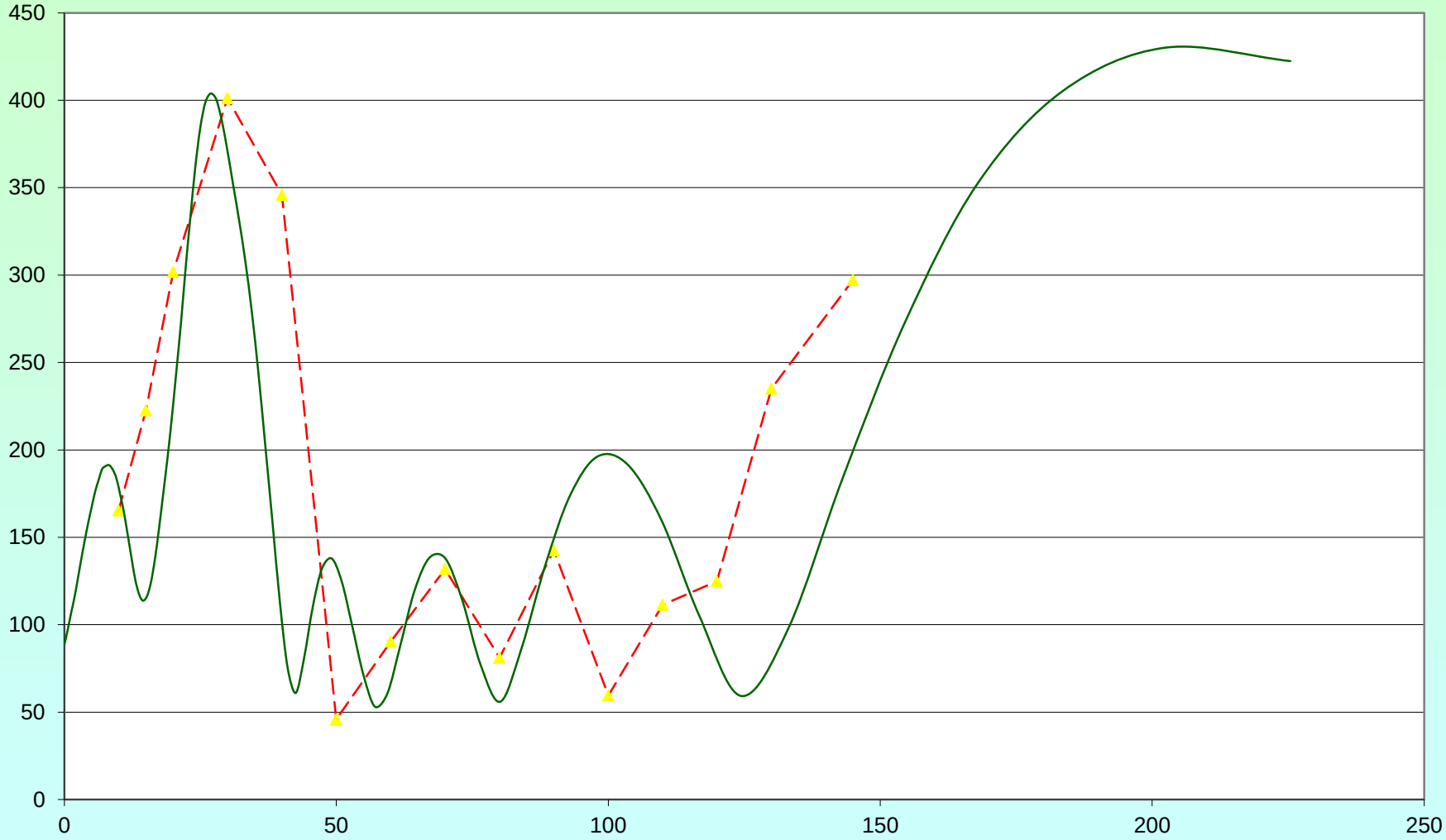


Coefficient W_t vs. distance, co-located site, FM, TV & GSM 900



Field Strength (mV/m) vs. distance (m)

RF = 1875.8 MHz; red- measured, green- calculated



Measured and calculated by ANATEL 2012, Eng . Agostinho Linhares de Souza Filho

RF Hazards limits & their impact on network planning

Excessive limits affect network planning

- Co-location and MIMO increase the safety distance and restrict mast construction near buildings
- Countries (e.g. Switzerland) reduce by 100 (and Salzburg by 9,000) the power density level and restrict the cellular BTS planning and location
- Lower RF exposure limits enforce to decrease the EIRP (in order to reduce the power density and field strength near the station) or to extend the distance of the mast from the public
- Handling low exposure thresholds by additional cellular antennas or RF Spectrum

Mitigation techniques to decrease the radiation level (1)

- 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
- Maximize the RF to operators in order to decrease sites

Mitigation techniques to decrease the radiation level (2)

- **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 p.19)
- **Increase, if possible, ant. 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 ant. (ITU-T 2007 K.70 p.22)

Low exposure thresholds by additional cellular antennas or RF Spectrum

Simplistic equations; see Mazar Wiley book, to be published April 2016

For a given network (technology, number of sites, RF spectrum, quality of service), better coverage is achieved by transmitting at higher effective power (for both downlink and uplink channels), installing base stations at higher altitude above ground level (less signal attenuation) and using lower radio frequency.

Max. channel capacity for each communications link in a given network is derived from Shannon Hartley monumental paper (**Shannon 1948 p.43, theorem 17**), relating *c*apacity (bit/s), RF *b*andwidth (Hz) and the *s*ignal to *n*oise (dimensionless) ratio

$$c = b \times log_2\left(1 + s/n\right)$$

Moreover, in urban scenario *s*/*n* is small. LTE RSRQ (Reference Signal Received Quality) quantifies the capacity; UE measures this parameter as reference signal. Values higher than −9dB guarantee the best subscriber experience; the range between −9 and −12dB can be seen as neutral with a slight degradation of Quality of Service. So for *s*/*n* very small relative to 1, 5.1 aims to:

$$c = b \times log_2\left(1 + s/n\right) \approx b \times \frac{s/n}{\ln 2} \approx 1.44 \times b \times s/n$$

Therefore, staying with the same *capacity* ***c***- less sites (reduced ***s***) can be compensated by more frequency *band* (***b***).

The capacity is limited by power *s* and noise density n_o.

Summary: cellular capacity is limited by power and noise; adding RF to base stations may decrease the number of base stations and the total EMF

Summary

1. Compliance with human exposure limits for EMF is a significant health and safety issue to regulators, service providers and wireless equipment suppliers
2. The SAR and the power-density reference levels in European countries, USA, Canada, China, Japan and Korea are compared and contrasted
3. The allowed SAR cellular handsets' exposure limits for localized heating are more restrictive in the USA, Canada and Korea (1.6 W/kg), relative to others (2 W/kg). Even the averaging is more restrictive: averaged over 1 g in N. America & Korea, versus 10 g tissue in ICNIRP 1998 & ANSI/IEEE C95.1-2005
4. Europe in general follows the ICNIRP 1998 levels from base stations. Despite the (non-mandatory) EU Council Recommendation 1999/519/EC, some EU countries adopt more restrictive thresholds
5. USA and Japan are the most liberal countries, adopting in 300–1,500 MHz power- density 4/3 of the ICNIRP1998 and IEEE 2005 levels
6. On 13 March 2015, Health Canada revised the 2009 PD limits (that were identical to the USA), and published more restrictive reference levels
7. There is no scientific reason to use different exposure limits in different countries. Some explanations of the different limits are provided

ATDI developed the Bhutan's National Radio Rules to Bhutan InfoComm and Media Authority (BICMA)

Related author's presentations

- A Global Survey and Comparison of Different Regulatory Approaches to Non-Ionizing RADHAZ and Spurious Emissions, IEEE TelAviv, COMCAS, November 2009. Hyperlink to the slides presentation; 9 November 2009
- A Comparison Between European and North American Wireless Regulations, presentation at the 'Technical Symposium at ITU Telecom World 2011' www.itu.int/worl2011 on 27 October 2011; hyperlink to the slides presentation, 27 October 2011
- Technical limits of Human Exposure to RF from Cellular Base Stations and Handsets, Jerusalem, 11 April 2013. Professional presentation of the Ministry of Communications to the experts of Ministry of Environmental Protection, human-exposure monitoring laboratories and cellular operators
- Technical limits of Human Exposure to RF from Broadcasting Emitters, Cellular Base Stations and Handsets, at 'Holon institute of technology', 30 January 2014
- Smart_Cities_RF_Human_Exposure_Ministries_of_Comms_Energy.pdf; presentation at intra-ministerial commission, on 21 January 2015
- January 2016, presentations in Singapore, Beijing, Chengdu and Shenzhen
- January2016_Human_Hazards_Mazar_SRTC_in_Chinese.pdf
- EMC_Europe2016_Wroclaw_Sep 2016_Mazar_20April16_EMF.pdf

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Any Questions ?