



IEEE Oakland East Bay Life Member Affinity Group



New IEEE EMF Exposure Safety Standard

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TC95 Chairman

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IEEE ICES

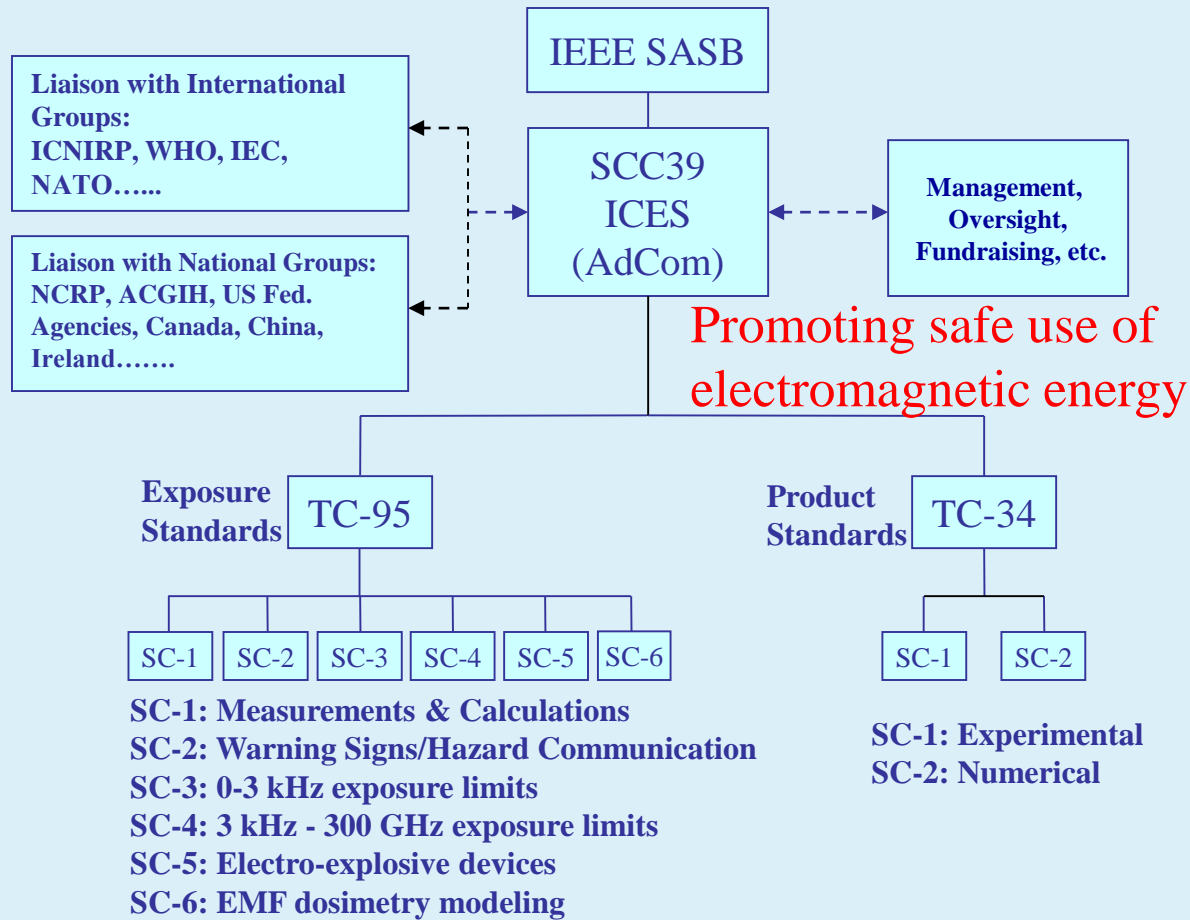
Outline

- History
- Literature reviews
- Similarities
- Differences
- Limit changes





ICES as the Focal Point in the Global Program for EME Safety Standards





IEEE Exposure Standards History

- 1960: USASI C95 Radiation Hazards Project and Committee chartered
- 1966: USAS **C95.1-1966** (2 pages)
10 mW/cm² (10 MHz to 100 GHz)
based on simple thermal model
- 1974: ANSI C95.1-1974 (limits for E² and H²)
- 1982: ANSI C95.1-1982 (**incorporates dosimetry**)
- 1991: IEEE C95.1-1991 (two tiers – reaffirmed 1997)
- 2002: IEEE C95.6-2002 (0-3 kHz)
- 2006: IEEE C95.1-2005 (3 kHz-300 GHz) published on April 19, 2006
(comprehensive revision, 250 pages, 1143 ref.)
- 2014: IEEE C95.1-2345-2014 (0-300 GHz) (NATO/IEEE agreement)
- 2015: NATO adopted C95.1-2345-2014
- 2019: IEEE C95.1-2019 (0-300 GHz) **to be published in October 2019**
(309 pages, 1550 ref.)



Weight of evidence



IEEE committee reviewed*:

- Quality of test methods
- Size and power of the study designs
- Consistency of results across studies
- Biological plausibility of dose-response relationships
- Statistical associations

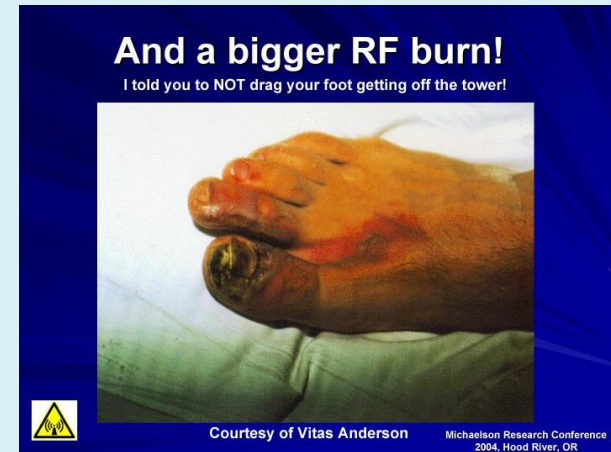


***Reviewed all literature (including both positive and negative effects, thermal and non-thermal effects)**



Risk profile for RF adverse effects (C95.1)

1. RF shocks and burns
2. Localized RF heating effects
3. Surface heating effects
4. Whole body heating effects
5. Microwave hearing effects
6. Low-level effects
(previously 'non-thermal effects')



Low-level effects ?

- No adverse effects have been established from low-level exposures despite 70 years of research
- No known interaction mechanisms
- No meaningful dose-response relationship
- Speculative
- Inappropriate for standard setting

Safety factors

[SAR applies 100 kHz- 6 GHz]



- **Whole body averaged**
Behavioral effects in animals over many frequencies, threshold at 4 W/kg
10X - 0.4 W/kg for upper tier
50X - 0.08 W/kg for lower tier
- **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





Revision of C95.1-2005 and C95.6-2002

- ❖ C95.1-2345-2014 “IEEE Standard for Military Workplaces—Force Health Protection Regarding Personnel Exposure to Electric, Magnetic, and Electromagnetic Fields, 0 Hz to 300 GHz” –**Adopted by NATO** in Nov. 2015 as **STANAG 2345** (Edition 4).
- ❖ C95.1-2019 “Draft Standard for Safety Levels with Respect to Human Exposure to Electric, Magnetic and Electromagnetic Fields, 0 Hz to 300 GHz” – **replaces C95.1-2005 and C95.6-2002**





Literature review

- ❖ The literature review conducted for the C95.1-2005 standard remains a strong foundation for the current standard (Annex C.2-7).
- ❖ Annex C.1 summarizes many recent health agency and expert group reviews confirm the protectiveness of the current limits.
- ❖ A review of the extensive literature reveals that **electrostimulation** is the dominant effect at low frequencies, and **thermal effects** dominate at high frequencies. Examination of the RF literature reveals no reproducible low level (non-thermal) adverse health effects. Moreover, the scientific consensus is that there are no accepted theoretical mechanisms that would explain the existence of such effects.
- ❖ **Major changes in limits in this standard are the DRLs and ERLs above 6 GHz based on recent thermal modeling studies. Detailed reviews of scientific studies dealing with effects at frequencies above 6 GHz are included in Annex C.8.**
- ❖ Since publication of ANSI C95.1-1982, significant advances have been made in our knowledge of the biological effects of exposure to EMF energy. This increased knowledge strengthens the basis for and confidence in the statement that the **ERLs and DRLs in this standard are protective against established adverse health effects.**



Similarities



- ❖ Scientific basis of the adverse effect levels, i.e., electrostimulation for low frequencies and heating for high frequencies.
- ❖ Exposure limits for electrostimulation effects are kept the same as in IEEE Std C95.6- 2002 and C95.1-2005.
- ❖ Exposure limits, termed dosimetric reference limits (DRLs), previously called basic restrictions, on whole body average and peak spatial-average specific absorption rates (SARs) remain the same to prevent heating effects from exposure over much of the RF spectrum.
- ❖ The exposure reference levels (ERLs), previously called maximum permissible exposure (MPE) levels, for the lower tier remain the same as in IEEE C95.1-2005.
- ❖ Continues to support the position of the earlier editions, i.e., upper tier ERLs are protective of public health and safety and that the risk of harm from exposure to fields below the lower tier ERLs has not been confirmed by scientific evidence.





Differences (1 of 3)

- ❖ C95.1-2005 two tiers; an upper tier for “people in controlled environments” and a lower tier “action level” for implementing an RF safety program or MPE for the general public. In this standard, maximum exposure limits are established for “persons in unrestricted environments” and for “persons permitted in restricted environments”.
- ❖ A dosimetry reference limit (DRL) replaces basic restriction, and exposure reference level (ERL) replaces MPE.
- ❖ The safety program initiation level (previously “action level”) is clarified as the ERL marking the transition point between the lower (unrestricted) tier and the upper (restricted) tier.
- ❖ The upper frequency boundary for whole body average (WBA) SAR has been changed from 3 GHz to 6 GHz because of improved measurement capabilities and to harmonize with the proposed new ICNIRP guidelines.





Differences (2 of 3)

- ❖ The averaging time is **30 minutes** for whole body RF exposure and **6 minutes** for local exposure.
- ❖ The term “**extremities**” as used in C95.1-2005 is changed to “**limbs**” involving the whole arms and legs, instead of portions distal to the elbows and knees. This change is to harmonize with C95.6-2002 and the ICNIRP guidelines.
- ❖ Local exposure ERL is now frequency dependent, instead of being a fixed factor of 20 times the whole-body ERL regardless of frequency.
- ❖ The upper tier **whole-body exposure ERLs above 300 MHz** are different from those in C95.1-2005 to maintain a consistent 5x factor between tiers and to harmonize with ICNIRP guidelines.





Differences (3 of 3)

- ❖ The local exposure DRL and ERL for frequencies between 6 GHz and 300 GHz have developed. The DRL is the epithelial power density inside the body surface, and ERL is the incident power density outside the body. Averaging power density area is defined as a 4 cm² square. Small exposed areas above 30 GHz: the epithelial power density is allowed to exceed the DRL or ERL by a factor of 2, with an averaging area of 1 cm².
- ❖ Peak DRL and ERL limits for local exposures to pulsed RF fields are defined, and new fluence limits for single RF-modulated pulses above 30 GHz are introduced. The averaging area for single pulse fluence is 1 cm² square.
- ❖ The former induced current limit for both feet is considered an unrealistic condition and is removed. The induced current limits for a single foot are retained.
- ❖ rms induced and contact current limits for continuous sinusoidal waveforms (100 kHz to 110 MHz) are changed from those in Table 7 of C95.1-2005 to frequency dependent values.





New limits (6 GHz – 300 GHz)

- ❖ Since the interactions are mostly at or just within the body surface and are quasi-optical, the DRLs are expressed in terms of a newly introduced metric, the “**epithelial power density**” and associated exposure averaging interval.
- ❖ The corresponding ERLs (**incident power density**) are defined as function of frequency to account for the increasing epithelial power entering into the body across the air/body. The local exposure DRLs and ERLs are both averaged over **4 cm²**. Above **30 GHz and small area exposure**, averaged over **1 cm²**.
- ❖ There are limited experimental human data upon which to set limits on exposures above 6 GHz. Pending availability of more data, the limits above 6 GHz were revised to provide a similar level of protection against thermal hazards as that provided in the current limits below 6 GHz, using the results of widely accepted thermal modeling and dosimetric studies.





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

^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).²⁵



Table 6— Local exposure DRLs (6 GHz to 300 GHz)



Conditions	Epithelial power density (W/m ²) ^{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 cm² 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 cm² 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 (defined as area in the shape of a square at the body surface).



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/m ²)		Averaging time (min)
			S_E	S_H	
0.1 to 1.34	614	$16.3 / f_M$	1000	$100\,000 / f_M^2$	30
1.34 to 30	$823.8 / f_M$	$16.3 / f_M$	$1800 / f_M^2$	$100\,000 / f_M^2$	30
30 to 100	27.5	$158.3 / f_M^{1.668}$	2	$9\,400\,000 / f_M^{3.336}$	30
100 to 400	27.5	0.0729	2		30
400 to 2000	—	—	$f_M / 200$		30
2000 to 300 000	—	—	10		30

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. (See notes to Table 7 through Table 11 in 4.3.5.)

^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.



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	$16.3 / f_M$	9000	$100\,000 / f_M^2$	30
1.0 to 30	$1842 / f_M$	$16.3 / f_M$	$9000 / f_M^2$	$100\,000 / f_M^2$	30
30 to 100	61.4	$16.3 / f_M$	10	$100\,000 / f_M^2$	30
100 to 400	61.4	0.163	10		30
400 to 2000	—	—	$f_M / 40$		30
2000 to 300 000	—	—	50		30

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 8. 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 8. (See notes to Table 7 through Table 11 in 4.3.5.)

^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.



Table 9—Local exposure ERLs (100 kHz to 6 GHz) persons in unrestricted environments



Frequency range (MHz)	Electric field strength (E) ^{a,b,c,d} (V/m)	Magnetic field strength (H) ^{a,b,c,d} (A/m)	Power density (S) ^{a,b,c,d} (W/m ²)	
			S_E	S_H
0.1 to 1.34	1373	$36.4/f_M$	5000	$500\,000/f_M^2$
1.34 to 30	$1842/f_M$	$36.4/f_M$	$9000/f_M^2$	$500\,000/f_M^2$
30 to 100	61.4	$353/f_M^{1.668}$	10	$47\,000\,000/f_M^{3.336}$
100 to 400	$21.2 \times f_M^{0.232}$	$0.0562 \times f_M^{0.232}$	$1.19 \times f_M^{0.463}$	
400 to 2000	—	—	$1.19 \times f_M^{0.463}$	
2000 to 6000	—	—	40	

NOTE 1—Below 6 GHz, portable devices are typically tested for DRL compliance (e.g., SAR), for which distinct limits for head and torso, pinnae and limbs are defined.

NOTE 2— 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 Determined in air at the location of the body surface.

^b Spatial and temporal peaks averaged over 6 min.

^c f_M is the frequency in MHz.

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

^e See notes to Table 7 through Table 11 in 4.3.5.

Table 10—Local exposure ERLs (100 kHz to 6 GHz) persons in restricted environments



Frequency range (MHz)	Electric field strength (E) ^{a,b,c,d} (V/m)	Magnetic field strength (H) ^{a,b,c,d} (A/m)	Power density (S) ^{a,b,c,d} (W/m ²)	
			S_E	S_H
0.1 to 1.0	4119	$36.4 / f_M$	45 000	$500\,000 / f_M^2$
1.0 to 30	$4119 / f_M$	$36.4 / f_M$	$45\,000 / f_M^2$	$500\,000 / f_M^2$
30 to 100	137.3	$36.4 / f_M$	50	$500\,000 / f_M^2$
100 to 400	$47.3 \times f_M^{0.232}$	$0.125 \times f_M^{0.232}$	$5.93 \times f_M^{0.463}$	
400 to 2000	—	—	$5.93 \times f_M^{0.463}$	
2000 to 6000	—	—	200	

NOTE 1—Below 6 GHz, portable devices are typically tested for DRL compliance (e.g., SAR), for which distinct limits for head and torso, pinnae and limbs are defined.

NOTE 2— 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 Determined in air at the location of the body surface.

^b Spatial and temporal peaks averaged over 6 min.

^c f_M is the frequency in MHz.

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

^e See notes to Table 7 through Table 11 in 4.3.5.

Table 11 —Local exposure ERLs (6 GHz to 300 GHz)



Frequency	Persons in unrestricted environments Incident Power Density (W/m ²) ^{a, b, c, d, e}	Persons in restricted environments Incident Power Density (W/m ²) ^{a, b, c, d, e}
6 GHz	40	200
6 GHz to 300 GHz	$55f_G^{-0.177}$	$274.8f_G^{-0.177}$
300 GHz	20	100

^a Incident power density is averaged over 6 min for local exposure.

^b Averaged over any 4 cm² of body surface for 6 GHz to 300 GHz (area defined as surface of the body in the shape of a square).

^c Small exposed areas above 30 GHz: If the exposed area on body surface is small (<1 cm² as defined by -3 dB contours relative to the peak exposure), the incident power density is allowed to exceed the ERL values of Table 11 by a factor of 2, with an averaging area of 1 cm² (defined as area in the shape of a square at surface of the body).

^d Assessed in air at the location of the body, but the body is absent during assessment.

^e f_G is the frequency in GHz.

^f See notes to Table 7 through Table 11 in 4.3.5.



Intense pulse fluence limits

- ❖ **Persons in unrestricted environments:**
 $< 0.2 \tau^{1/2} \text{ kJ/m}^2$
- ❖ **Persons permitted in restricted environments:**
 $< 1 \tau^{1/2} \text{ kJ/m}^2$

NOTE—Units for coefficients in the above equations are $\text{kJ}\cdot\text{m}^{-2}\cdot\text{s}^{-1/2}$, where τ is the pulse width in seconds. For this limit the exposure is to be averaged over 1 cm^2 areas of body surface. For pulsed fields above 30 GHz, the averaging area is 1 cm^2 . For other pulsed fields, the averaging areas are the same as for continuous wave exposure.



Table B.1— Application of “Safety Factors” to DRLs for whole body exposure to environmental fields



Frequency Range	Adverse Effect	Safety Factor (Divisor)		Applied Metric
		Upper Tier SF_U	Lower Tier SF_L	
≤ 100 kHz CW; ≤ 5 MHz (pulsed)	Pain (PNS)	3	9	<i>in-situ</i> E-field (V/m)
	Synapse Modulation (CNS)	3	9	
100 kHz to 6 GHz	Thermal stress (e.g., as reflected in work stoppage)	10	50	SAR (W/kg) or incident power density (W/m ²)
> 6 GHz	Thermal pain in skin	2 to 5	10 to 25	epithelial power density (W/m ²)

*See Annex B.3.2.

NOTE 1—Safety factors in this table apply to DRLs for whole body exposures to environmental fields. Special exceptions may exist for localized exposure. See Annex B.3.2.

NOTE 2—The safety factors at low frequencies (1st row of data) apply to the magnitude of the internal E-field. Factors at RF frequencies apply to power, and therefore are applied to the square of the internal or surface field.





C95.1-2019 Annexes

- ❖ Annex A (informative) Approach to revision of IEEE Stds C95.1-2005 and C95.6-2002 (R2007)
- ❖ Annex B (informative) Rationale
- ❖ Annex C (informative) Identification of levels of exposure associated with adverse effects: summary of the literature
- ❖ Annex D (informative) Practical examples—applications
- ❖ Annex E (informative) Bibliography



Free IEEE C95 Safety Standards



Get IEEE C95™ STANDARDS: Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields <https://ieeexplore.ieee.org/browse/standards/get-program/page/series?id=82>

- IEEE C95.1™-2019 (when published)
IEEE Standard for Safety Levels with Respect to Human Exposure to Electric, Magnetic, and Electromagnetic Fields, 0 Hz to 300 GHz
- IEEE C95.1-2345™-2014
Military Workplaces--Force Health Protection Regarding Personnel Exposure to Electric, Magnetic, and Electromagnetic Fields, 0 Hz to 300 GHz
- IEEE C95.2™-2018
IEEE Standard for Radio-Frequency Energy and Current-Flow Symbols
- IEEE C95.3™-2002
Measurements and Computations of Radio Frequency Electromagnetic Fields with Respect to Human Exposure to Such Fields, 100 kHz-300 GHz
- IEEE C95.3.1™-2010
Measurements and Computations of Electric, Magnetic, and Electromagnetic Fields with Respect to Human Exposure to Such Fields, 0 Hz to 100 kHz
- IEEE C95.4™-2002
IEEE Recommended Practice for Determining Safe Distances From Radio Frequency Transmitting Antennas When Using Electric Blasting Caps During Explosive Operations
- IEEE C95.7™-2014
Recommended Practice for Radio Frequency Safety Programs, 3 kHz to 300 GHz

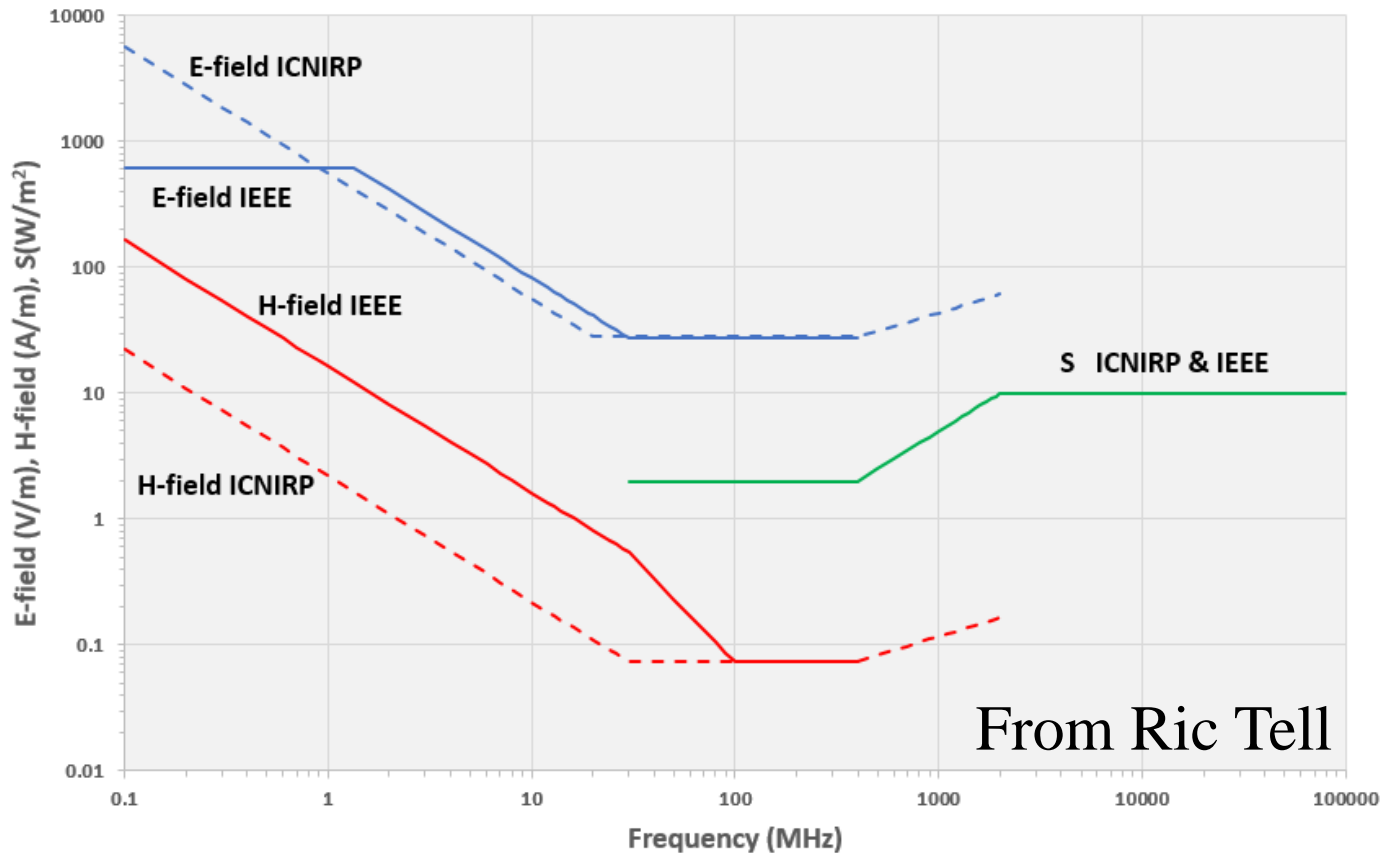
Sponsored by the United States Navy, Air Force, and Army.





Differences in limits

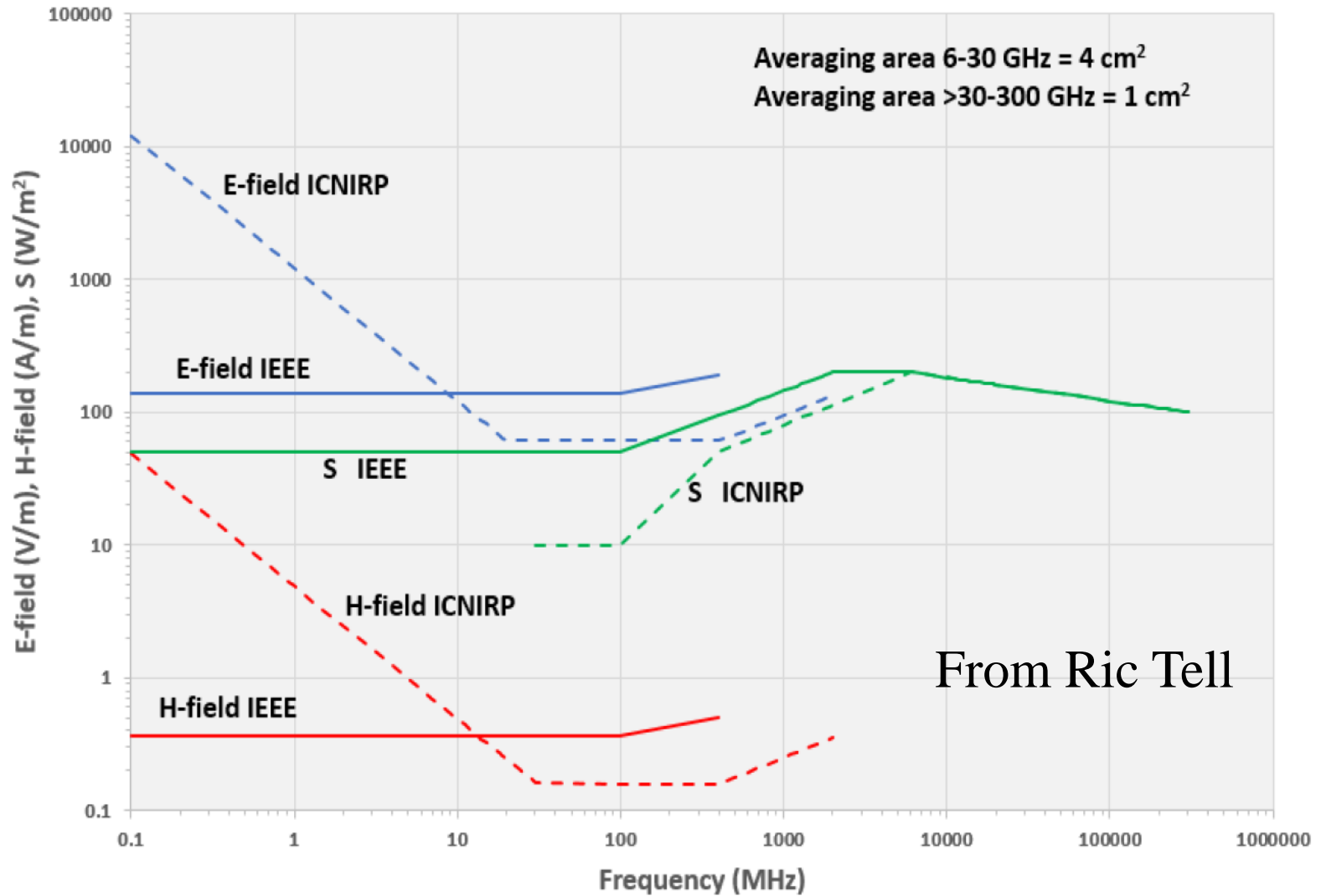
Comparison of Proposed ICNIRP and Proposed IEEE Exposure Limits for General Public/Unrestricted Environments



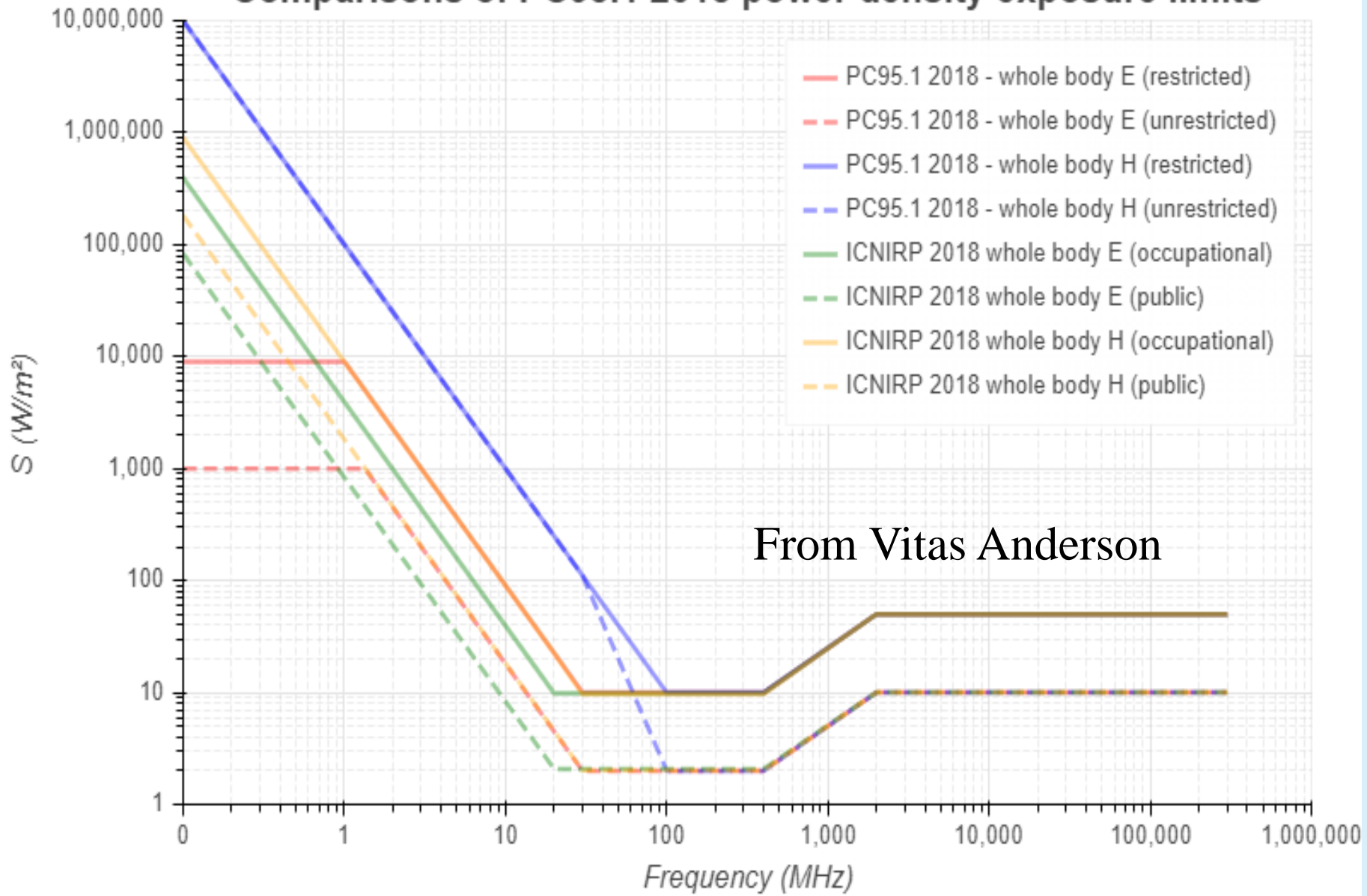
From Ric Tell



Comparison of Proposed ICNIRP and Proposed IEEE Local Exposure Limits (assumed 6-minute exposure)



Comparisons of PC95.1 2018 power density exposure limits



From Vitas Anderson





BioEM 2019 Workshop

Differences of Exposure Limits between the New ICNIRP Guidelines and IEEE C95.1-2019 Standard

Co-Chairs: C-K. Chou and Eric van Rongen

Speakers:

ICNIRP: Rodney Croft, Akimasa Hirata

ICES: Kenneth R. Foster, Richard Tell

June 25, 2019

Montpellier, France



Conclusions

- ❖ C95.6-2002 and C95.1-2005 are combined into C95.1-2019 to protect against established adverse health effects.
- ❖ Due to thermophysiological considerations, time averaging now depends on whether it is a whole-body or local exposure.
- ❖ Main changes are the limits in the frequency range of 6 GHz to 300 GHz. Local exposure DRLs and ERLs are derived from recent thermal modeling studies. The “epithelial power density” at the body surface is a newly introduced DRL for frequencies above 6 GHz.
- ❖ The standard is approved by IEEE on February 11, 2019. A corrigendum is being processed.
- ❖ Expected publication in October 2019.



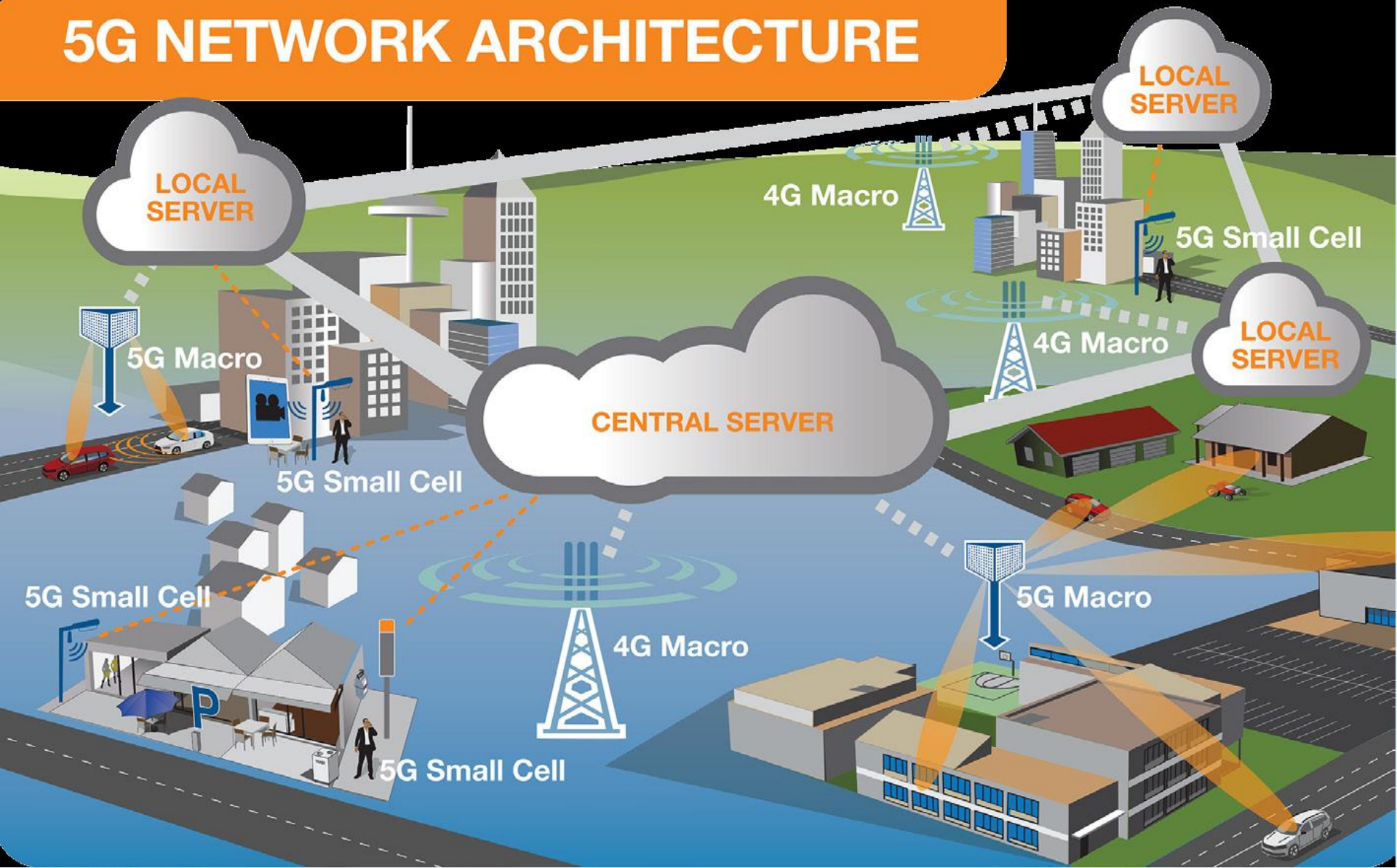
Promoting safe use of electromagnetic energy



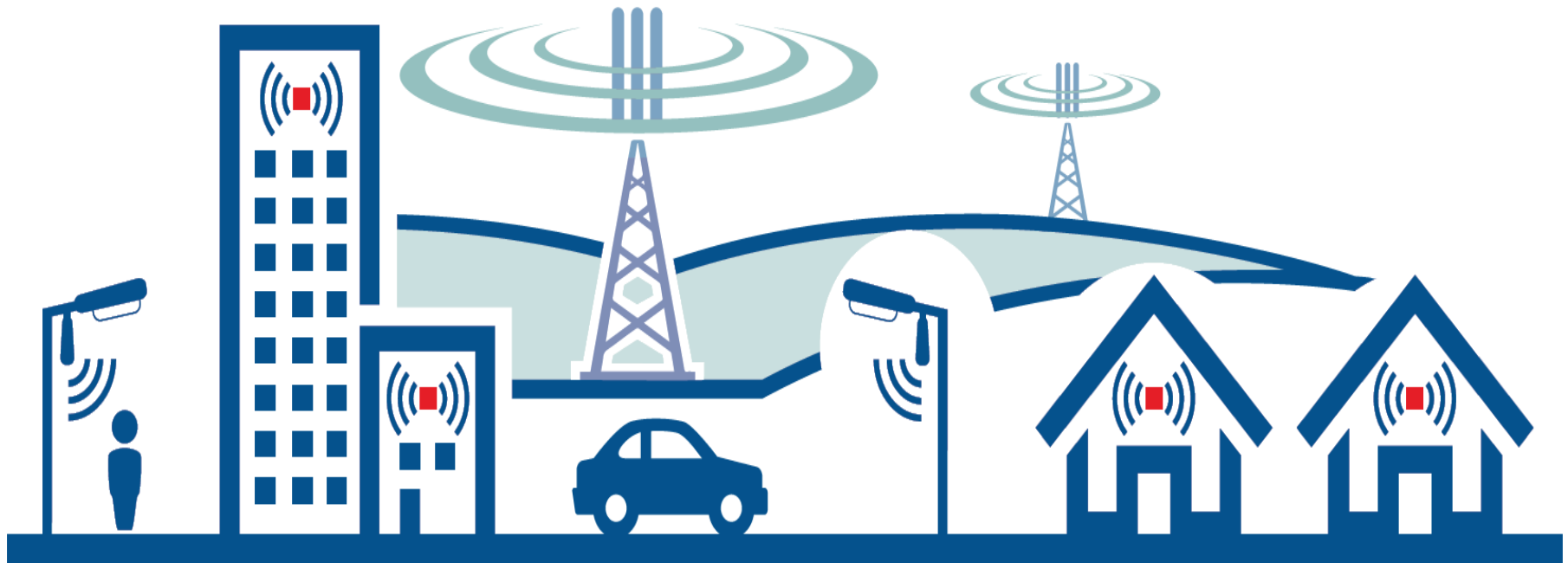
Thank you



5G NETWORK ARCHITECTURE



Macro cells for wide area coverage



In-building and street small cells

Home small cells

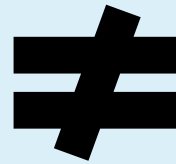


Root of Concerns: "Radiation"

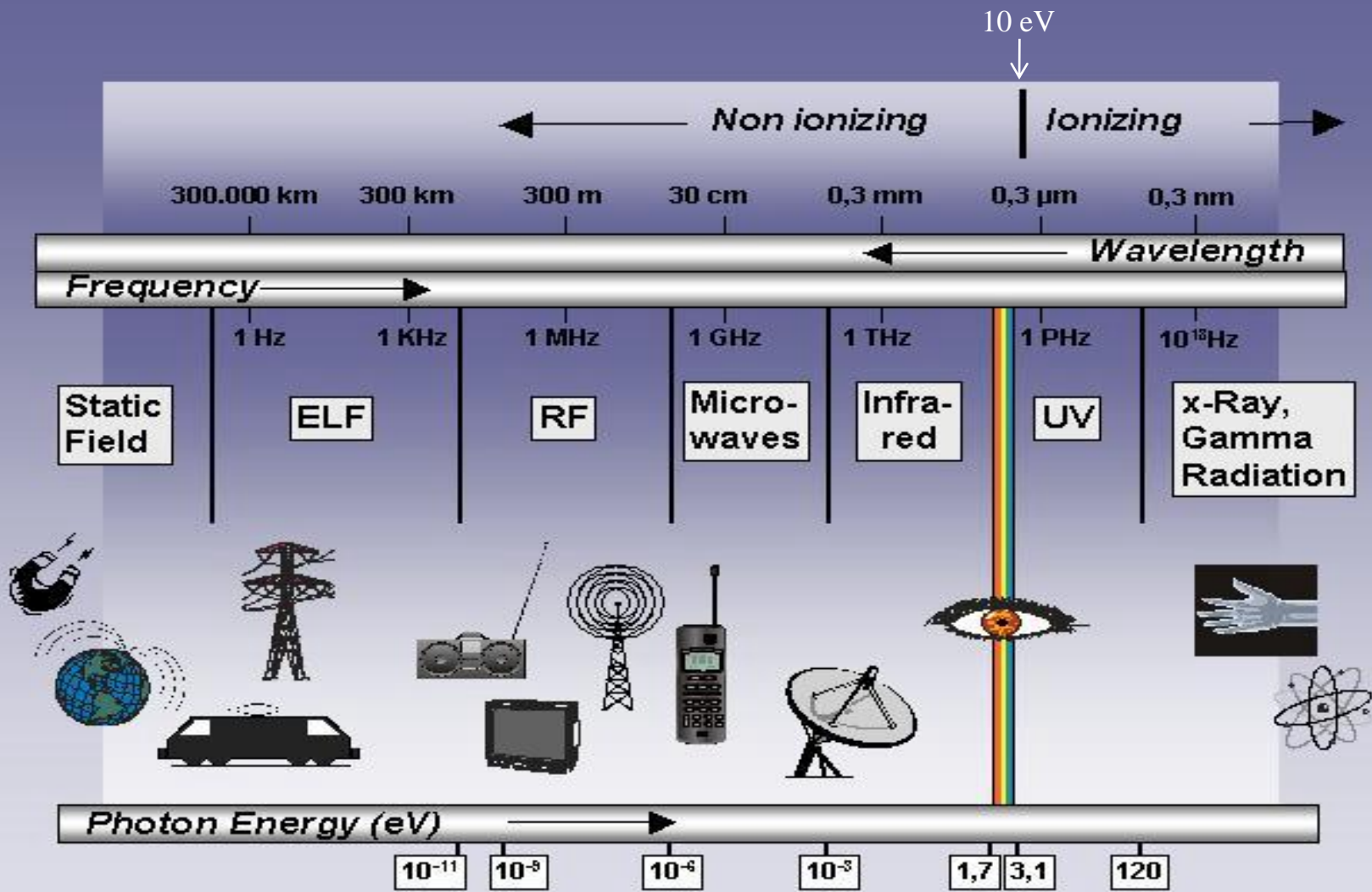
RF Exposure



Nuclear Radiation



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Biological Complexity

❖ In vivo study

- Species
- Strain
- Sex
- Age
- Extrapolation from animal to humans



❖ In vitro study

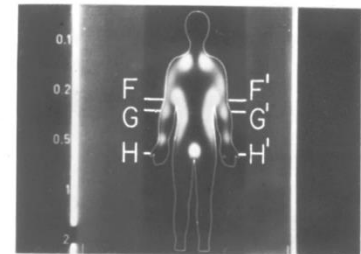
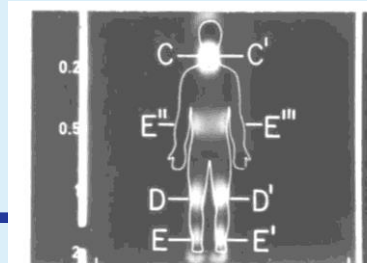
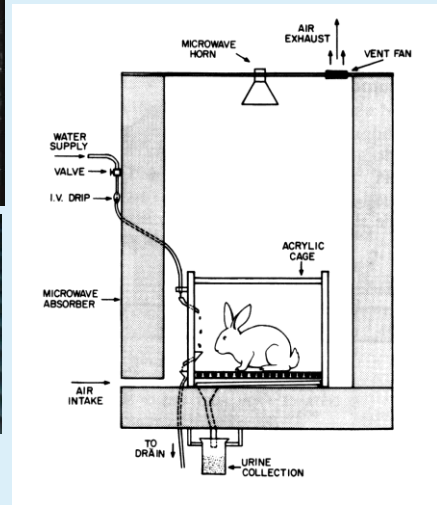
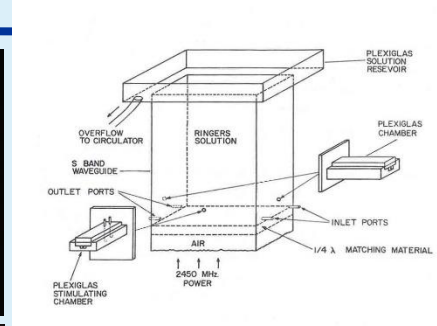
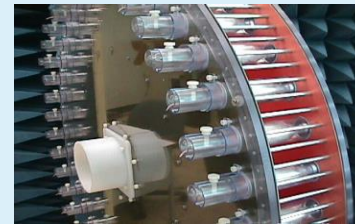
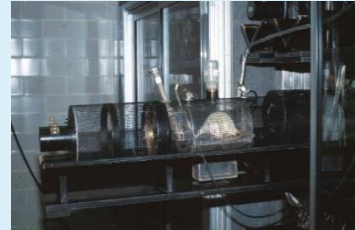
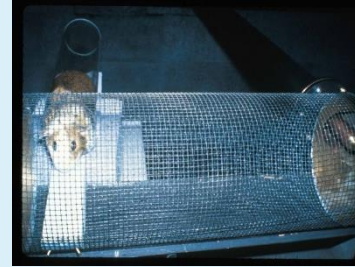
- Monolayer
- Cell suspension
- Isolated tissue
- Extrapolation to in vivo





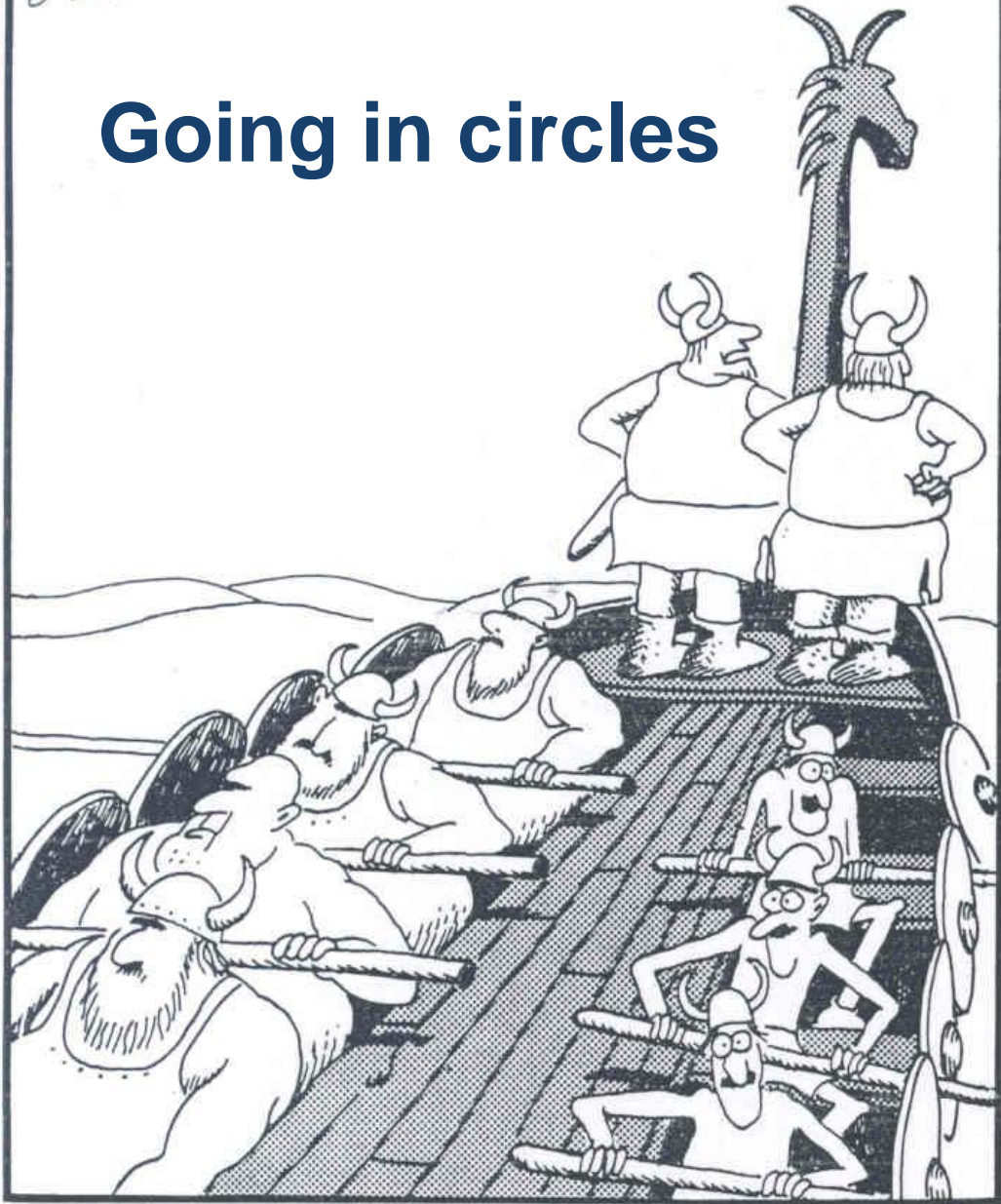
Engineering Complexity

- ❖ Exposure systems
- ❖ Far Field
- ❖ Near Field
- ❖ Dosimetry
- ❖ Resonance
- ❖ Modulation
 - CW, Pulsed
 - AM, FM, TDMA, CDMA, LTE , 5G
- ❖ Experimental Artifacts
- ❖ Temperature Control



Lalson

Going in circles



"I've got it, too, Omar . . . a strange feeling like we've just been going in circles."

Unbalanced research ability in either biological science or engineering expertise (or both are weak) makes dealing with the complexities difficult



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Quality of Science (Established vs. Possible)



↑
Increasing validity

A	Confirmed and Established Science	
B	Unconfirmed report (could be useful)	?
C	Unconfirmed report contradicts A	?
D	Unconfirmed report with clear flaws and artifacts	?
E	Junk report in peer-reviewed literature	?
F	Junk report in non-peer-reviewed literature	?

Facts

Opinions

Adapted from Osepchuk [2004]

“Good science is never outdated.” -- Herman P. Schwan



Expert Reviews (2010-2018)

Statements from Governments and Expert Panels Concerning Health Effects and Safe Exposure Levels of Radiofrequency Energy (70 citations)

<http://www.ices-emfsafety.org/expert-reviews/>

Adverse health effects have not been confirmed for RF exposures that comply with contemporary science-based safety guidelines, such as those developed by ICNIRP and IEEE/ICES.



National Toxicology Program (NTP) Study on Male Rats (2018)



Pathology findings – Brain

Hyperplastic Brain Lesions in Male Rats

	Control	GSM Modulation			CDMA Modulation		
	0 W/kg	1.5 W/kg	3.0 W/kg	6.0 W/kg	1.5 W/kg	3.0 W/kg	6.0 W/kg
Number examined	90	90	90	90	90	90	90
Malignant glioma [‡]	0*	3 (3.3%)	3 (3.3%)	2 (2.2%)	0	0	3 (3.3%)
Glial cell hyperplasia	0	2 (2.2%)	3 (3.3%)	1 (1.1%)	2 (2.2%)	0	2 (2.2%)

[‡] Historical control incidence in NTP studies: 11/550 (2.0%), range 0-8%

* Significant SAR-dependent trend for CDMA exposures by poly-6 ($p < 0.05$)

National Toxicology Program (NTP) Study on male rats (2018)



Pathology findings – Heart

Hyperplastic Heart Lesions in Male Rats

	Control	GSM Modulation			CDMA Modulation		
	0 W/kg	1.5 W/kg	3.0 W/kg	6.0 W/kg	1.5 W/kg	3.0 W/kg	6.0 W/kg
Number examined	90	90	90	90	90	90	90
Schwannoma [‡]	0*	2 (2.2%)	1 (1.1%)	5 (5.5%)	2 (2.2%)	3 (3.3%)	6** (6.6%)
Schwann cell hyperplasia	0	1 (1.1%)	0	0	0	0	3 (3.3%)

[‡] Historical control incidence in NTP studies: 9/699 (1.3%), range 0-6%

* Significant SAR-dependent trend for GSM and CDMA exposures by poly-3 ($p < 0.05$)

** Significant different than controls poly-3 ($p < 0.05$)

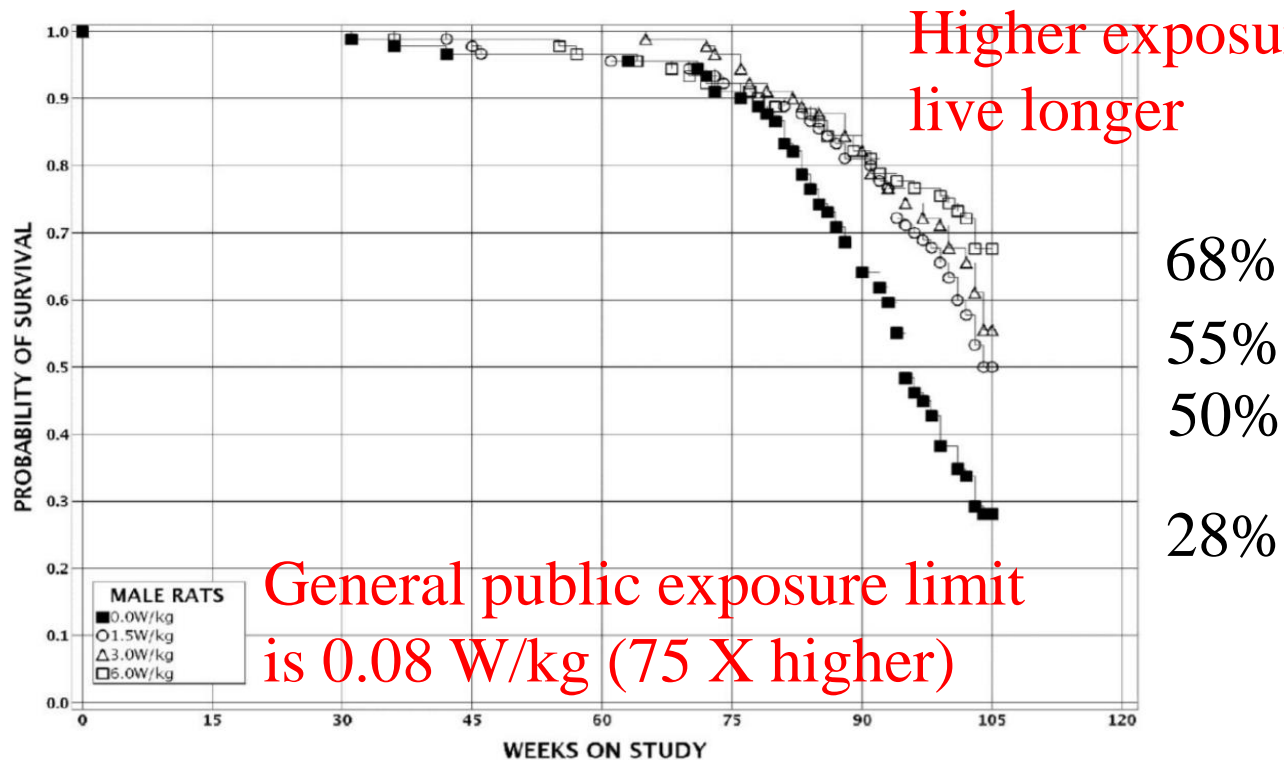




NTP study (2018)



Survival in male rats exposed to GSM RFR



- Greater survival in all groups of exposed males compared to controls

16

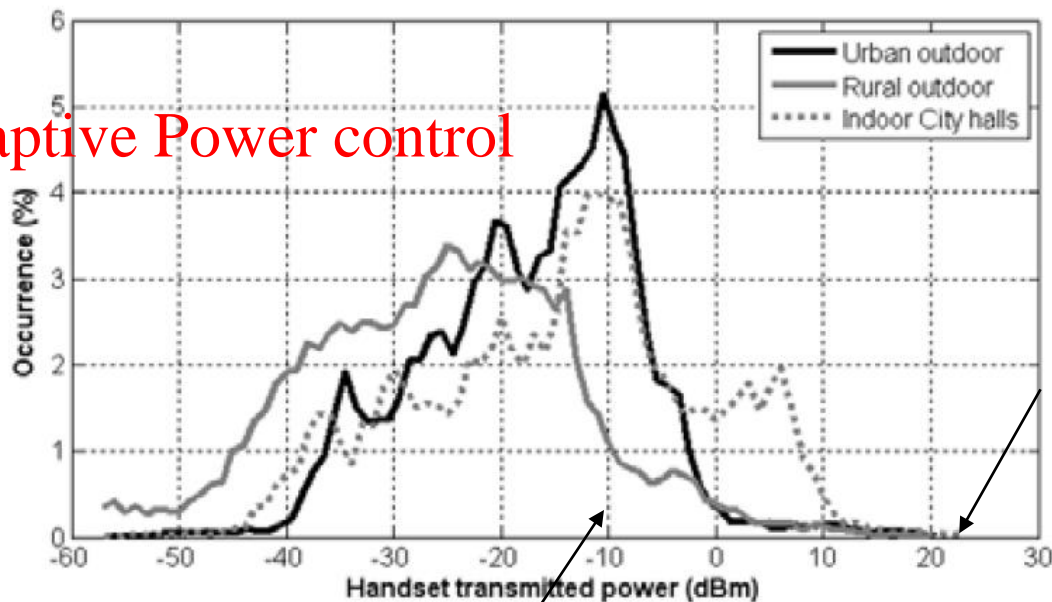




Actual handset transmitted power (3G)

- ❖ **Gati et al.**, Exposure induced by WCDMA mobiles phones in operating networks, IEEE Transactions on Wireless Communications, 8(12):5723-5727, December 2009. IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS, VOL. 8, NO. 12, DECEMBER 2009

Adaptive Power control



Max power
125 mW

Mostly 0.1 mW

Fig. 3. Distribution of mobile phone transmitted power in different areas.



Actual 4G phone transmitted power

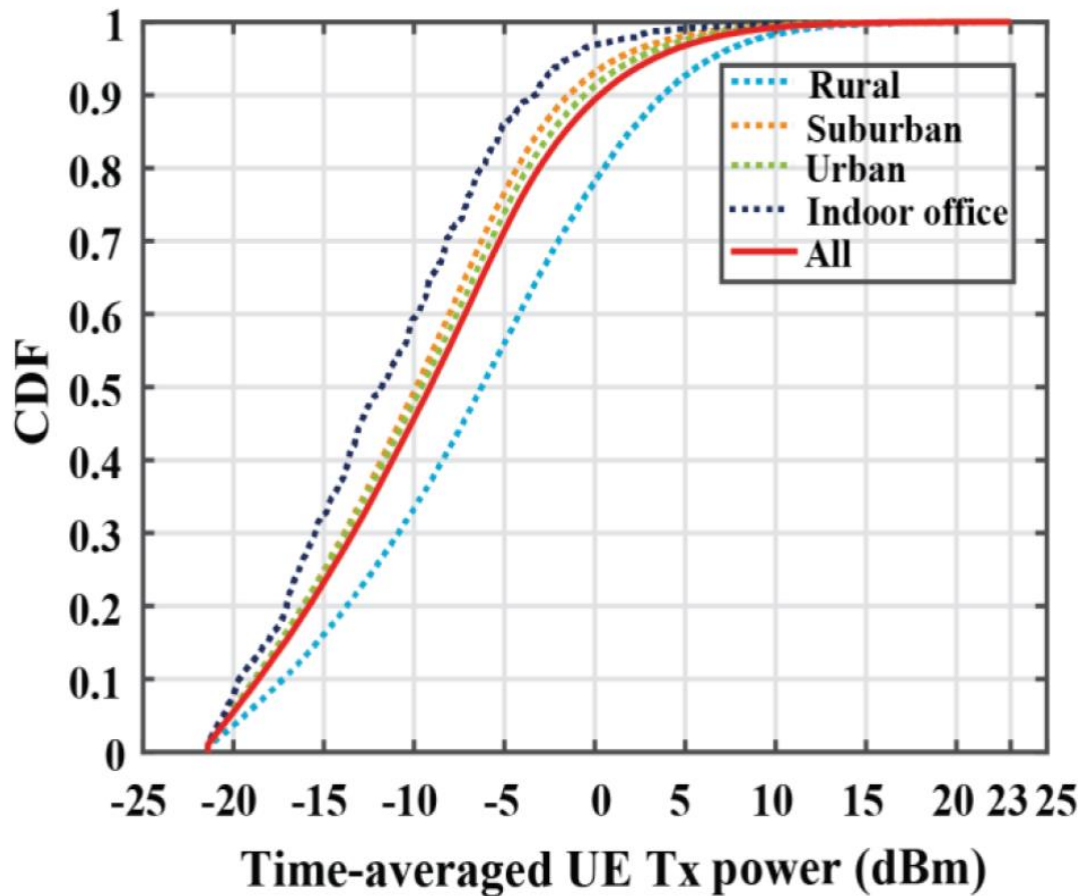


FIGURE 3. Distribution of time-averaged output power of UE in LTE network in different environments.

Joshi et al.
“Output Power Levels of 4G User Equipment and Implications on Realistic RF EMF Exposure Assessments”
IEEE Access
5:4545-4550,
2017



IEEE ICES

Established Scientific Understanding (in green)



- ❖ Microwave radiation is dangerous
- ✓ Only when at high intensity
- ❖ We don't have enough understanding of its effects
- ✓ About 70 years of research
- ❖ Many reports show non-thermal effects
- ✓ Either not repeatable or no proven health effects
- ❖ It can cause cancer, and many other diseases
- ✓ No proof and no mechanism other than heating
- ❖ The standards are not protective
- ✓ Worldwide expert groups and health authorities agree they are
- ❖ Need precautionary measure to be safe than sorry
- ✓ Safety standards already have large safety margins

