

**Mobile Manufacturers Forum
Workshop
EMF Exposure Limits and
Compliance Assessment of
Future Wireless Devices Above 6
GHz**

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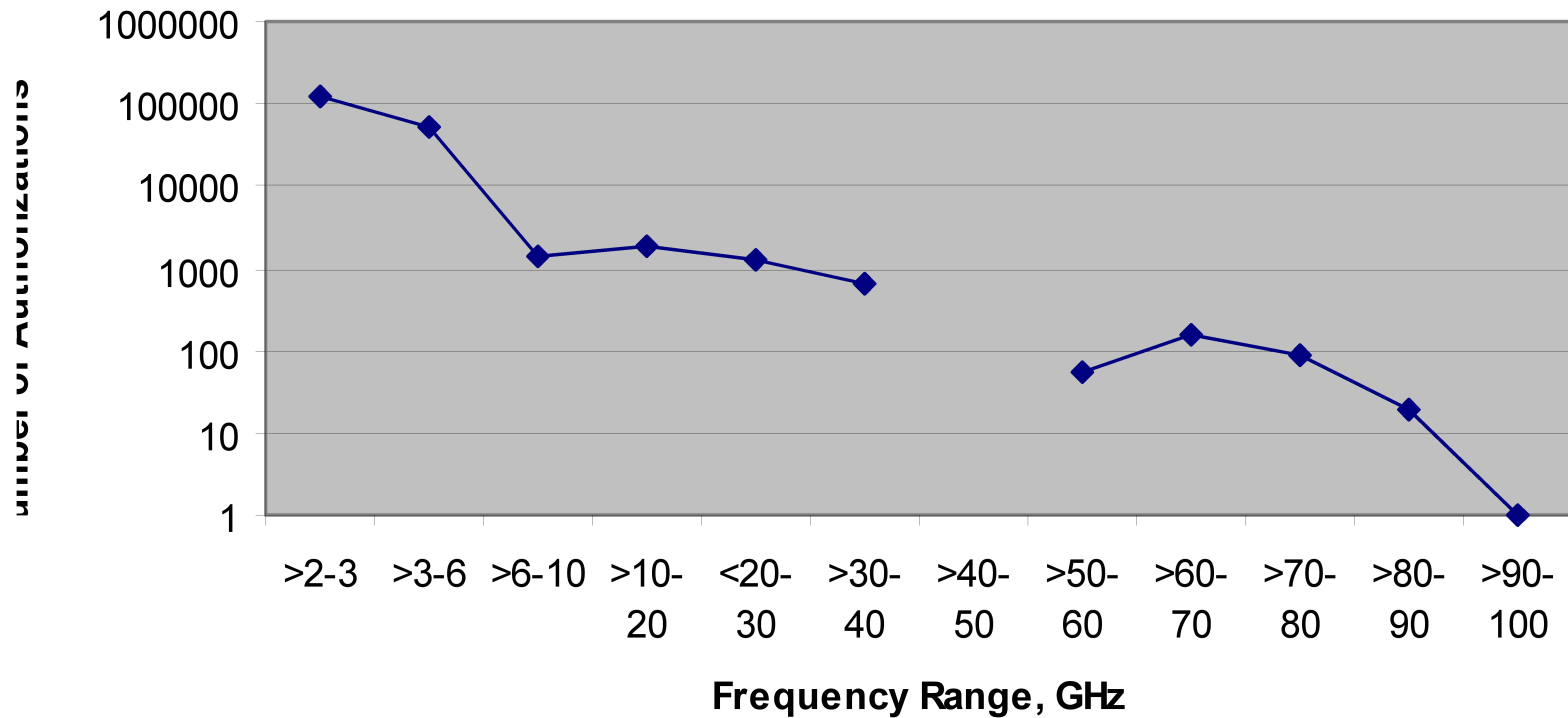
“to put large amounts of new bandwidth into play there is only one way to go: up in frequency. Fortunately, vast amounts of relatively idle spectrum do exist in the mmWave range of 30–300 GHz, where wavelengths are 1–10 mm. There are also several GHz of plausible spectrum in the 20–30 GHz range.”

(J. G. Andrews, S. Buzzi, W. Choi, S. Hanly, A.

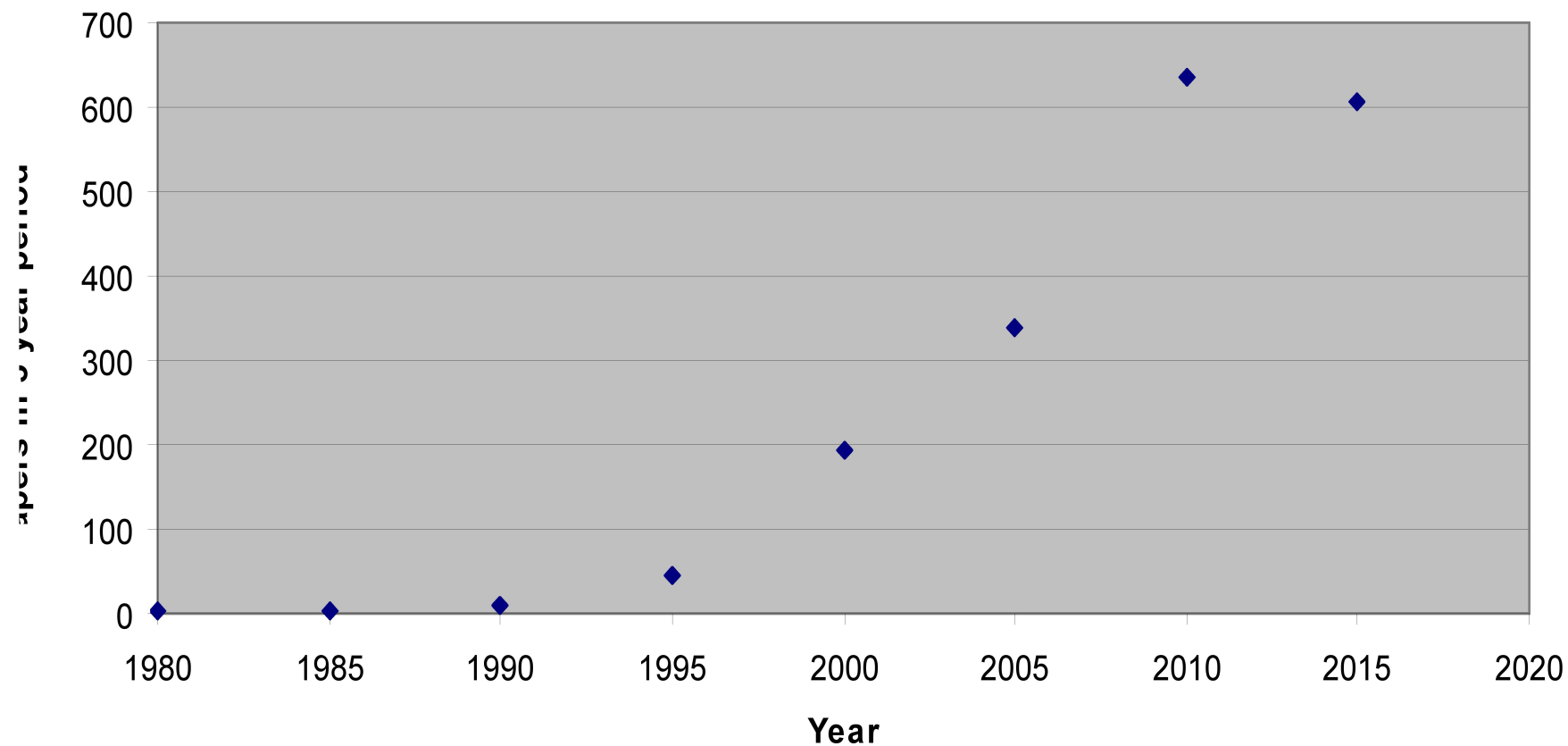
Lozano, A.C.K. Soong, and J. Zhang, "What will 5G be?," IEEE Journal on Selected Areas in Communications, Vol. 32, No. 6, pp. 1065 - 1082, June 2014.)



FCC Authorizations By Frequency



Cell Phone Frequencies (EMF Portal) >1800 papers



IEEE ICES database mm –THz wave

Human / Provocation

Blood Pressure, Heart Rate, Circulation, and Respiratory Rate	<u>0</u>	<u>0</u>	<u>1</u>	<u>1</u>
Dielectrometry, Spectroscopy & Tissue Parameters	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>
Theoretical Mechanisms	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>
Total	0	0	1	1

In Vitro

Behavior, Neurochemistry, Neuropathology	<u>0</u>	<u>0</u>	<u>1</u>	<u>0</u>
Dielectrometry, Spectroscopy & Tissue Parameters	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>
DNA Breaks, Repair, & Mutation	<u>0</u>	<u>1</u>	<u>1</u>	<u>0</u>
Gene Expression, Protein Activity	<u>0</u>	<u>4</u>	<u>0</u>	<u>2</u>
Growth Rate, Cell Cycle, Apoptosis	<u>0</u>	<u>4</u>	<u>1</u>	<u>1</u>
Hematology & Immune Function	<u>0</u>	<u>1</u>	<u>0</u>	<u>0</u>
Membrane Biochemistry, Fluidity, Electroporation	<u>0</u>	<u>2</u>	<u>0</u>	<u>0</u>
Oxidative Stress	<u>0</u>	<u>0</u>	<u>0</u>	<u>1</u>
Signaling (Ca++/Ion Efflux, Neuron Conduction, Muscle Contraction)	<u>0</u>	<u>1</u>	<u>0</u>	<u>1</u>
Total	0	13	3	5

In Vivo

Behavior, Neurochemistry, Neuropathology	<u>0</u>	<u>1</u>	<u>0</u>	<u>0</u>
Biochemical endpoints (general)	<u>0</u>	<u>1</u>	<u>0</u>	<u>0</u>
Blood Pressure, Heart Rate, Circulation, and Respiratory Rate	<u>0</u>	<u>0</u>	<u>1</u>	<u>0</u>
Chemical-Radiation-Genetically Initiated Tumor Bioassay	<u>0</u>	<u>0</u>	<u>0</u>	<u>1</u>
DNA Breaks, Repair, & Mutation	<u>0</u>	<u>1</u>	<u>0</u>	<u>0</u>
Gene Expression, Protein Activity	<u>0</u>	<u>1</u>	<u>1</u>	<u>0</u>
Hematology & Immune Function	<u>0</u>	<u>2</u>	<u>0</u>	<u>0</u>
Long Term Animal Bioassay	<u>0</u>	<u>1</u>	<u>0</u>	<u>0</u>
Teratogenicity, Reproduction, & Development	<u>0</u>	<u>1</u>	<u>0</u>	<u>0</u>
Total	0	8	2	1





**IEEE Standard for Safety Levels with
Respect to Human Exposure to Radio
Frequency Electromagnetic Fields,
3 kHz to 300 GHz**

ICNIRP GUIDELINES

**FOR LIMITING EXPOSURE TO TIME-VARYING
ELECTRIC, MAGNETIC AND ELECTROMAGNETIC
FIELDS (UP TO 300 GHz)**



Limits vary in:

Transition frequency

Spatial peak exposure

Averaging area

Also in time averaging provisions

TABLE I
 GENERAL PUBLIC BASIC RESTRICTIONS VALID BELOW AND ABOVE CERTAIN
 TRANSITIONS FREQUENCIES, f_{tr} (S.P. = Spatial Peak, Av. = Averaged over,
 λ = wavelength in free space, f = frequency in GHz)

	FCC	ICNIRP	IEEE
f_{tr} (GHz)	6	10	3 ^a
PD limit (W/m ²) $f \geq f_{tr}$	10 (S.P.)	10 (Av. 20 cm ²)	10 ($f \leq 30$ GHz \Rightarrow Av. 100 λ^2) ($f \geq 30$ GHz \Rightarrow Av. 100 cm ²)
		200 (Av. 1 cm ²)	18.56 $f^{0.699}$ ($f \leq 30$ GHz, S.P.) 200 ($f \geq 30$ GHz, S.P.)
Localized SAR limit (W/kg) $f \leq f_{tr}$	1.6 (Av. 1g)	2 (Av. 10 g)	2 (Av. 10 g)

^a To provide a transition in the frequency range 3 GHz to 6 GHz, compliance with IEEE C95.1 may be demonstrated by evaluation of either incident power density or local SAR.



Questions:

- **What are appropriate exposure limits > 6 GHz, particularly for devices used close to the body?**
 - **What are the limiting hazards that should inform the design of limits above present cell phone frequencies?**
 - **Can a general model be developed for hazards that can be used to design exposure limits above present cell phone frequencies?**
 - **What uncertainties/gaps in present data need to be addressed to allow design of adequate protection?**

