Lessons learned from international RF-EMF monitoring and expectations for 5G networks

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Environmental radio signals

- FM
- T-DAB
- TETRA
- GSM900
- GSM1800
- 3G
- LTE
Mobile levels similar to other radio sources

- **Average urban, TV and radio**: 0.06
- **Baby monitors (20 cm)**: 9.22
- **Average urban, base stations**: 0.01
- **WLAN access point (20 cm)**: 0.41
- **DECT cordless phone (20 cm)**: 3.93

Based on [Valberg et al., 2007](#)
Mobile network levels similar between countries

Global average more than 5,500 times below limit values

Based on Rowley and Joyner, 2012
RF-EMF exposure levels low and constant

Figure 3: répartition géographique des 2 851 mesures réalisées en 2017, des 2 999 mesures réalisées en 2016, des 2 977 mesures réalisées en 2015 et des 1 999 mesures analysées en 2014

Figure 6: distribution des niveaux de champs électriques mesurés selon le cas A du protocole de mesure et zoom sur la distribution des valeurs supérieures à 1 V/m

Figure 9: valeurs médianes (barres bleues) et percentiles à 99 % (traits noirs) en fonction des années
Continuous monitoring of RF-EMF

- Italian national network 2002 to 2006
- >50 million data points
  - About 40% below detection limit of probes
- Results:
  - no values exceeded exposure limits
  - no more than an 18% annual variation
  - mean value for mobile networks 0.047 mW/cm² (2005-2006)
- Global mean environmental cellular RF typically <0.1 mW/cm²

Rowley and Joyner, 2016
Are further RF-EMF measurements needed?

- ‘All exposure level studies and surveillance systems used in our country and in Europe confirm repeatedly that they are hundreds or thousands of times below those recommended by the EU, WHO and the ICNIRP and national legislation (RD1066/2001). Therefore, it is not recommended to invest resources in new surveillance systems that do not provide significant innovation regarding levels of exposure already known.’

- Comité Científico Asesor en Radiofrecuencias y Salud (CCARS), 2017

http://ccars.org.es/
What do we know about current technologies (non beamforming)?

- Example of a 4G cell
RF-EMF exposure from advanced antenna technologies

- Maintain high throughput in more efficient ways
- Reduce network interference and electromagnetic energy in unintended directions
- New techniques for assessing RF-EMF exposure due to moving beams
What do we know about new technologies (beamforming)?

- Time & space variation of RF transmitted power with 5G massive MIMO

The actual transmitted power (time-avg) does not exceed a threshold (= actual maximum threshold)
- Power reduction factor (actual max threshold/configured max) range: from x0.2 to x0.5 (3 – 7 dB)
- Actual RF compliance boundary reduction factor typical range: from x0.45 to x0.7
What does IEC TR62669 recommend?

General principle for RF compliance based on actual max power:
[from 13.1.2, informal draft 16.10.2018]

- The real time-averaged transmitted power by BSs during service, called actual transmitted power, is generally below the time averaged maximum transmitted power.

- The actual maximum transmitted power can be used to determine the RF compliance boundary provided that the operator is implementing tools ensuring this threshold is not exceeded over time during service.

- These tools can be based on BS counters and features developed by manufacturers to monitor and control the RF transmitted power or EIRP and other relevant characteristics of the BS.

- This applies to all types of BS, whether they are using fixed beams or steerable beams like with mMIMO.
Implementation of the novel compliance approach defined in IEC TR62669

- Example with current radio technologies (non beamforming)

![Graph showing normalized EIRP and configured max EIRP, with a threshold marked as 'Not allowed'.]

- Monitoring & control tools
- Proof points available upon request
- EMF compliance boundary assessment and site declaration/approval
IEC TR62669 RF compliance process based on actual max power

a) Define the actual max threshold
   a) i) use the maximum value from measurements taken on a single operational BS
   a) ii) use a percentile from measurements taken on a larger number of representative BS sites
   a) iii) otherwise use a percentile from computation models on BS sites with similar config. & env.

b) Before putting into service
   b) i) Define the RF compliance boundary using the actual max threshold
   b) ii) Configure the BS and implement tools ensuring the actual max threshold is not exceeded over time

b) ii) Record periodically the CDF of the time-averaged transmitted power or EIRP

b) ii) Record the CDF in the assessment reports

c) During service
   c) i) Define the RF compliance boundary using the actual max threshold
   c) ii) Configure the BS and implement tools ensuring the actual max threshold is not exceeded over time
   c) iii) otherwise use a percentile from computation models on BS sites with similar config. & env.

c) ii) Record the CDF in the assessment reports

d) iii) In case of threshold change (config. or perf.)
**Novel compliance approach: standards & regulations milestones**

- **Global RF exposure assessment standard**
  - IEC 62232:2017

- **Implementation guide**
  - IEC TR62669
  - Novel approach (rationale and principles for RF compliance based on actual max power)
  - Adopted in ITU-T K.Sup16

- **Introduction of the novel compliance approach in IEC 62232**
  - 1st consolidated draft (committee draft)

- **IEC 62232 new edition**
  - Technical freeze (committee draft for vote)

- **National authorities update RF compliance regulations for early 5G deployments**

**Timeline:**
- Jul’17
- Dec’18/Jan’19
- Dec’19
- Dec’20
5G levels expected to be similar to existing technologies

Wood (Telstra) at MWF 5G Workshop at BioEM 2018
Twenty-one studies met eligibility criteria
RF-EMF data collected between 2005 and 2013
Typical RF-EMF levels substantially below limits:
  - Highest levels in public transportation due to the uplink
  - Outdoors downlink was main source but broadcasting underestimated
  - Exposure levels in homes lower than outdoors

Sagar et al., 2017
Everyday RF-EMF exposures in Europe (2/2)

Home

Outdoor

A. Spot Measurement

Sagar et al., 2017
Conclusions

- RF-EMF measurements in multiple countries and for many years show low levels from mobile communication networks.

- Downlink and broadcast important for outdoor measurements, indoors need to also consider Wi-Fi and DECT (and uplink).

- Post installation measurements not needed for most sites.

- Statistical approaches provide more accurate time averaged RF-EMF assessment for mobile technologies.
Thanks for listening

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