Efficient EMF 5G exposure measurements using broadband instruments

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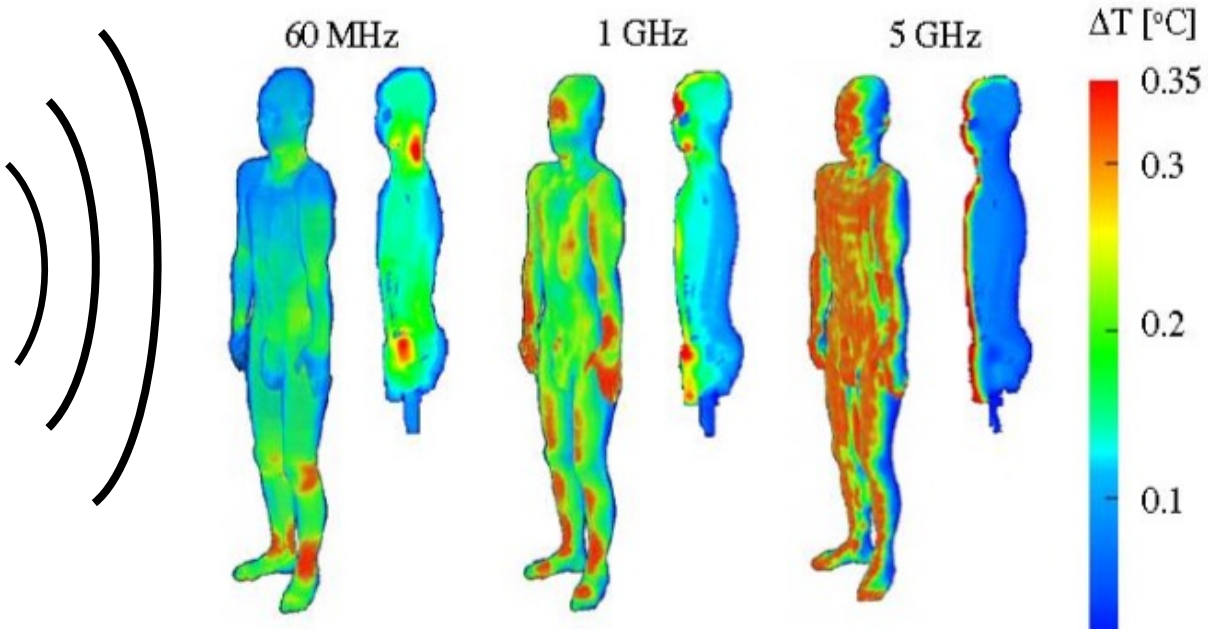
1. EMF assessments in telecom, why?
2. EMF measurements - 5G challenges
3. 5G measurement approaches
4. In situ load emulation - broadband measurement method.

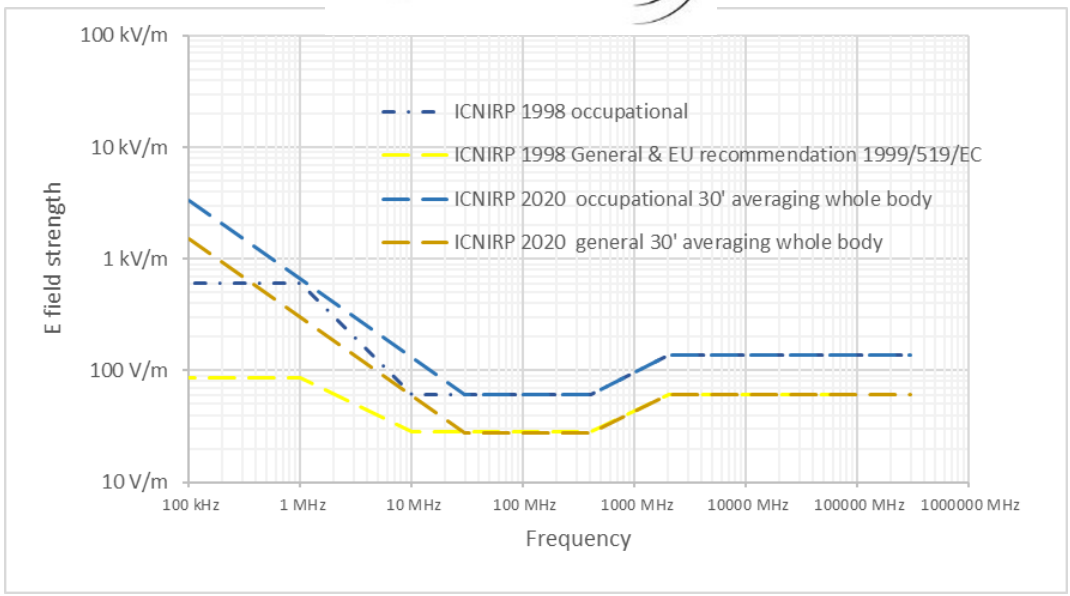
EMF measurements in telecom

EMF measurements, why?

RF EMF (> 100 kHz) are absorbed by the human body and tissues so it should be limited.



ICNIRP



IEC

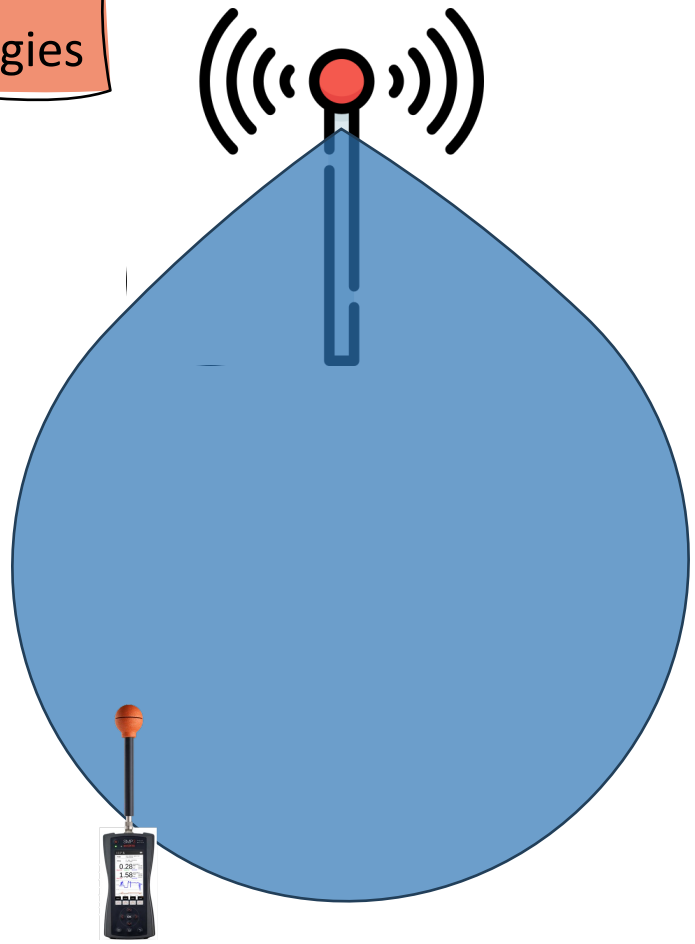
IEC 62232

ITU

ITU-T K.91
ITU-T K.100
ITU-T K.121

5G challenges on EMF measurements

Former Technologies

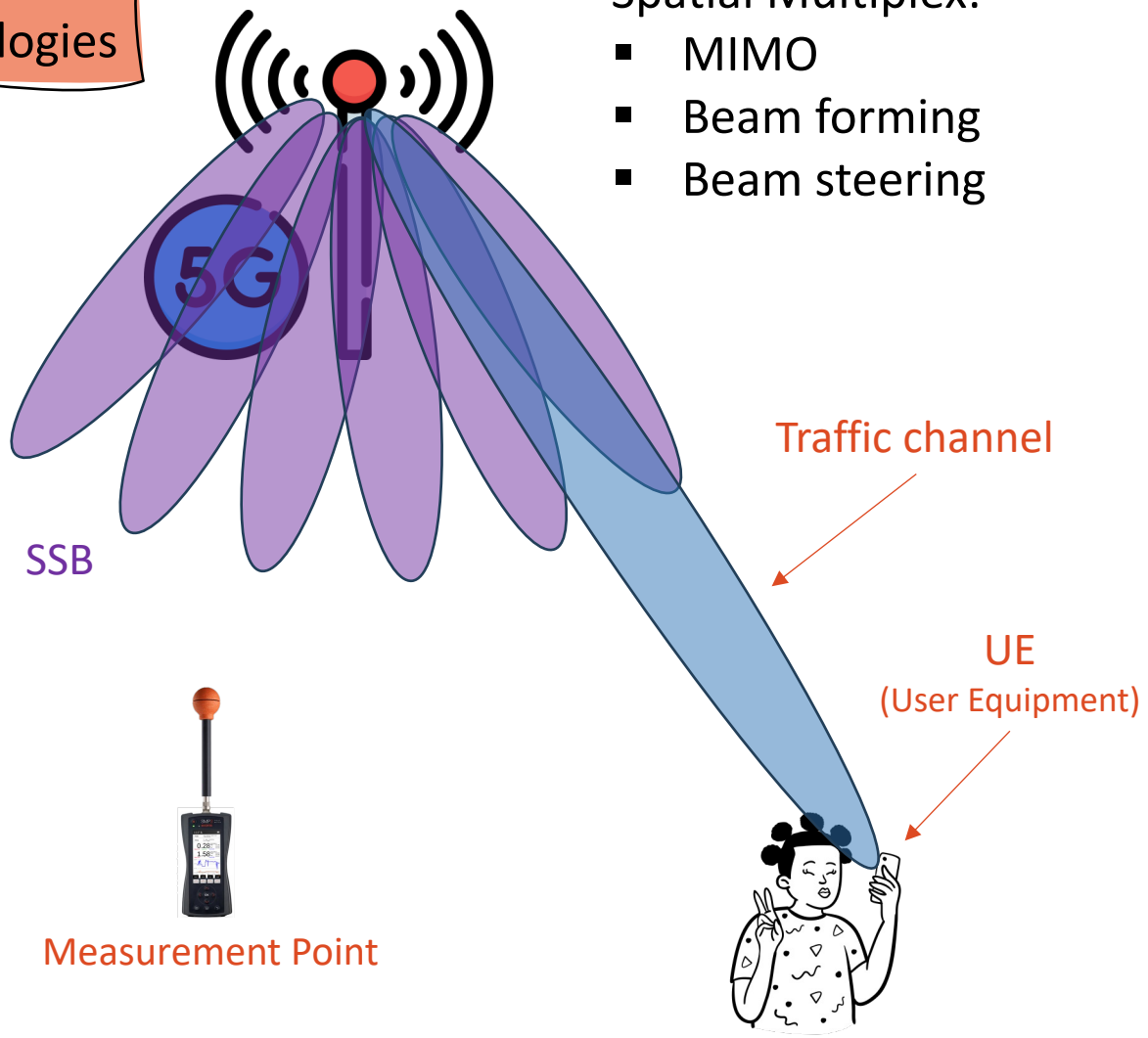


Measurement Point

Current Technologies

Spatial Multiplex:

- MIMO
- Beam forming
- Beam steering



Measurement Point

5G EMF measurement approaches

There are **3 main approaches** in 5G EMF measurements specified in IEC 62232:2022

a) **Extrapolation to the maximum values (IEC 62232 B.8)**

b) **In-situ measurement - *As observed* (IEC 62232 B.4.2.3/B.4.2.4)**

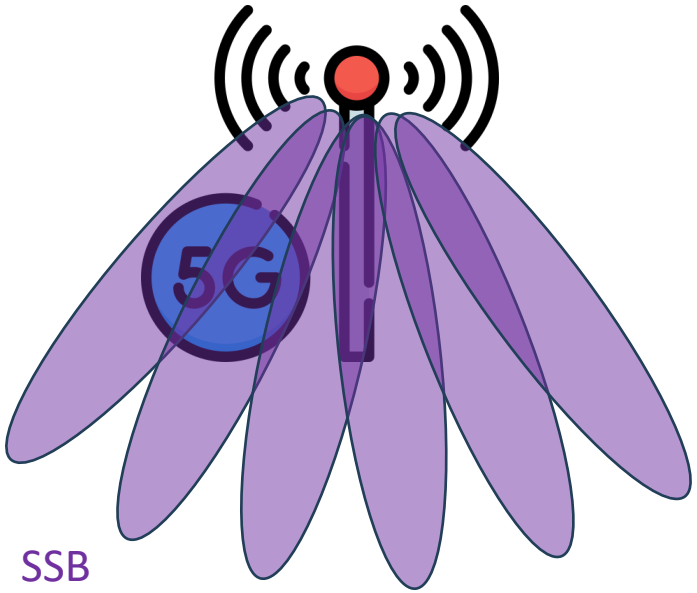
c) **In-situ measurement – *With emulated BS load* (IEC 62232 B.4.2.5.4)**

5G EMF measurement approaches

a) Extrapolation to the maximum exposure

- The maximum radiated field is **calculated by extrapolation** of the evaluated field from:
  - Measurement of the SSB synchronization channel
  - Antenna nominal maximum power
- It is necessary to have access to **some key parameters** of the BS configuration → **the operator help is needed**.
- **Code or frequency selective** instruments, and **post-processing calculation** is needed, based on the BS parameters.
- Accurate but complex and calculation-based method.

→ This method overestimates the exposure. A calculation of the ***actual maximum*** has been developed, based on statistical data of the antenna actual radiated power.



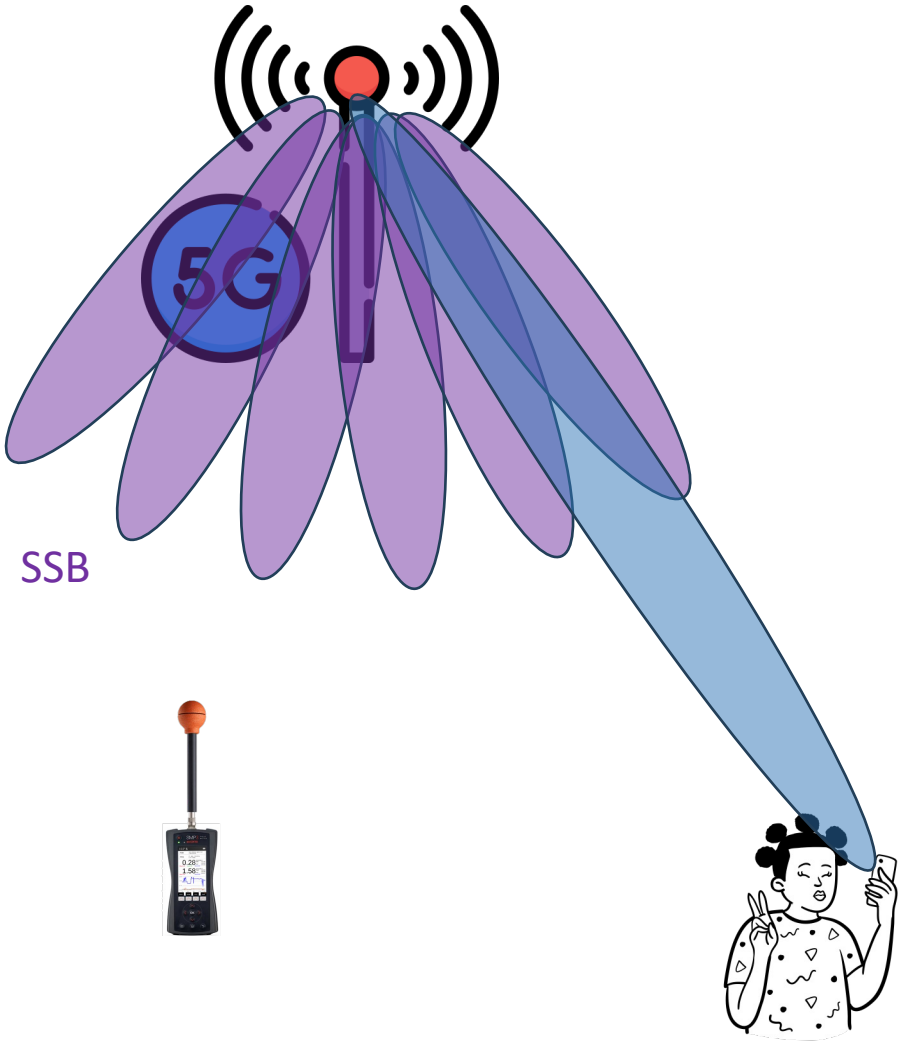
Measurements
+ BS data
+ calculation

→ Maximum
Actual maximum

5G EMF measurement approaches

b) In-situ measurement - *As observed*

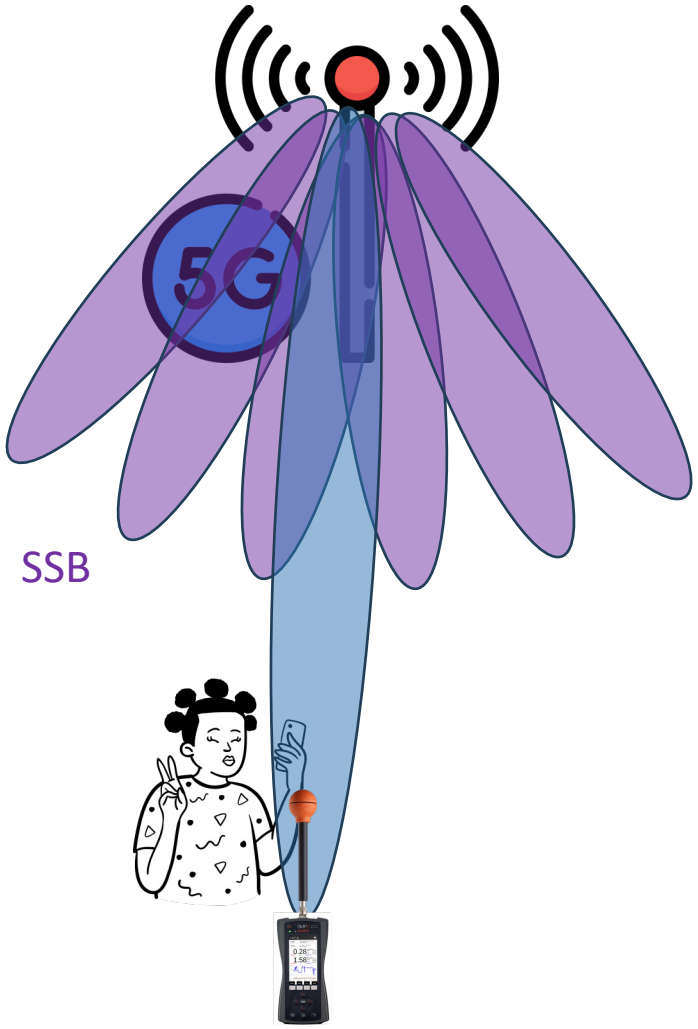
- Field level is measured in selected places at points of interest, *as observed*.
- This is like what it's been done with former technologies.
- What will be assessed in this case is the general public exposure when the user is not using its mobile terminal. It does not assess a typical or a maximum exposure when a mobile terminal is being used.
- Some regulators use this method.
- It is very fast and straightforward method.



5G EMF measurement approaches

c) In-situ measurement with emulated BS load

- In this method, **different BS load conditions are emulated**, by means of a mobile terminal, **directing the beam to the measurement equipment**.
- **Does not require neither detailed information on the BS nor extrapolation or calculation** → does not require the Operator intervention, does not require post-processing.
- It produces **direct results on the human exposure** for different traffic conditions, so the **exposure is assessed in realistic scenarios**.



In-situ measurements with emulated BS load.

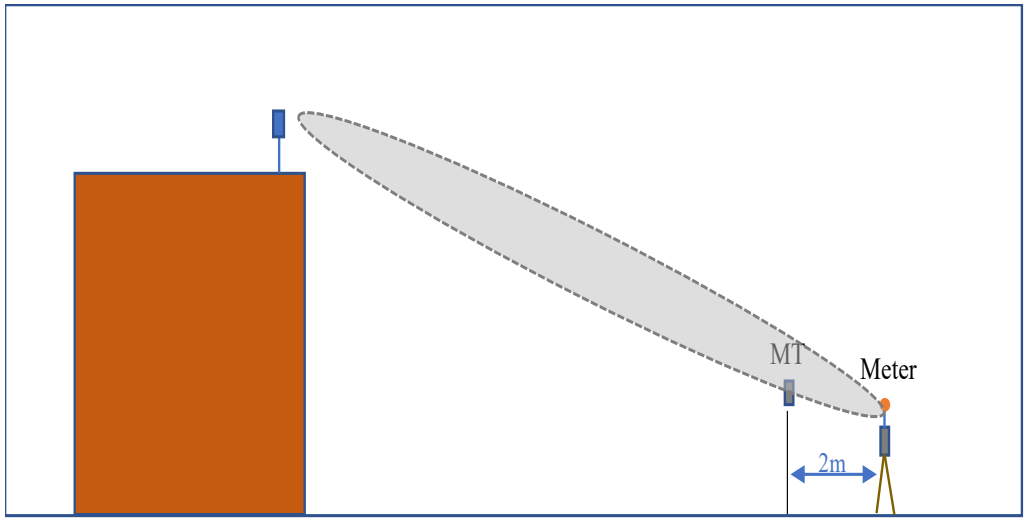
Broadband method.

Broadband in-situ measurements with emulated BS load

This method describes 3 different ***utilization scenarios*** representing 3 different types of ***BS load profiles:***

- **Non-specific BS load profile:** Time averaged measurement (e.g. 6 min) without any traffic serving the UE.
- **Typical BS load profile:** Time averaged measurement while streaming a video (e.g. 4K HD), livestreaming TV, or downloading a file (e.g. 1 GB data file).
- **High BS load profile:** Time averaged measurement while a continuous high bit rate data stream (e.g. UDP downlink transfer) is transmitted in the downlink direction.

The UE or mobile terminal is used to generate load and direct the beam from the BS to the meter.



The mobile terminal is placed between the BS and the meter to avoid measuring the uplink.

Broadband in-situ measurements with emulated BS load

Practical implementation: ¿what is needed?

1. Professional broadband EMF meter with correct specs in terms of frequency range, frequency response, linearity, isotropy, etc.
2. Commercial 5G mobile terminal (with no data limitation)
3. UDP downloading tool (e.g. iPerf *) + Server service with enough bandwidth and traffic capability.

What is needed for each utilization scenario:

- **Non-specific BS load profile:** Meter
- **Typical BS load profile:** Meter + 5G Terminal
- **High BS load profile:** Meter + 5G Terminal + UDP tool & Server

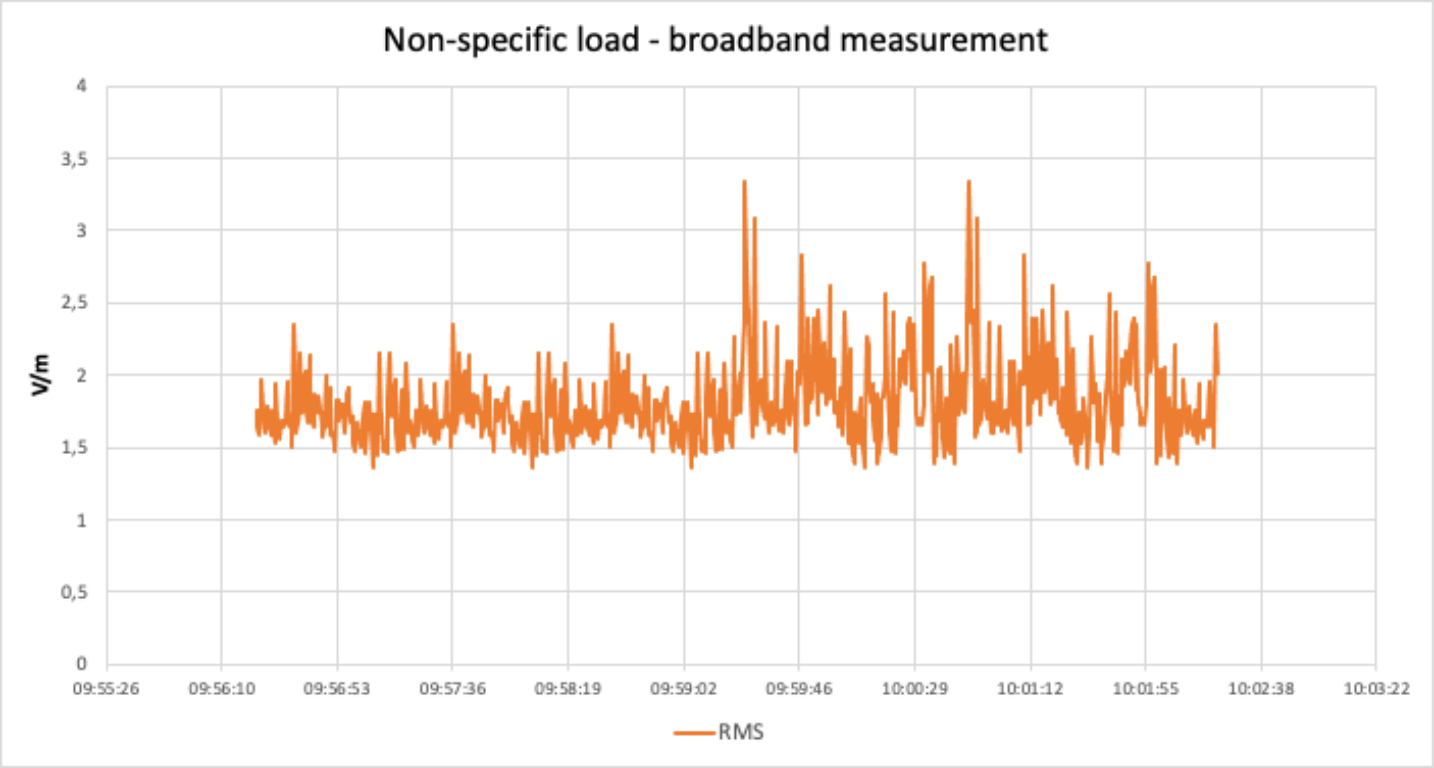
* Open source software tool for the BW testing of IP networks

Broadband in-situ measurements with emulated BS load

Base Station (BS) mMIMO: frequency band 3710 – 3800 MHz

Non-specific BS load profile

6 min time averaged measurement without any traffic serving the User Equipment



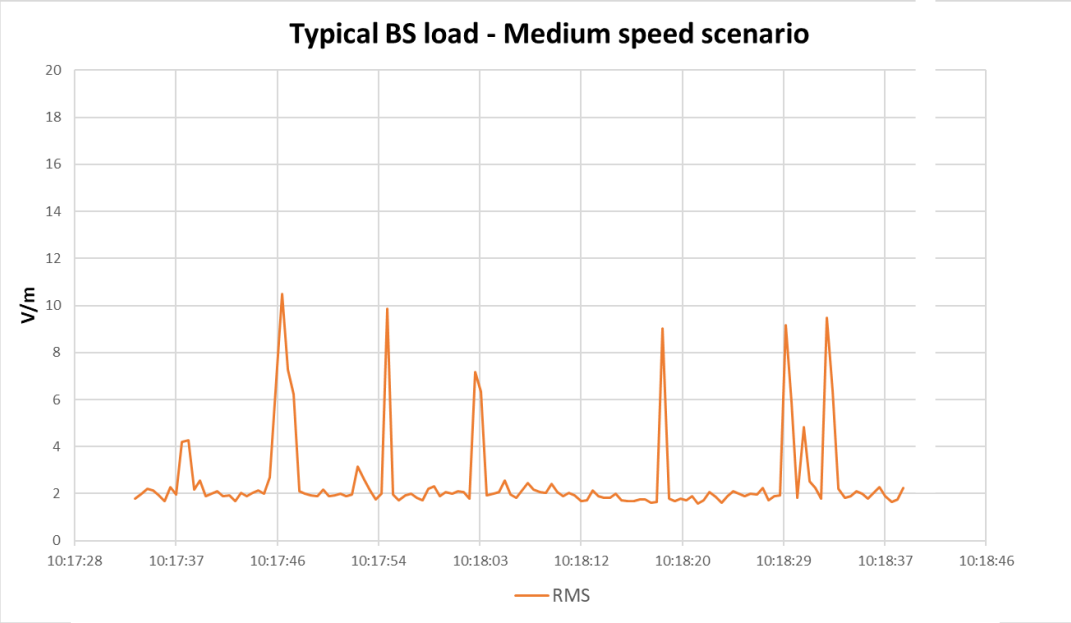
Parameter	6' RMS average broadband measurement
Average RMS E field	1.8 V/m
Equivalent power density	0.0086 W/m^2 (0.09 % limit)
Exposure limit	10 W/m^2 (ICNIRP 2020 general public)

The measurement is equivalent to the ambient field.

Typical BS load profile scenario

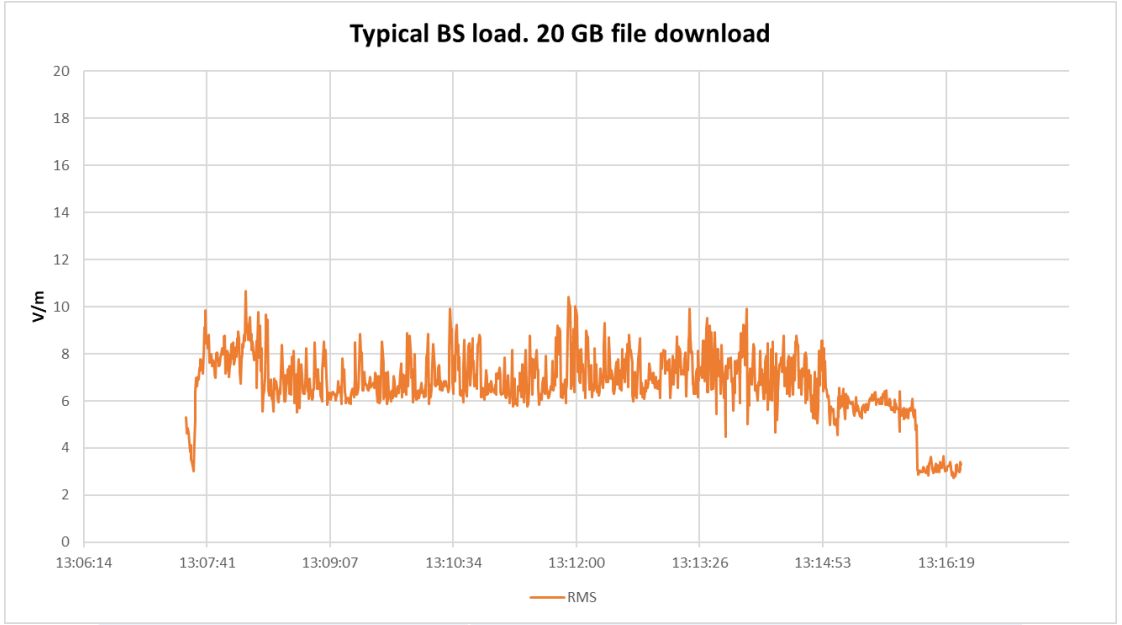
Two measurements are made with typical utilizations (loads):

a) 8K video download with speeds of 100-300 Mbps.



Parameter	6’ RMS average broadband measurement
Average RMS E field	2.6 V/m
Equivalent power density	0.017 W/m^2 (0.2% limit)
Exposure limit	10 W/m^2 (ICNIRP 2020 general public)

b) 20 GB file download from a free speed-test server. Download speed of 30 – 40 Mbps.



Parameter	6’ RMS average broadband measurement
Average RMS E field	7.0 V/m
Equivalent power density	0.13 W/m^2 (1.3 % limit)
Exposure limit	10 W/m^2 (ICNIRP 2020 general public)

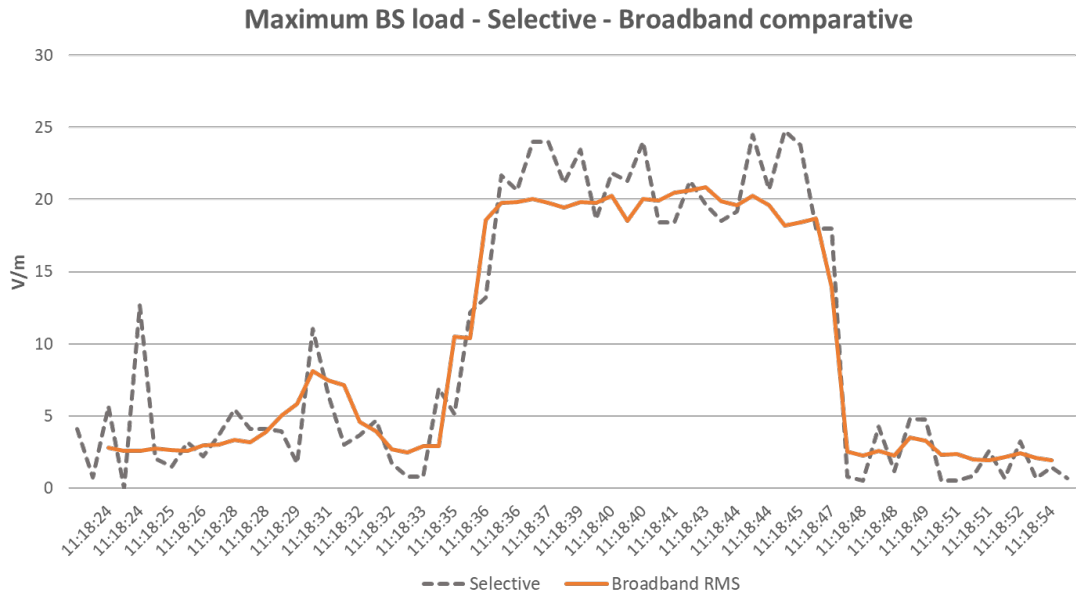
High BS load profile

Goal: Achieve the BS maximum load (to make the BS work at its maximum throughput)

→ The iPerf tool and a dedicated server is used.

→ This tool can make UDP data transfers with the speed only limited by the server or the network, so we will put the BS at its maximum load and throughput.

→ Data download speeds of 1000 - 1200 Mbps have been achieved.



Parameter	20 '' RMS average broadband measurement
Average RMS E field	19,9 V/m
Equivalent power density	1,05 W/m^2 (10,5% limit)
Exposure limit	10 W/m^2 (ICNIRP 2020 general public)

Summary

— This method allows the exposure assessment in **realistic utilization scenarios**.

— It is not necessary to make any **calculation or post-processing**

— It is not necessary to **require information from the Operator**.

— Complex instruments are not necessary. All load scenarios are obtained with a broadband meter and a 5G mobile phone using available apps.

— It allows **to evaluate the maximum EMF human exposure** in real scenarios (depending on the traffic conditions of the BS).

— The limitation of any broadband method is that we cannot measure the theoretical maximum of individual BS (unless they are isolated enough).

Thank you for your attention

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