ITU Forum "Towards 5G Enabled Gigabit Society"

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5G & IoT

Challenges for Network Implementation

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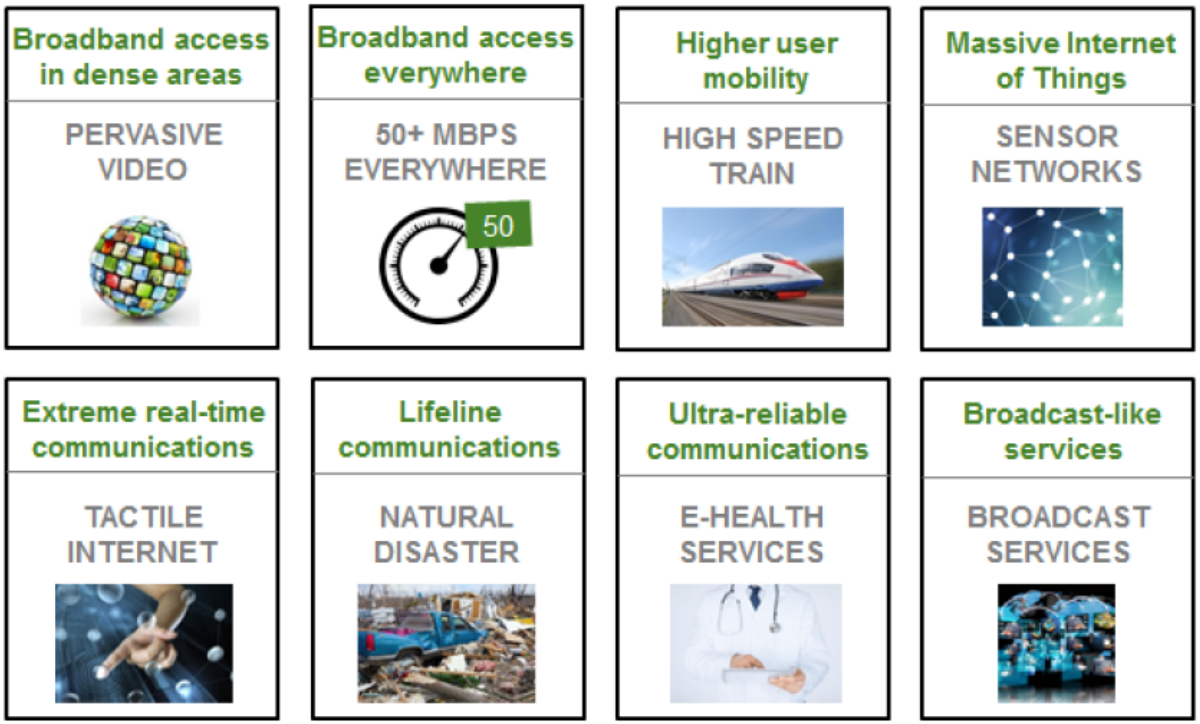
COSMOTE Network Mobile Broadband Facts

With the highest Coverage of MBB Services

	Population Coverage
2G	99,8%
3G	99,2%
4G	98,4%
4G+	92,9%
4G++	35,5%

5G Evolution



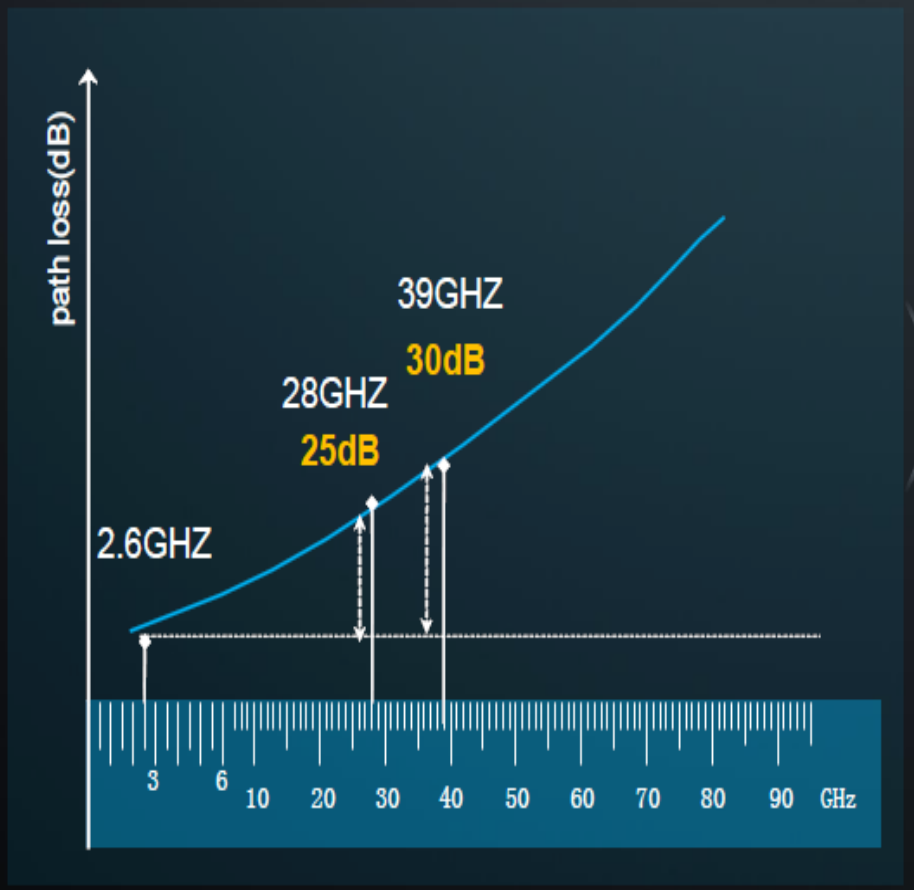
Source: NGMN Alliance,5G White Paper

Requirements

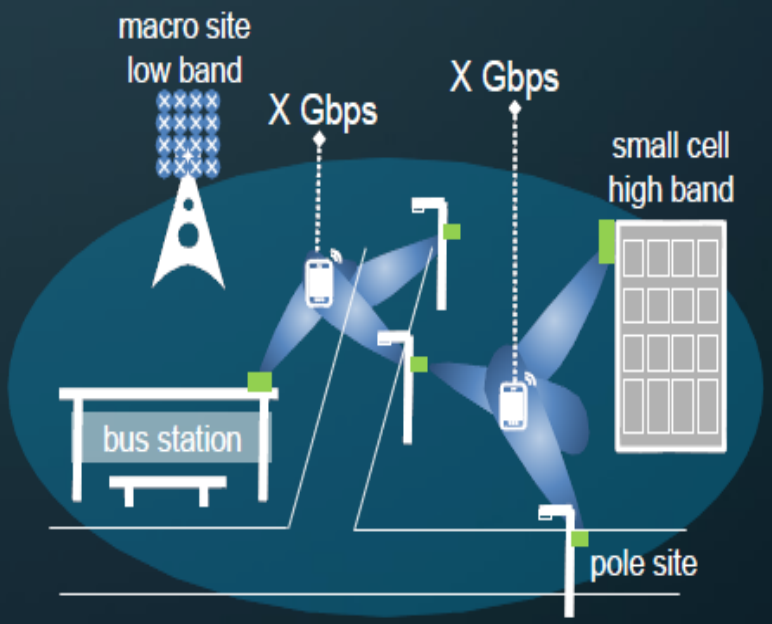
- Mean transmitting rate 300-500Mbps & max >10Gbps.
- Latency < 1ms.
- 100% coverage.
- 1000 reduction of energy consumption.
- High effectiveness (indoor > 99.999%).
- 30×device densification.
- 10-100× more connected devices.
- Higher safety level of communication.

5G Needs Double Sites as 4.5G

more path loss in high band



Macro Site Densification is Essential together with small cells to build ultra dense network



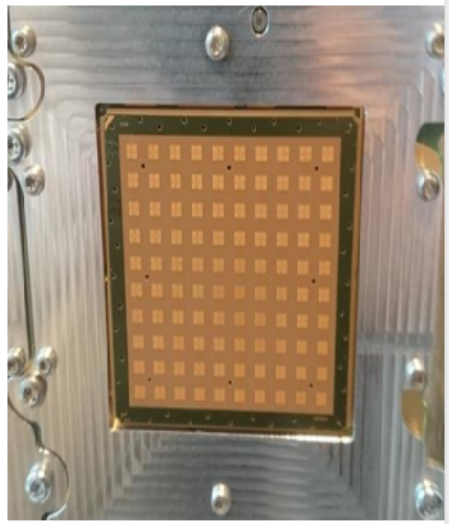
1. high band deployment make BS spacing decreasing
2. various BS form make site resource acquisition easy

Source: HUAWEI

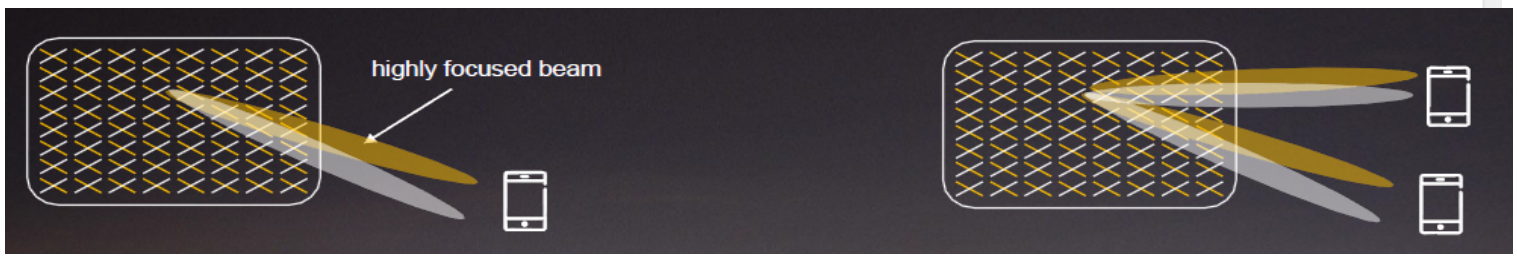
EMF Compliance for 5G?

EMF challenges for 5G

› Massive MIMO and beamforming
- More complex EMF compliance assessments
- Potentially higher EIRP and larger EMF compliance boundaries (exclusion zones) than for conventional antennas
- Site design of increasing importance

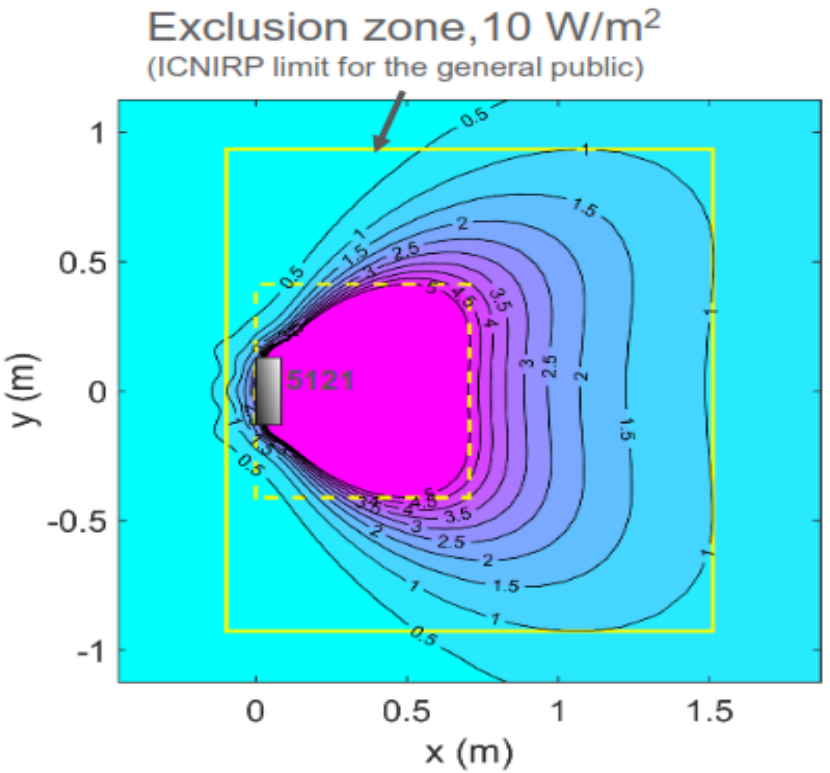


› Frequency bands above 10 GHz
- Test methodology and standards available but need to be further refined and accepted by regulators
- EMF limits more conservative in the nearfield which leads to larger compliance distances for small cell base stations and which may affect maximum UE power



Source: Ericsson

28 GHz m MIMO Small Cell



Ericsson AIR 5121
28 GHz
512 antenna elements
8 lobes
0.8 W total output power
Gain: 24 dBi
Beam steering: ± 60° (h), ± 15° (v)
Beamwidth: 12°

Massive MIMO antenna's have higher gain in horizontal and vertical direction, however the beams are spread to different directions.

Computation assuming maximum power in all beam directions

EMF compliance not an issue for normal installations but larger exclusion zone than for similar 4G small cell product (< 50 cm)

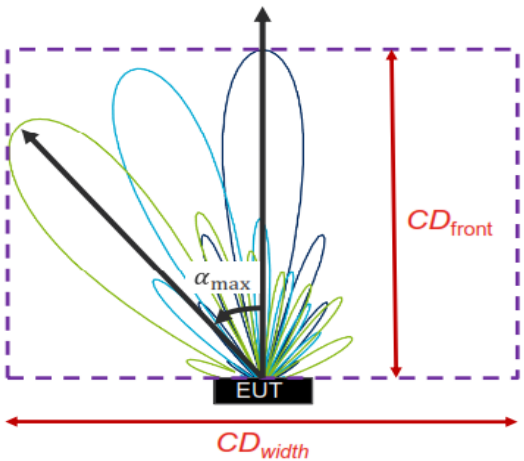
Source: Ericsson

Realistic EMF Exposure From Massive MIMO Antennas

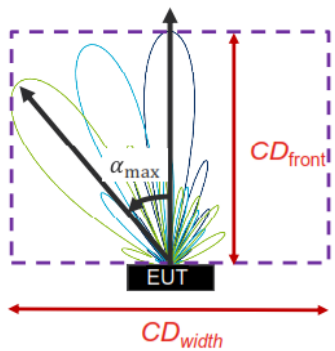
IEC 62232 (2017) opens up for possibility to use actual maximum power levels (95th percentile) when assessing RF EMF exposure.

Rationales for power reductions

- Not all energy will be focused in the same direction for several minutes.
- 100% utilization is very unlikely
- TDD will limit transmit time



5G RBS compliance boundary determined using **theoretical maximum** transmitted power

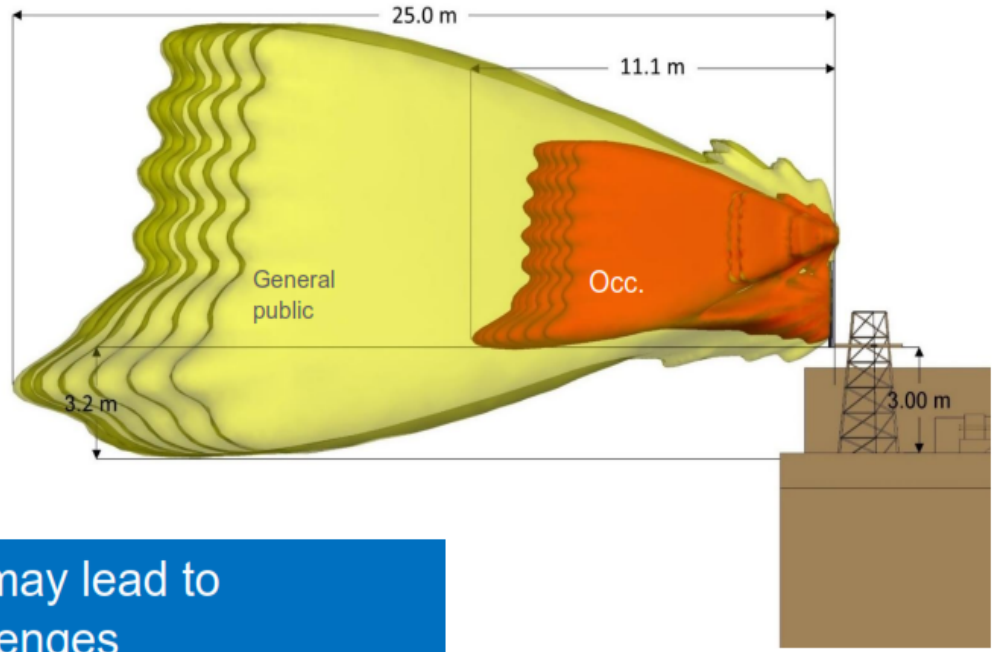


5G RBS compliance boundary determined using **actual maximum** transmitted power

Source: Ericsson

3.5 GHz – 5G Site with Massive MIMO

- 3.5 GHz, 200 W
- Massive MIMO (64 elements)
- EIRP of 72 dBm
- Installation on existing site with 2G, 3G and 4G antennas (typical power levels)
- Theoretical maximum power (100% simultaneous utilization) assumed for all antennas
- ICNIRP limits, 10 W/m² (GP), 50 W/m² (Occ.)



Very large exclusion zone that may lead to substantial 5G deployment challenges

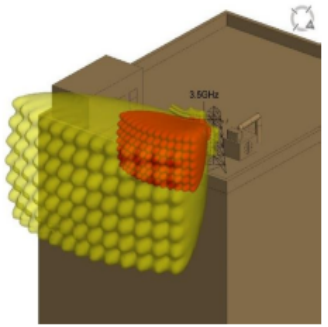
IEC 62232 Ed.2 (2017) opens up for use of actual maximum output power (95th percentile)

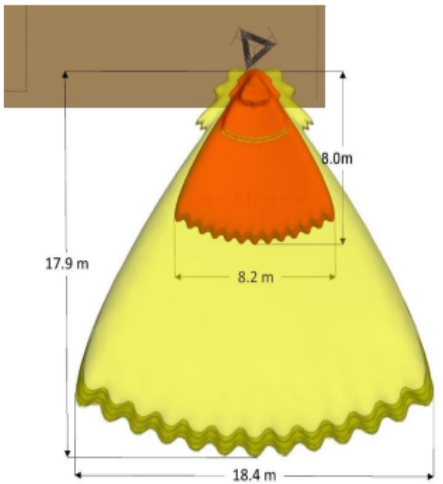
Source: Ericsson

Example: Massive MIMO at 3.5 GHz

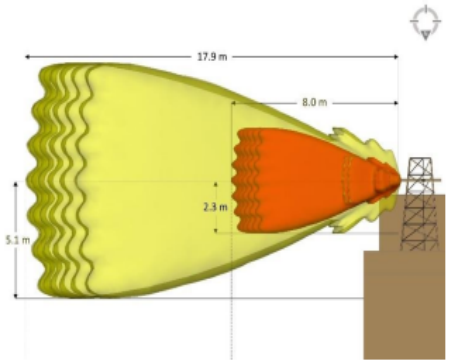
Example

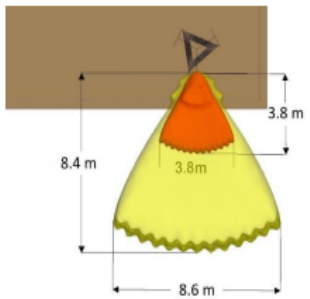
3.5 GHz
64 antenna element array
EIRP of 76 dBM
60° horizontal scan range
15° vertical scan range





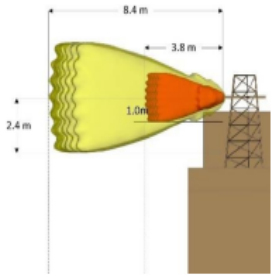
Theoretical maximum power





Realistic power

Ericsson statistical model: 25% of maximum power

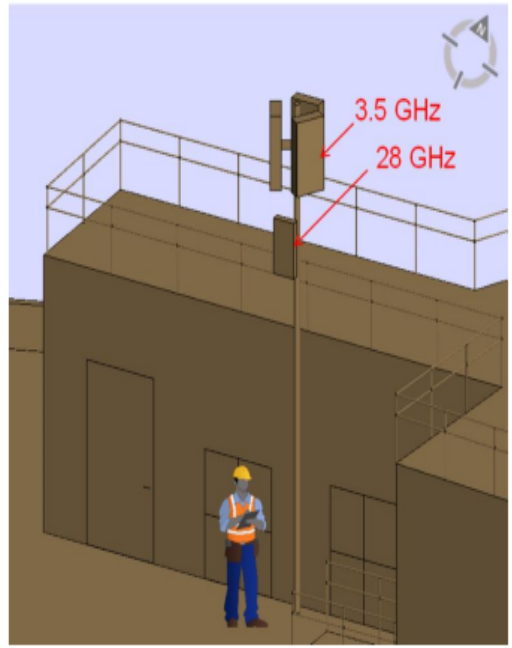


- Not all energy will be focused in the same direction for several minutes.
- 100% utilization is very unlikely
- TDD will limit transmit time

Source: Ericsson

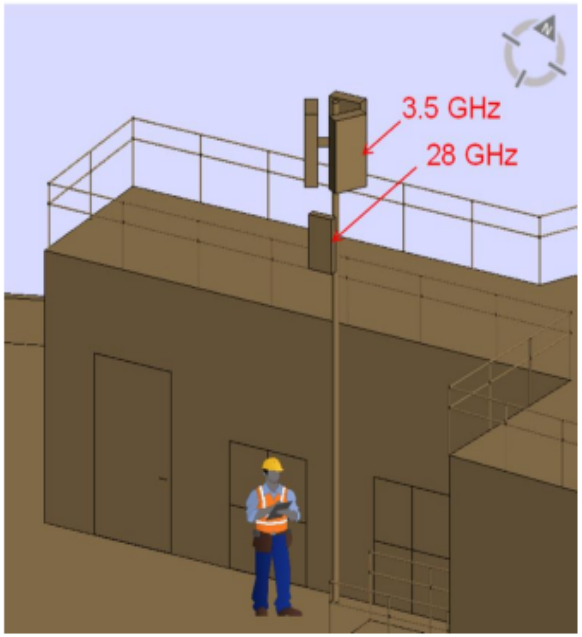
IEC TR 62669: 5G Case Studies

- Two 5G massive MIMO case studies to be included in IEC Technical Report TR 62669
  - Based on actual maximum power (statistical model)
  - Case study 2: Product compliance assessment of 28GHz 5G RBS employing Massive MIMO
  - Case study 7: Product installation compliance assessment of RBS site with 5G Massive MIMO antennas transmitting at 3.5 GHz and 28 GHz
- TR 62669 to be completed in 2018
  - Working group formed to develop annexes specifying statistical approaches on how to assess actual maximum exposure from massive MIMO base stations based on calculations or measurements
  - Contributions from vendors and operators

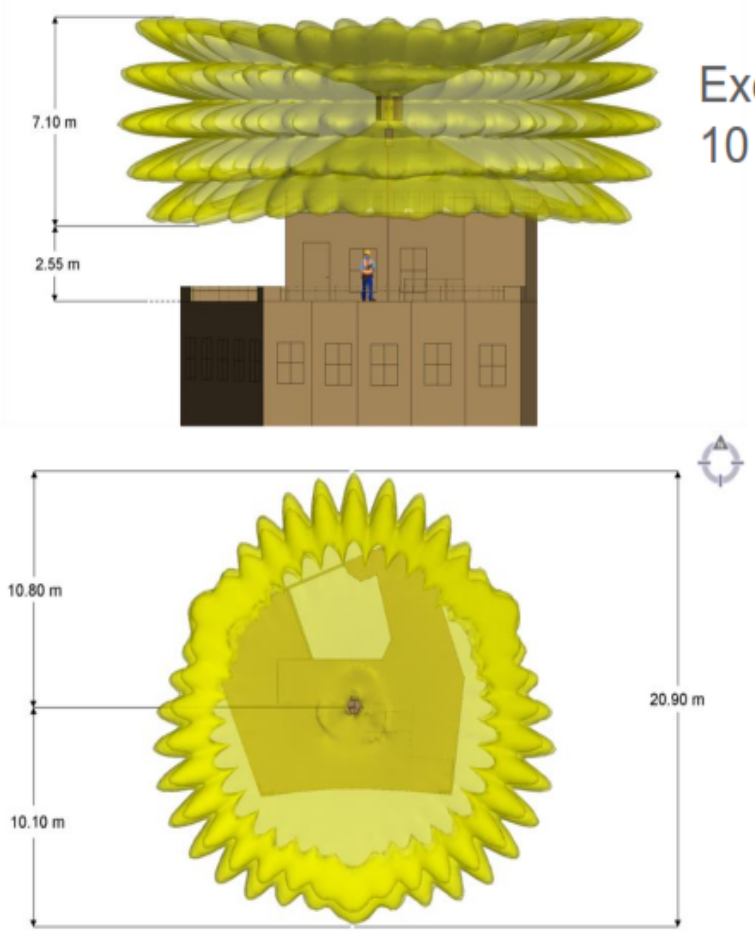


Source: Ericsson

Case Study (5G M MIMO) 3.5 GHz & 28 GHz



5G roof-top installation



Exclusion zone
10 W/m^2

Source: Ericsson

EMF Compliance

MMIMO antennas Characteristics, Realistic EMF Calculations
(Average Output Power, Average Antenna Pattern)

Working area

- Massive MIMO antenna's have higher gain in horizontal and vertical direction, however beams are spread to different directions and has a result of antenna Gain reduction. Effective radiated power rather than max EIRP per band.

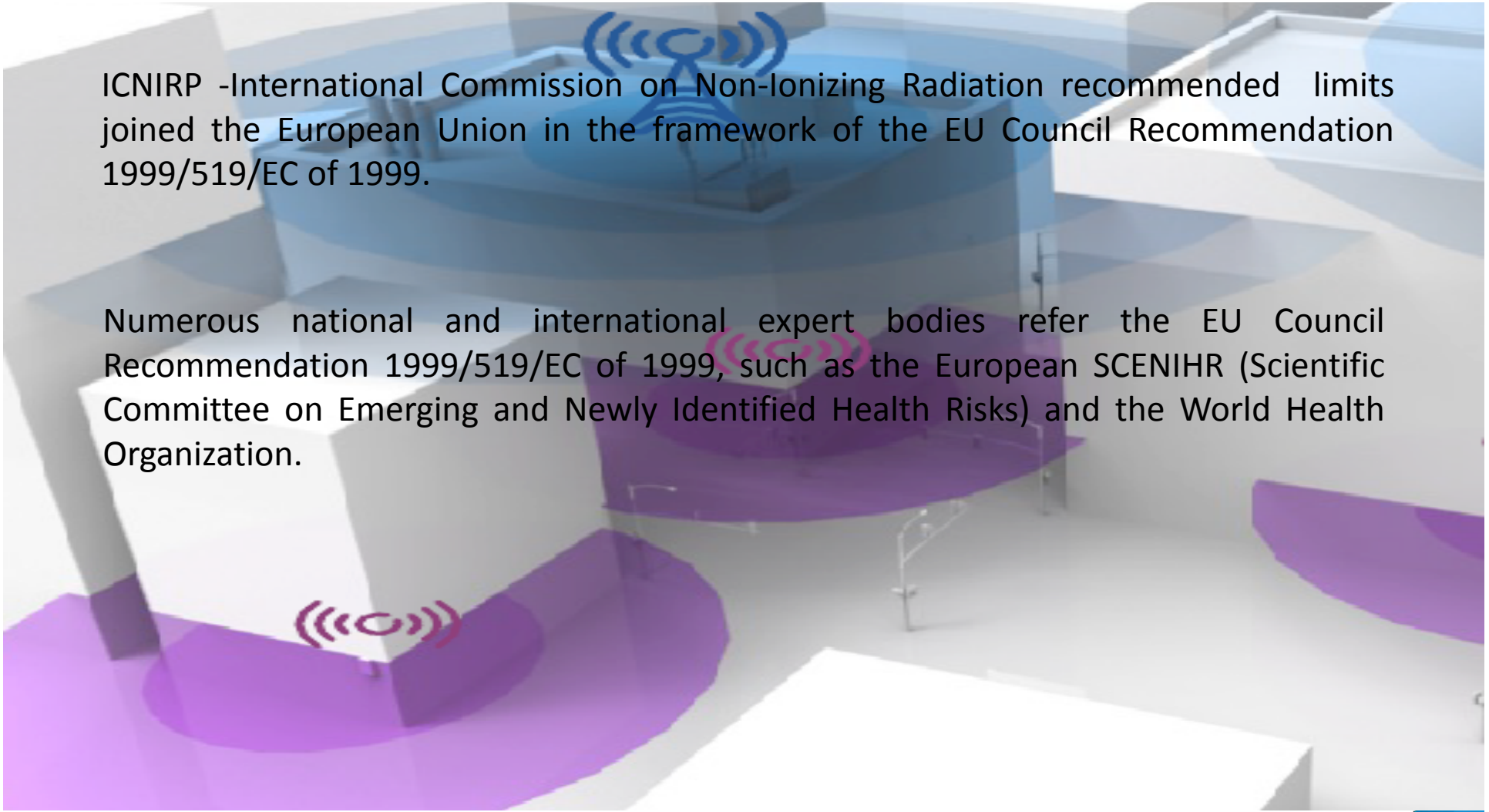
- Massive MIMO spreads the output power to all directions.

Discussion

Compliance boundary from the envelope of all possible beams and using maximum EIRP is overly conservative for the following reasons:

- Antenna elements are used to transmit signals in one or a few narrow beams which are steered in the direction of UEs.
- Served UEs move and the direction of the beam is constantly changing
- Some UEs will be served by legacy transmission modes (TM3/TM4)
- Very high user throughput implies that transmission time for each UE is much faster than averaging period of EMF measurement (typically 6 minutes)
- TDD is fractionally DL, usually for MBB case around 75% of the time

EMF Limits and Regulations



ICNIRP -International Commission on Non-Ionizing Radiation recommended limits joined the European Union in the framework of the EU Council Recommendation 1999/519/EC of 1999.

Numerous national and international expert bodies refer the EU Council Recommendation 1999/519/EC of 1999, such as the European SCENIHR (Scientific Committee on Emerging and Newly Identified Health Risks) and the World Health Organization.

EMF Limits and Regulations

ICNIRP Reference levels (general public)Power density		Greek Reference levels (general public)Power density	
400 MHz< *f* ≤ 2 GHz	f > 2 GHz	f > 2 GHz	
		70% of ICNIRP	60% of ICNIRP*
f/200 W/m2	10 W/m2	7 W/m2	6 W/m2

* In case of “sensitive buildings” existence in an area 300m close to BS

Low EMF limits may cause difficulties to 5G network implementation in urban environments, in case max allowable limits have been reached considering the existing 2G, 3G and 4G networks, due to theoretical EMF calculations. Further expansion to new Bands or technologies will be a challenge.

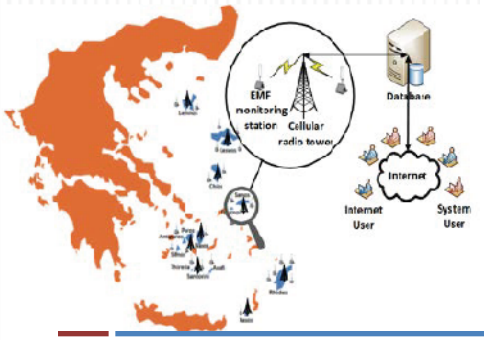
EMF Measurement Infrastructure for existing Networks in Greece – PEDION24 (www.pedion24.gr)

Total 236 measurement stations (100kHz-3GHz) measure on a 24-hour basis the total electromagnetic field emitted from different sources, such as FM and television broadcasts and cellular telephony base stations

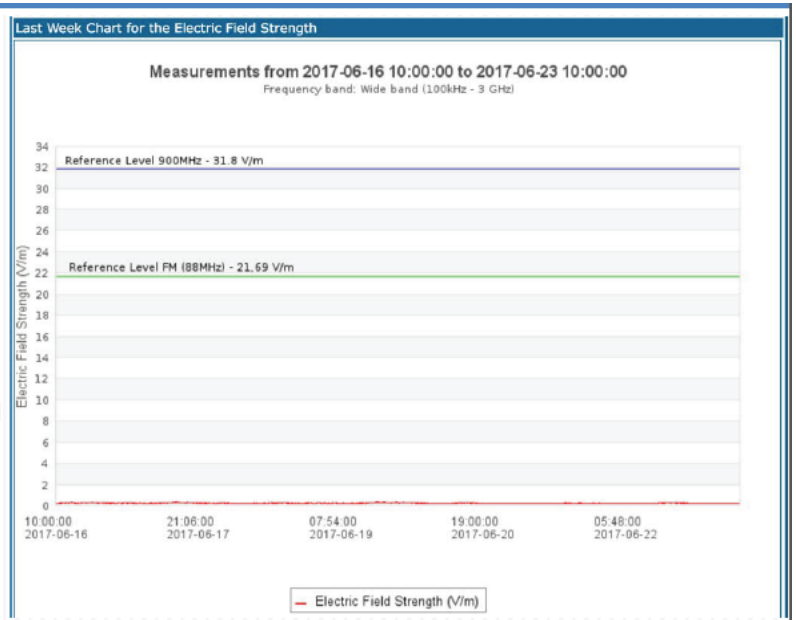
Each University monitors and controls a portion of stations:

- **30 are located on 17 Greek Aegean sea islands** (AEGEAN)
- **141 are located on South-Central Greece and Ionian islands** (NTUA)
- **65 are located in Northern Greece** (AUTH)

CCSL



- Measurements-specific information is provided through tables and graphs regarding:
  - The mean value up to the date of the last update
  - The maximum recorded value until the last update



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Small Cell Implementation in Cities

Typical Micro Layer

- Common Transport
- Modem or MW
- Indoor Equipment Deployment
- Feeder/Combiner Usage

Small Cell

Street furniture sites

Vault site

Key Takeaways

LICENSING

Quick, simple, hassle – free network deployment is critical. Therefore:

- Network implementation must be supported with fast and simple site permission process promoting the deployment of Macro and Small Cells.

EMF

- EMF limits to align with ICNIRP (EU recommended levels) in order to introduce new technologies (5G)
- Introduction of the realistic maximum transmitted power to EMF calculation models. Based on reasonable assumptions, the realistic maximum transmitted power was found to be around of 25% of the theoretical maximum power which translates to a reduction in EMF compliance boundary with a factor of about 2.
- Massive MIMO spread the beams to different directions and has a result of antenna Gain reduction.

Street Furniture sites, vault sites! Need to educate both the Authorities and the public.

EMF compliance for 5G networks is a challenge considering

i) Existing networks (2G, 3G, 4G)
ii) New MIMO antennas,
iii) Existing Standard for EMF calculations
iv) Stricter EMF limits in Greece

Thank You!

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GROUP OF COMPANIES