5G and RF-EMF Exposure

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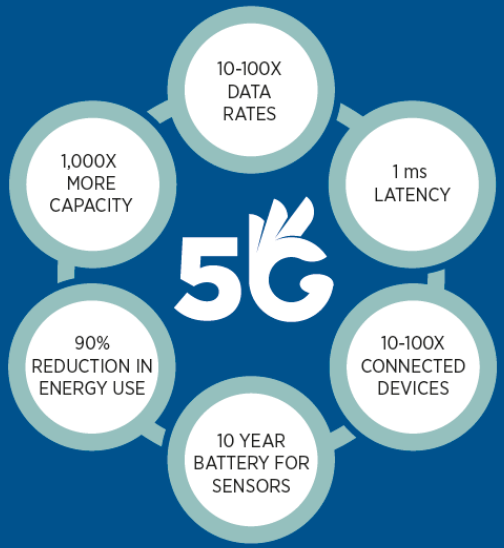
5G BENEFITS



ULTRA-LOW POWER FOR INTERNET OF THINGS (IoT)

SMART CITIES

WEARABLES

ENHANCED DATA RATES

SMART HOMES

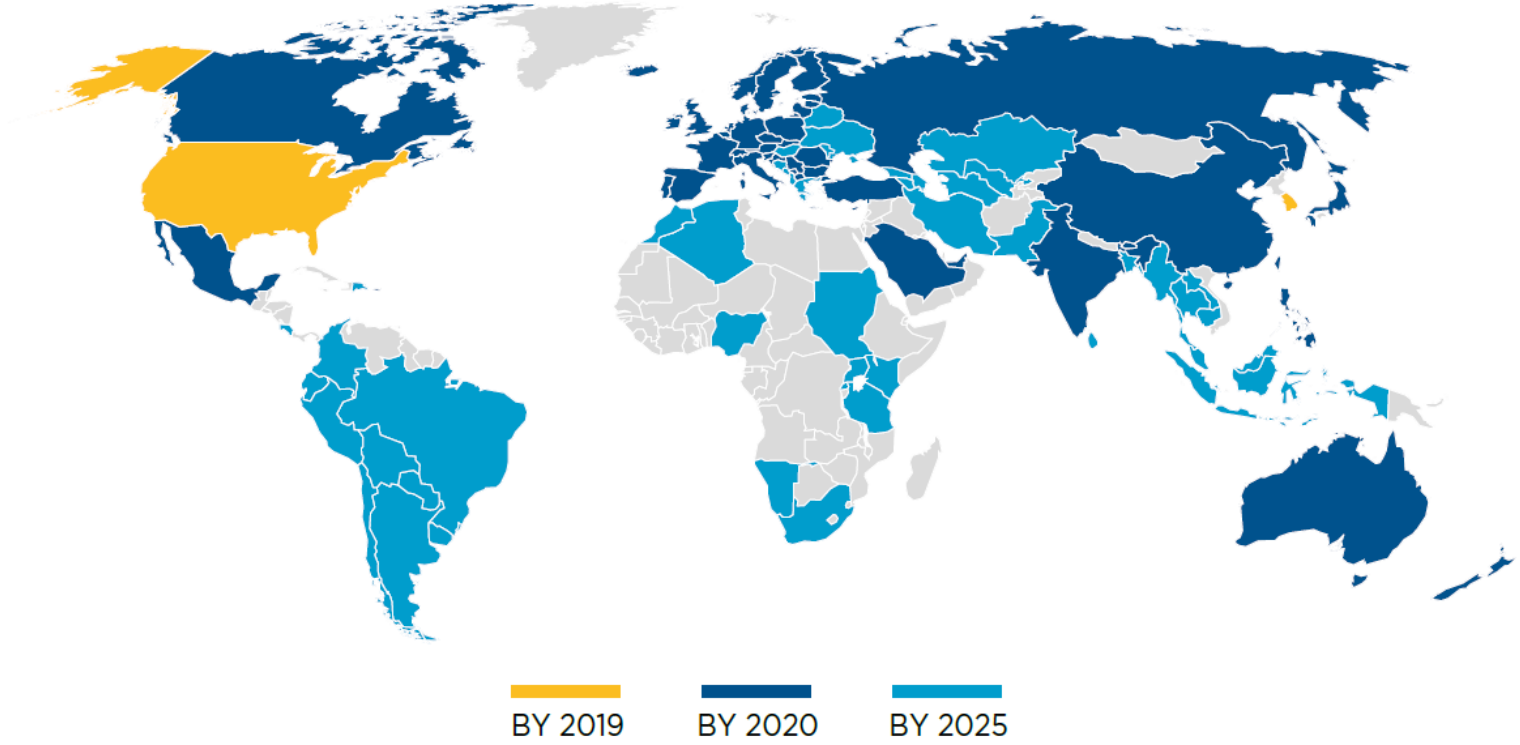
AUGMENTED REALITY

ULTRA-RELIABLE AND LOW-LATENCY

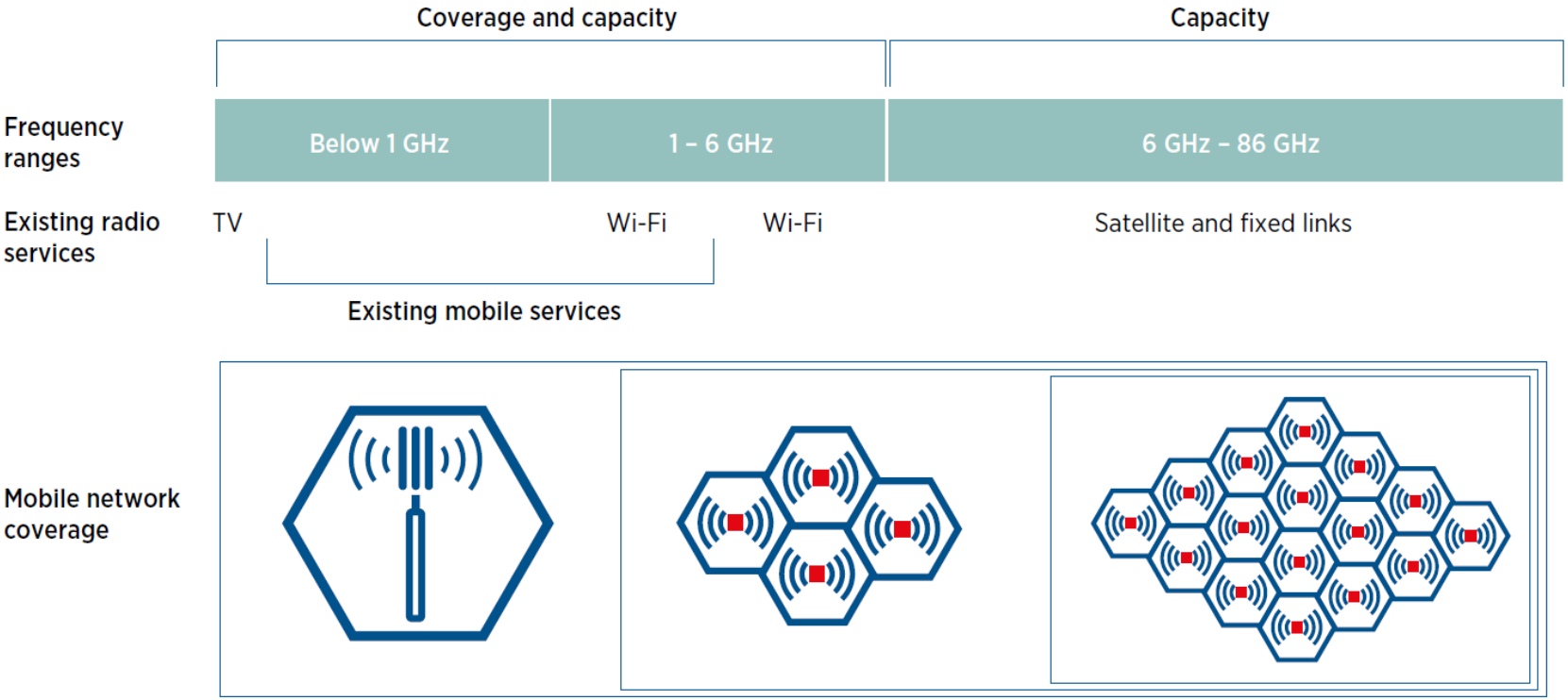
MANUFACTURING

AUTOMOTIVE

Projected plans for 5G launches per country (Source: GSMA Intelligence)



5G needs spectrum within three key frequency ranges



Existing RF-EMF exposure limits apply to 5G

Europe Union:

'The strict and safe exposure limits for electromagnetic fields recommended at EU level apply for all frequency bands currently envisaged for 5G.' (European Commission, 2017).

Norway:

'Measurements show that the total exposure from mobile and radio transmitters that we are exposed to today is weak and is far below the limits for what is harmful to health. We have no reason to believe that the introduction of 5G will change this.' (DSA, 2019)

United Kingdom:

'…point-to-point microwave links and some other types of transmitters that have been present in the environment for many years. ICNIRP guidelines apply up to 300 GHz, well beyond the maximum (few tens of GHz) frequencies proposed for 5G.' **(PHE, 2019)**

Australia:

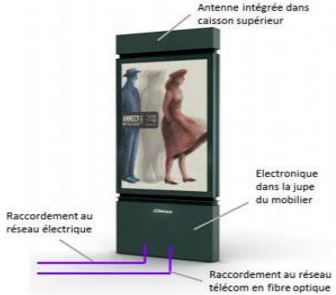
'Although the 5G mobile phone network is new, limits set in safety standards, our understanding of the evidence of health effects and the need for more research have not changed.' **(ARPANSA, 2019)**

Small cell exposure levels similar to macro sites

Final analysis (December 2018) showed that 4G small cells:

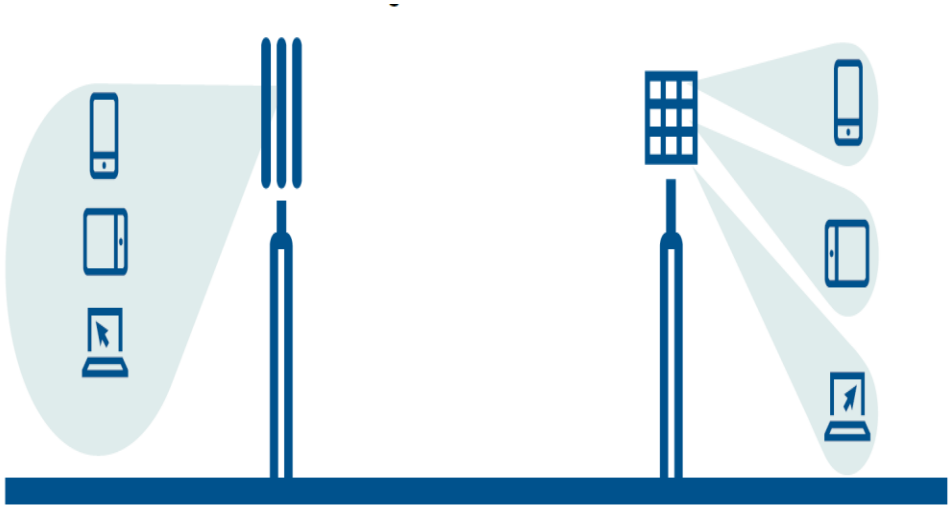
- Increased data rates, with uplink >20 Mb/s in 75% of cases and downlink >50 Mb/s in 50% of cases
- Reduced mobile phone output power at comparable data rates
- Exposure level was about the same as that of the “macro” network

ANFR
AGENCE NATIONALE DES FRÉQUENCES



Source: ANFR, 2018

Increased deployment of smart antenna technologies



- Maintain high data throughput in more efficient ways
- Reduce network interference and electromagnetic energy in unintended directions
- More variability in space and time in the exposure levels

5G exposure levels similar to existing technologies

4G	Actuelle	Future
Puissance maximale	60 W	160 W
Gain maximal de l'antenne	18 dBi	18 dBi
Atténuation sur 6 minutes	- 4 dB	- 4 dB
Vitrage	- 2 dB	- 2 dB
E estimé à 100 m	**1,7 V/m**	**2,8 V/m**

5G	Hypothèse basse	Hypothèse haute
Puissance	80 W	200 W
Gain	24 dBi	24 dBi
Atténuation sur 6 minutes	- 13,5 dB	- 13,5 dB
Vitrage	- 2 dB	- 2 dB
TDD	- 1,25 dB	- 1,25 dB
E estimé à 100 m	**1,1 V/m**	**1,8 V/m**

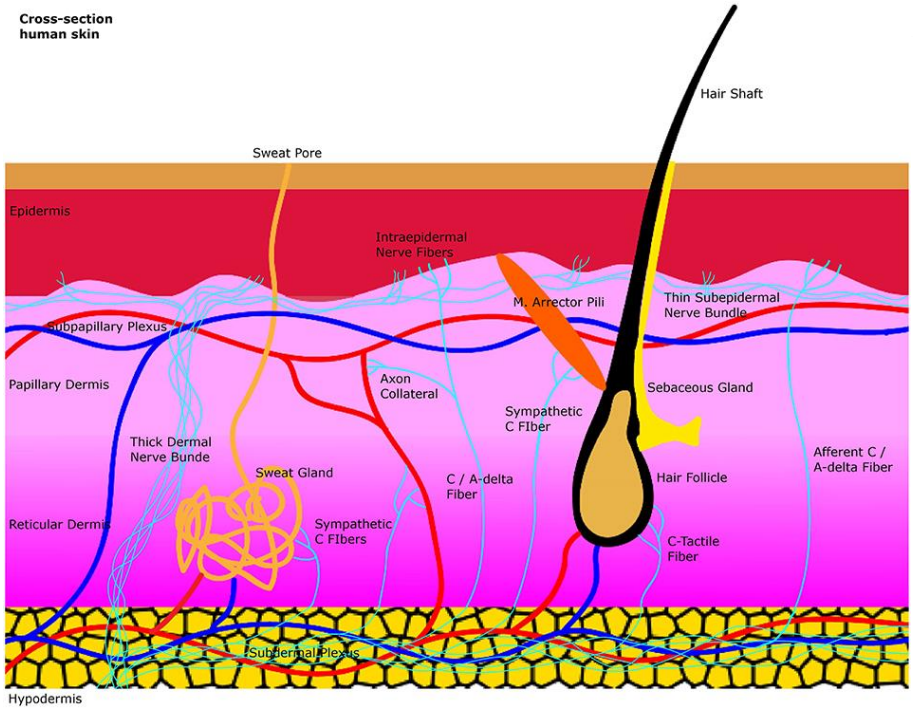
Note: Estimated exposures at 100 m in the interior of a building.

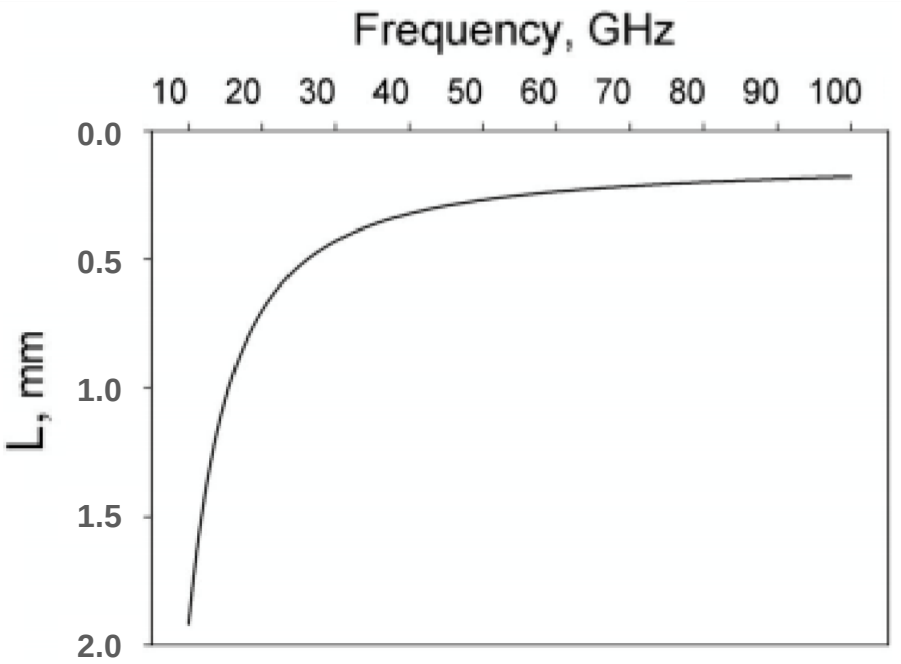
Source: ANFR, 2019

Millimetre-waves are well studied

- Existing applications in communications, radar, security scanners, medical therapies (Eastern Europe), non-lethal crowd control.
  - Roughly 30 GHz to 100 GHz (in biological literature)
  - Significant body of western scientific literature, more in the former Soviet Union
- Main biological effects are skin and eye heating at levels of exposure above levels allowed by limits

mmWaves mostly absorbed in outer skin layers





Glatte et al, 2009

Active Denial Technology (1/2)

- Operates at 95 GHz
- Penetrates the skin to a depth equivalent to three sheets of paper
- Minimal risk of injury due to the shallow energy penetration and normal human instinctive reactions

Active Denial System 2
Official Department of Defense Image

Active Denial Technology (2/2)

- Exposures significantly higher than exposure guidelines
- Health risk assessment:
  - 15 years of studies
  - 13,000 exposures on volunteer subjects
  - No promotion or co-promotion of skin cancer in animal study
  - No effect on male or female reproduction

Active Denial System 2
Official Department of Defense Image

IEC Standard and Technical Report

- **IEC 62232:2017** Determination of RF field strength and SAR in the vicinity of radiocommunication base stations for the purpose of evaluating human exposure

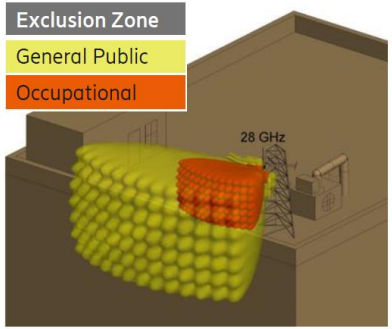
- **IEC TR62269:2011/2019** Case studies supporting the implementation of IEC 62232 - determination of RF field strength, power density and SAR in the vicinity of radiocommunication base stations for the purpose of evaluating human exposure

Actual maximum approach for accuracy

Example – massive MIMO @ 28 GHz (Macro)

Perspective view

Exclusion Zone
General Public
Occupational



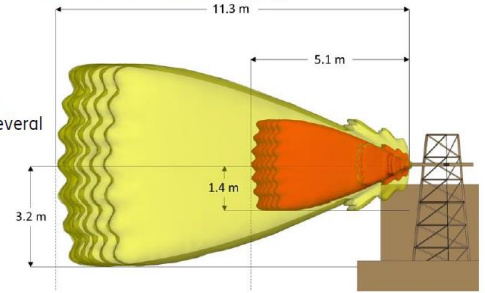
Array antenna with 8×8 elements

$f = 28$ GHz
60° horizontal scan range
15° vertical scan range
$EIRP_{\max} = 72$ dBm

Without considering the effect of beamforming

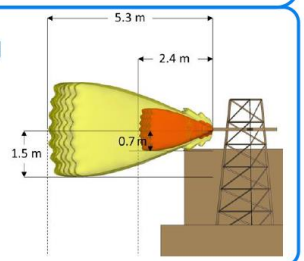
All transmitted power assumed directed in the same beam for several minutes

Process repeated for all beams



Considering the effect of beamforming

Distribute the power per beam to obtain statically conservative compliance boundaries

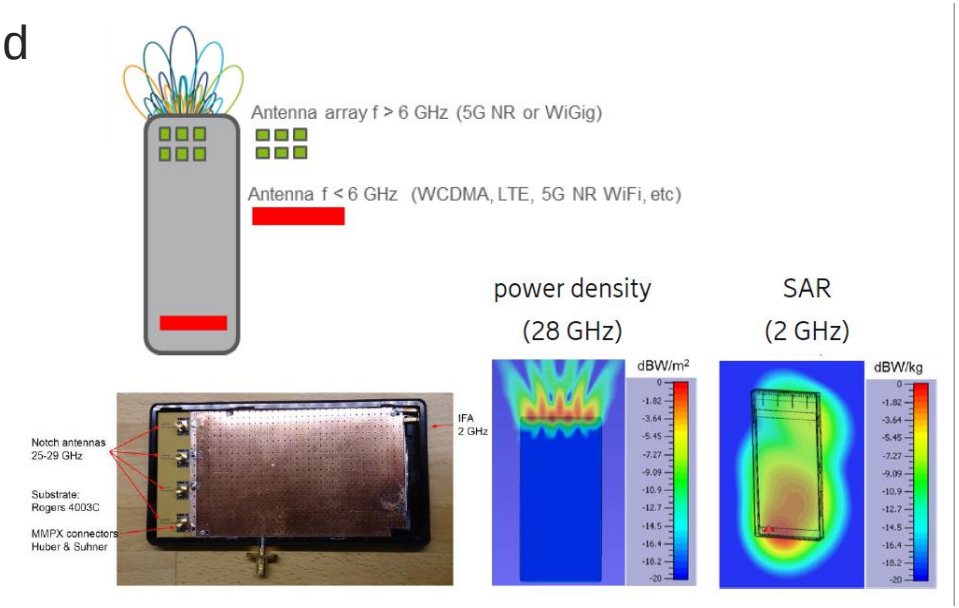


See also BioEM 2018 poster PB 26

Colombi, pre-BIOEM2018 Workshop

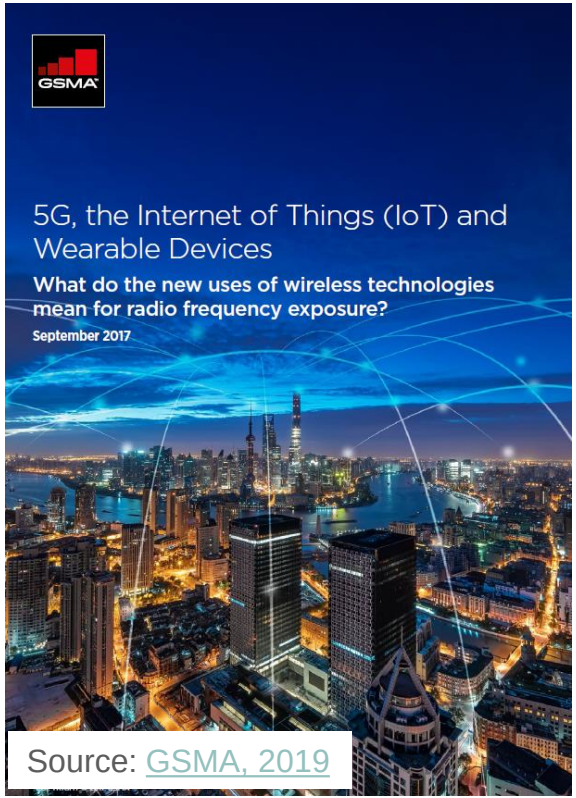
Assessing compliance of devices above 6 GHz

- Multiple antennas above and below 6 GHz
- Basic restriction changes from SAR to power density
- Need to measure power density very close to a device



Colombi, pre-BIOEM2018 Workshop

GSMA - 5G EMF Information



Source: GSMA, 2019

Multiple languages

5G is the next generation of mobile technology that will transform the role of mobile connectivity in society, enabling changes in the way we live and do business. The radio signals used for 5G are similar to those used by current technologies and are covered by the same international safety guidelines that protect all members of the public and the environment.

5G is an evolutionary mobile technology that supports many new capabilities

5G is the next generation of mobile technology. It is designed to support new applications through Gigabit data rates, low latency and high reliability. It will also provide efficient support for large numbers of connections, enabling the Internet of Things (IoT). 5G will deliver smarter and more convenient living and working. Initial 5G networks launched in 2018 and 5G connections will grow to around 15% of global connections by 2025.

5G is covered by existing international safety guidelines

The radio signals used by mobile technologies have been extensively studied for decades. This scientific evidence is the basis for the international safety guidelines for radio signals.[1] These guidelines include all the frequencies under consideration for 5G.

The consistent conclusion of public health agencies and expert groups is that compliance with the international guidelines is protective for all persons (including children) against all established health risks.

Public health agencies confirm no health risks expected from 5G

Australia:
'Although the 5G mobile phone network is new, limits set in safety standards, our understanding of the evidence of health effects and the need for more research have not changed.' (ARPANSA, 2019)

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Many initial 5G deployments will be at frequencies similar to 3G/4G mobile networks and Wi-Fi. This also means that many existing antennas sites can be reused for 5G.

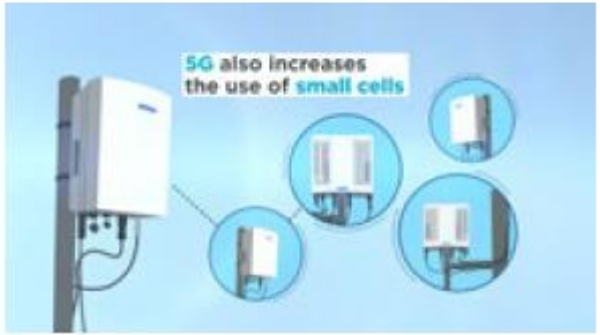
To achieve higher capacity 5G can also use frequencies that are today used for fixed radio links. These frequencies are known as millimetre-waves (mmW or mmWaves) and they are covered by the safety guidelines.

The same limit values that protect people also protect the environment. The responsible German government agency[2] says that there is no scientifically reliable evidence of a risk to animals and plants exposed to radio signals at levels below limits in the international guidelines.

(Continued on reverse)

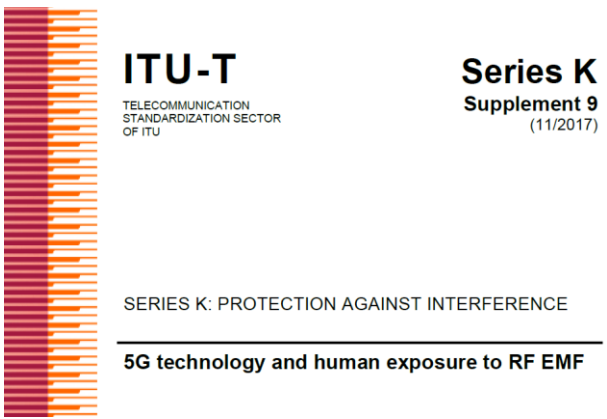
Source: GSMA, 2019

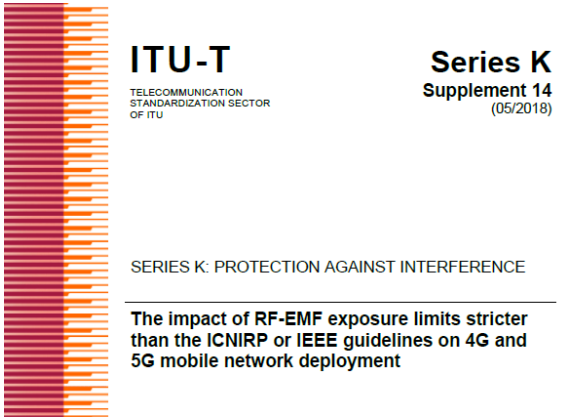
Animation

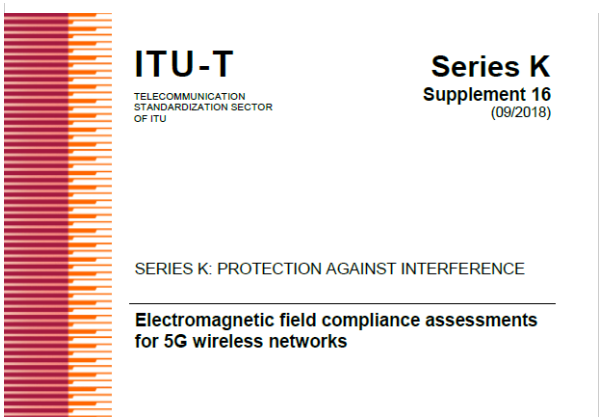


Source: GSMA, 2019

ITU - 5G EMF Information







- Updates to ITU EMF Guide

Changing media narrative on 5G and EMF

July 2018

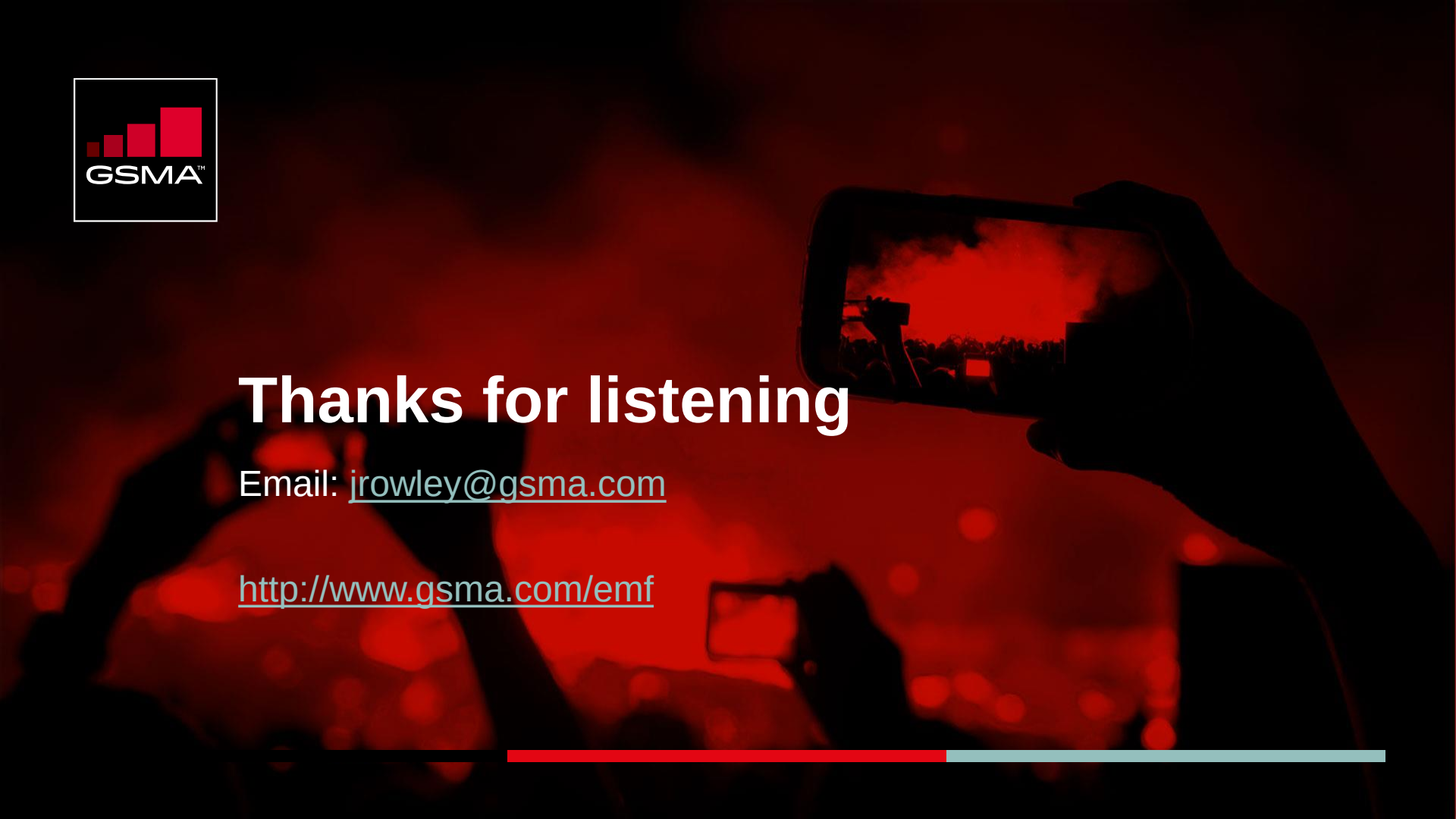
July 2019

Conclusions

- International RF-EMF limits cover the frequencies and modulations relevant to 5G and health agencies say that no health hazards are expected at levels below the limits

- 5G assessments show levels similar to 4G meaning that overall exposures will not change by much, remaining a small fraction of the limit values

- mmWave frequencies are used today by the mobile and satellite industries, they have been extensively researched and are covered by the international safety guidelines



Thanks for listening

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http://www.gsma.com/emf