INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

EMF Standards for 5G technologies

Human exposure compliance assessment procedures for mobile device and network equipment operating from 6-100 GHz

Mike Wood

Chairman IEC TC106

ITU-D Session on modern policies, guidelines, regulations and assessments of human exposure to RF-EMF

10 October 2018

What is 5G?

5G is the 5th generation of mobile networks

Extreme speeds - Gbps
High Capacity – 10x
Low Latency – 1ms

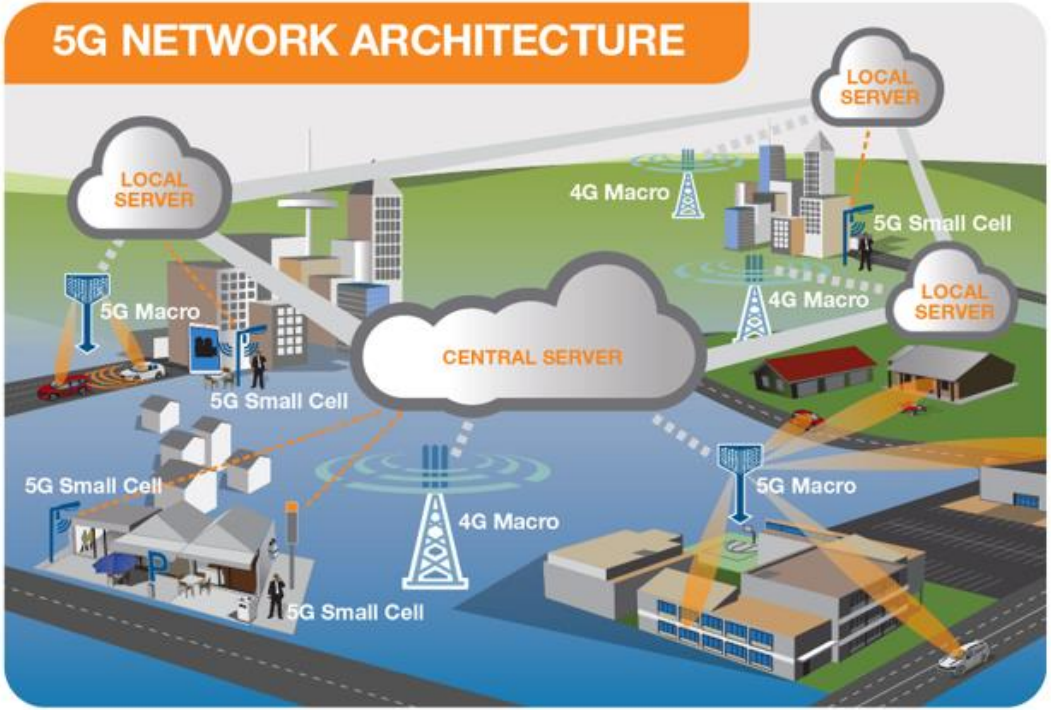
1G	2G	3G	4G	5G
1980s	1990s	2000s	2010s	2020
Analogue	Digital SMS	Multimedia Video Calling Mobile internet	Mobile Broadband Enhanced Video	Mobile Connected World Enhanced Mobile Broadband Low latency applications Internet of Things AR & VR

5G Timeline

Fixed wireless access for homes and enhanced mobile broadband services are likely to be the first applications using new 5G wireless access modems and hot spots.

Mobile handsets with 3G, 4G and 5G connectivity expected in the 2019 – 2021 timeframe
Low latency and widespread machine to machine applications using 5G in similar timeframe

5G – Implications for EMF Assessment



5G and 4G working together, with central and local servers providing faster content to users and low latency applications

EMF Assessment Considerations

New Spectrum	mmWave
Macro Cells, Small Cells	near & far field
MIMO Beam Steering	power averaging
5G and 4G together	multiple technologies
Many devices	complex assessments

Challenges for 5G & EMF Standards

- **Globally harmonised EMF exposure limits**
- **Revised ICNIRP, IEEE, FCC exposure guidelines are critical especially for 5G devices >6/10GHz**
- **Development and implementation of new network and device testing procedures to meet 5G technology evolution**

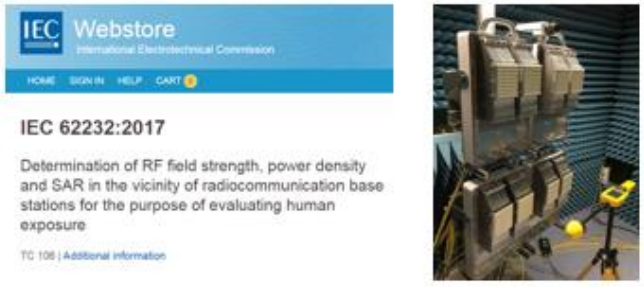
Devices
- mmWave
- Complex devices
- Far field – E or H is measured
- Near field - E&H field, Phase, field reconstruction
- Multiple tx, beam steering & varied shapes
- Advanced modelling techniques

Networks
- mmWave
- Complex antennas
- Near field and far field
- MIMO & beam steering
- Power averaging for true EMF level
- Advanced modelling techniques

Challenge – IEC TC106 has responsibility to develop assessment standards for 5G devices and networks to 100GHz (by 2018)

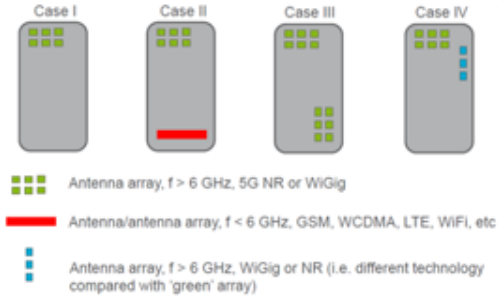
New 5G Exposure Assessment Standards - IEC

- **IEC Strategic Business Plan - prepare for 5G**
- **Ensure Standards and Technical Reports are developed**
  - Trials & early deployments in 2018 – 2019, Commercial Launch 2019 - 2020



5G Networks

IEC 62232 ED2 110 MHz to 100GHz	2017
IEC TR 62669 – case studies inc 5G	2018

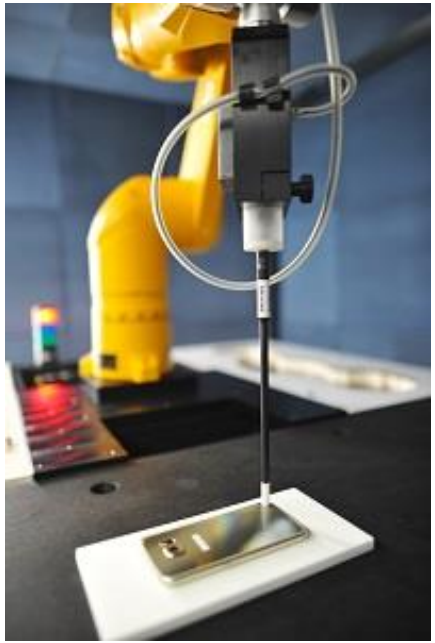


5G Devices

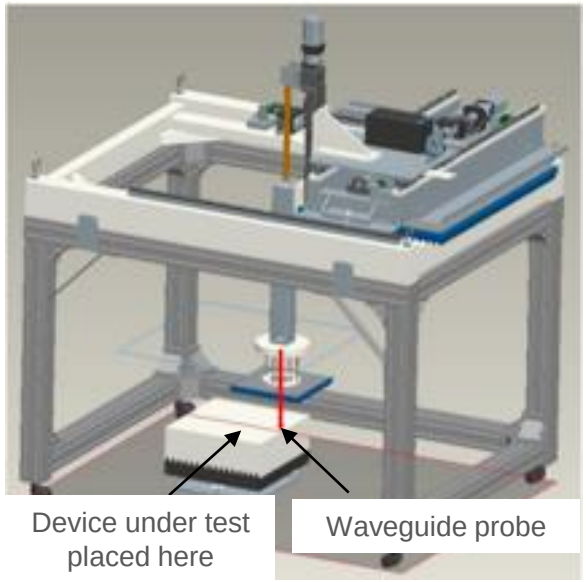
IEC TR 63170 Technical Report 6 to 100GHz	July 2018
IEC / IEEE International Std 6 to 300 GHz	Dec 2020

5G Device Test systems – power density measurements

During development of the IEC 5G Technical Report in 2017, test laboratories initiated development of 5G mmWave device test systems



IT'IS EUmmW Poynting vector probe



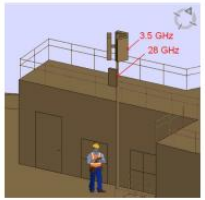
Art-Fi mmWave guide probe development

APREL mmWave probe development

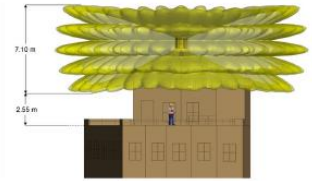
5G Macro Cell Assessment using IEC 62232

Example: 5G site with massive MIMO

3.5 GHz and 28 GHz, actual maximum power



5G urban roof-top installation



Exclusion zone 10 W/m²

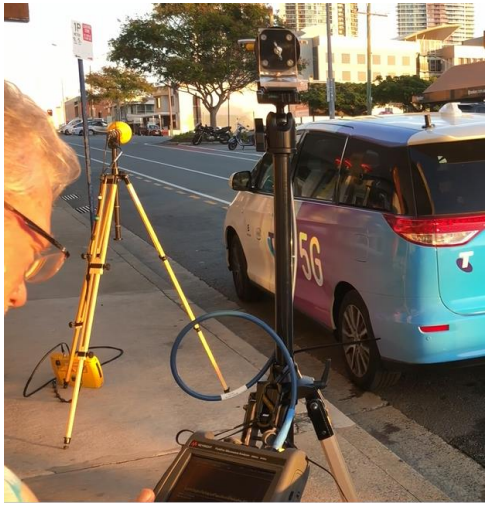
ICNIRP general public limit

Actual maximum power = 25% of theoretical maximum

RF EMF exposure below ICNIRP limits in public areas

Case study to be included in IEC TR 62669 (2018) and ITU-T Supplement on 5G EMF compliance

Modelling actual power due to beam steering



Measurements of 5G in Australia using IEC 62232

Locating beam and observing level variation

IEC/IEEE Team

IEC and IEEE have formed a Joint Working Group to ensure 5G assessment standards are globally harmonised and meet the 5G release timeframes

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THANK YOU

Electromagnetic Field (EMF) Exposure assessment of Telstra's 5G trial network on the Gold Coast, Australia

ITU – D Session on modern policies, guidelines, regulations and assessments of human exposure to RF-EMF

Geneva, Switzerland **10th Oct 2018**

Mike Wood
Debbie Wills

Telstra Corporation Limited

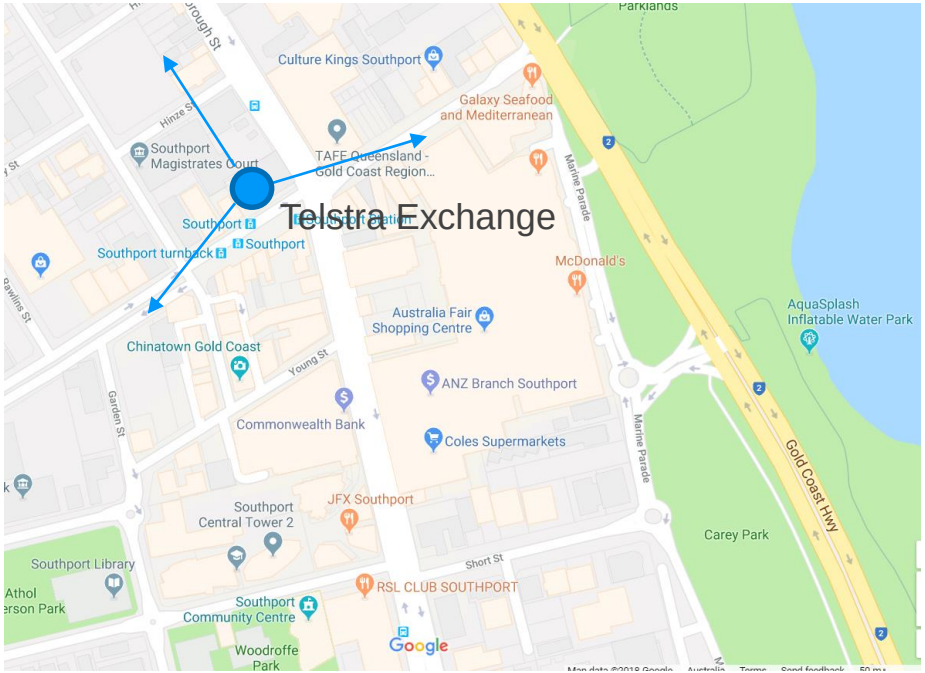
Background

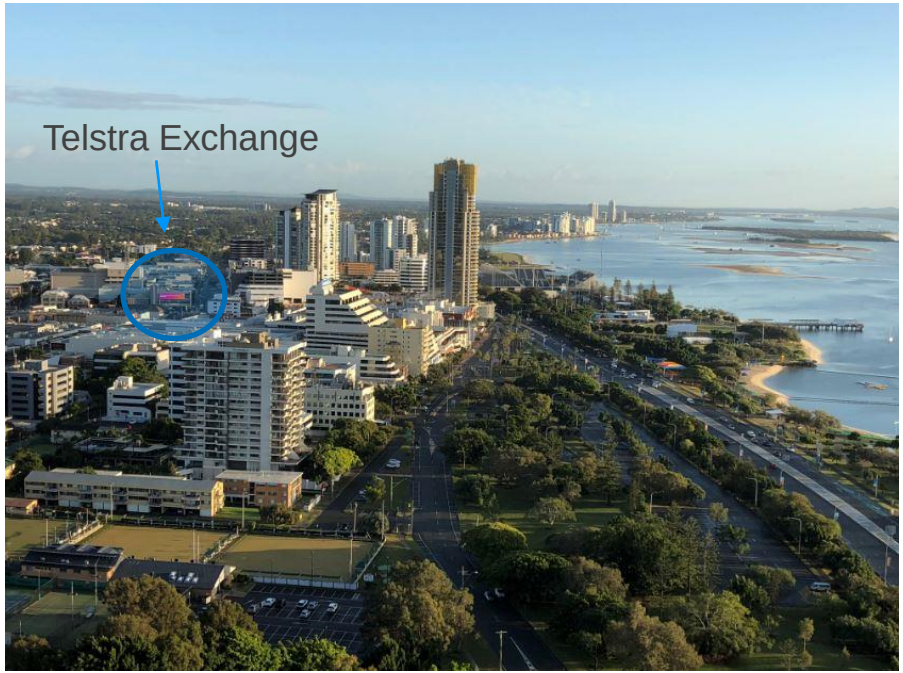
Telstra recently opened a new 5G Innovation Centre at our Southport Exchange on the Gold Coast. The centre will be the home for testing the next generation of mobile technologies in local conditions to support the early commercial deployment of 5G in Australia.

The innovation centre has a

- **27GHz indoor 5G network** operating at similar power to the current indoor mobile technology
- **27GHz outdoor base station** on a tower operating at similar power to a medium range small cell (E100) (63Watts EIRP)

Location – Southport, Queensland





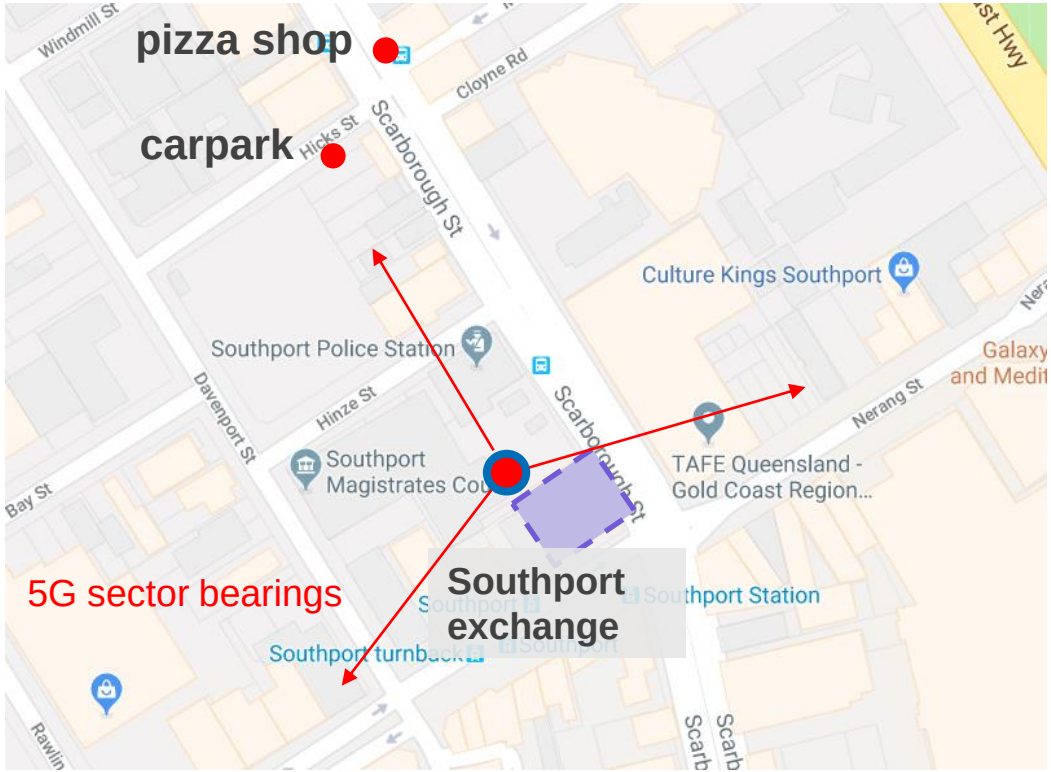
Purpose & Objectives

The purpose of the measurements was to ascertain the electromagnetic field (EMF) or electromagnetic energy (EME) levels associated with this new technology

Objectives

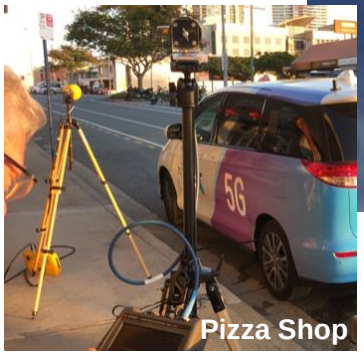
- ❑ Compare actual measured EMF levels with theoretical predictions of EMF levels from a 5G antenna to assess confidence in the computation of exclusion zones
- ❑ Assess environmental EMF levels from 5G and other radio sources at both indoor and outdoor areas in the vicinity of the base station
- ❑ Assess suitability of test equipment for mmWave measurements
- ❑ Determine next steps and ongoing EMF learning & assessment requirements

Outdoor measurements

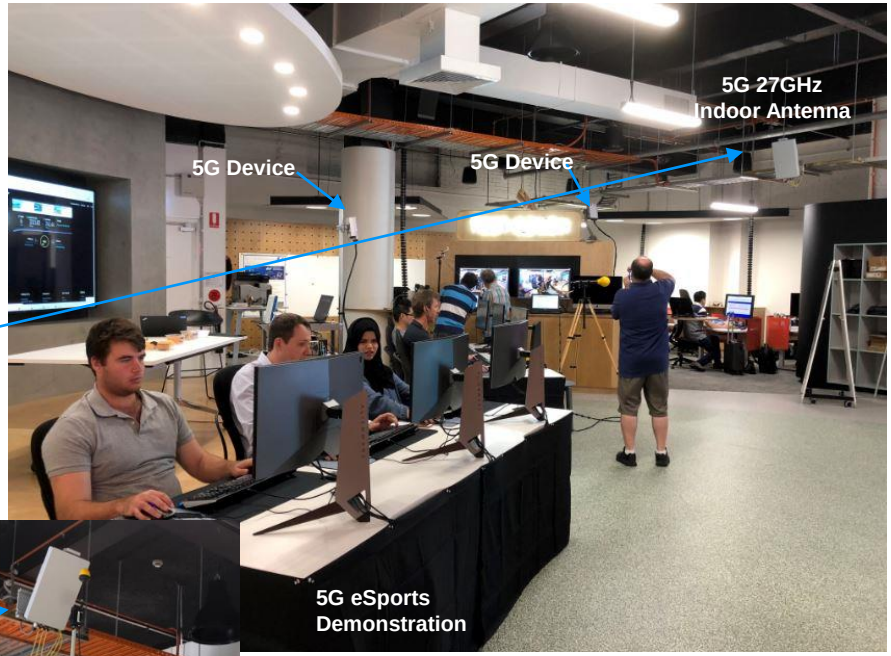


https://www.google.com.au/maps/@-27.974846,153.3818768,14z

44 m radio tower



Indoor measurements



EMF measurements from 5G base station antenna

Transmitter configuration

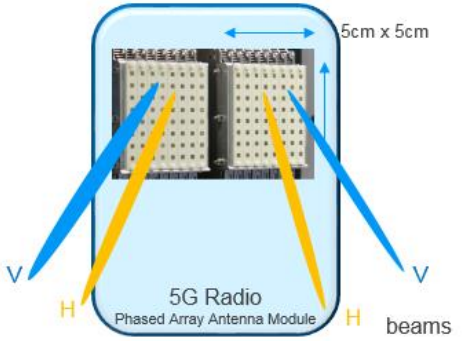
Line of sight along the boresight beam

- **Indoor**:
  single antenna array under program control
  single constant boresight beam, single polarisation, 800 MHz, 42 dBmW (15.8 W) EIRP

- **Outdoor**:
  base station antenna 2x2 MIMO, 400 MHz, 45 dBmW (31.5 W) EIRP,
  vehicle mounted *user equipment* (UE) antenna connected to base station to 'attract' the beam

- Broadband probe (< 1m from antenna), spectrum analyser and horn antenna (≥ 1m)

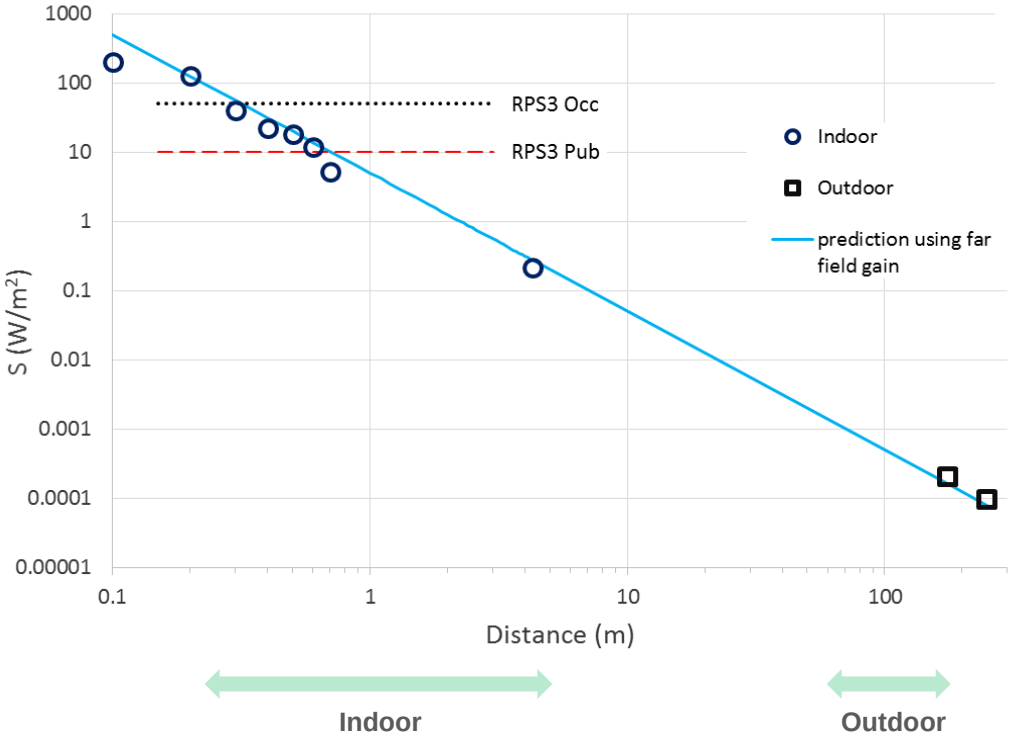
- TDD downlink/uplink ratio 23:1, high downlink (dummy) traffic generating 1-2 Gbps



Massive MIMO antenna

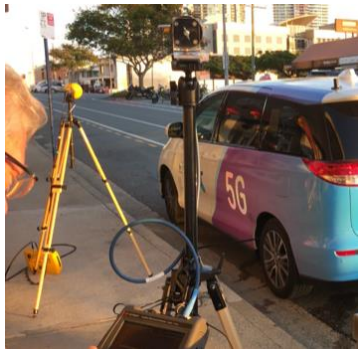
EMF measurements along boresight beam

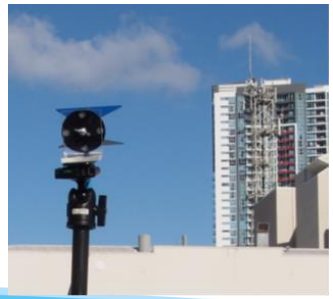
Compare actual measured EMF levels with theoretical predictions



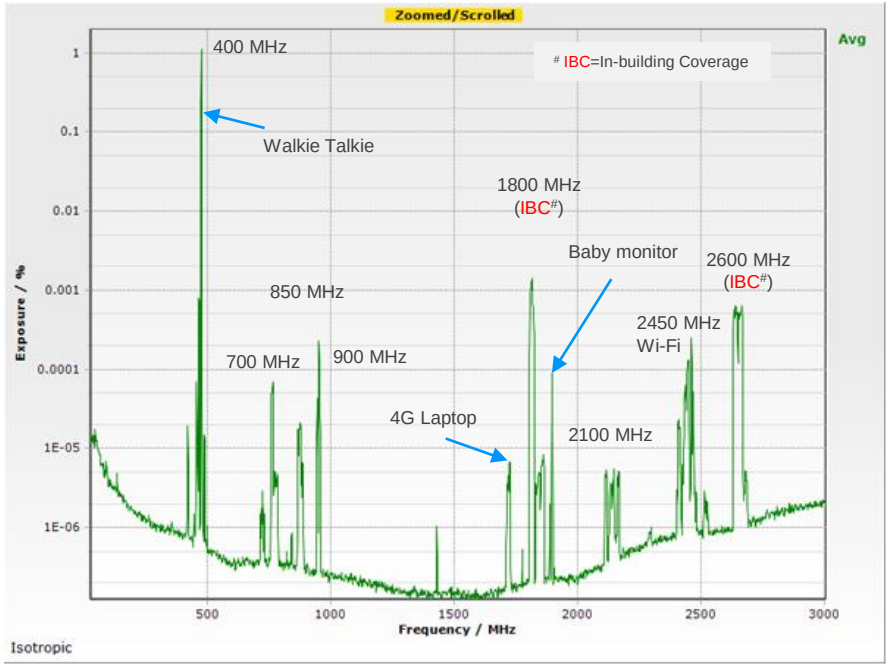
Notes

- Measurements scaled to 63 W total EIRP
- Uncertainties: precise measurement location with respect to boresight, field scattering, calibration.

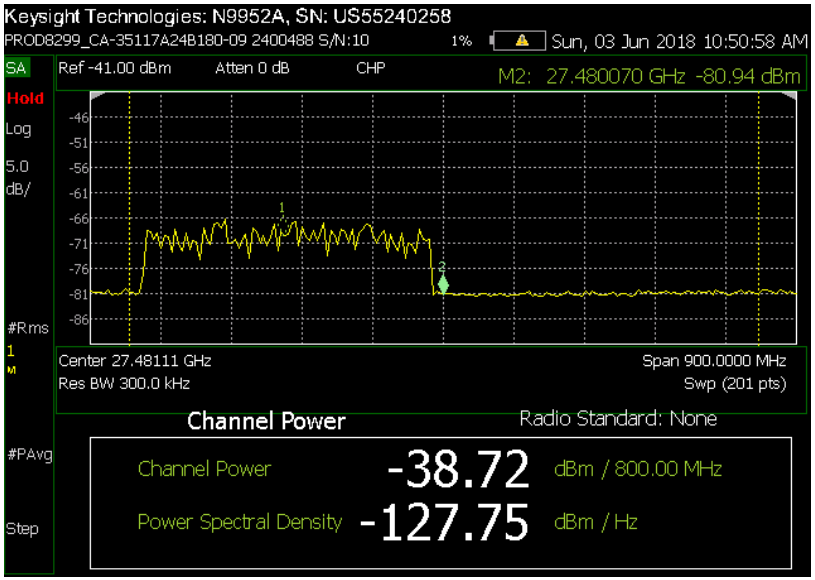




Environmental EMF - indoor spectrum



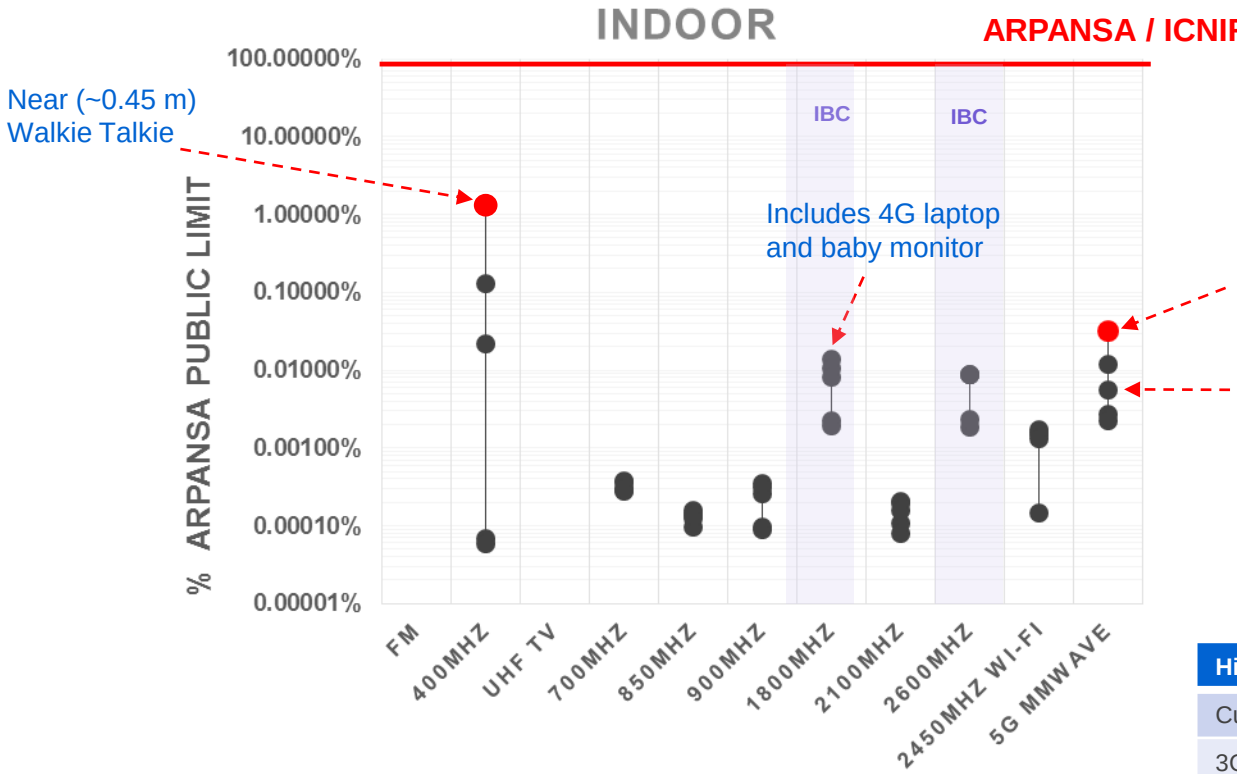
27 MHz – 3 GHz (1 min average)

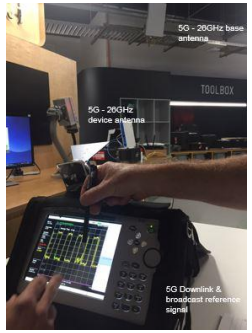


5G - 27 GHz

Channel power measurement with spectrum analyser and horn antenna

Environmental EMF levels - indoor

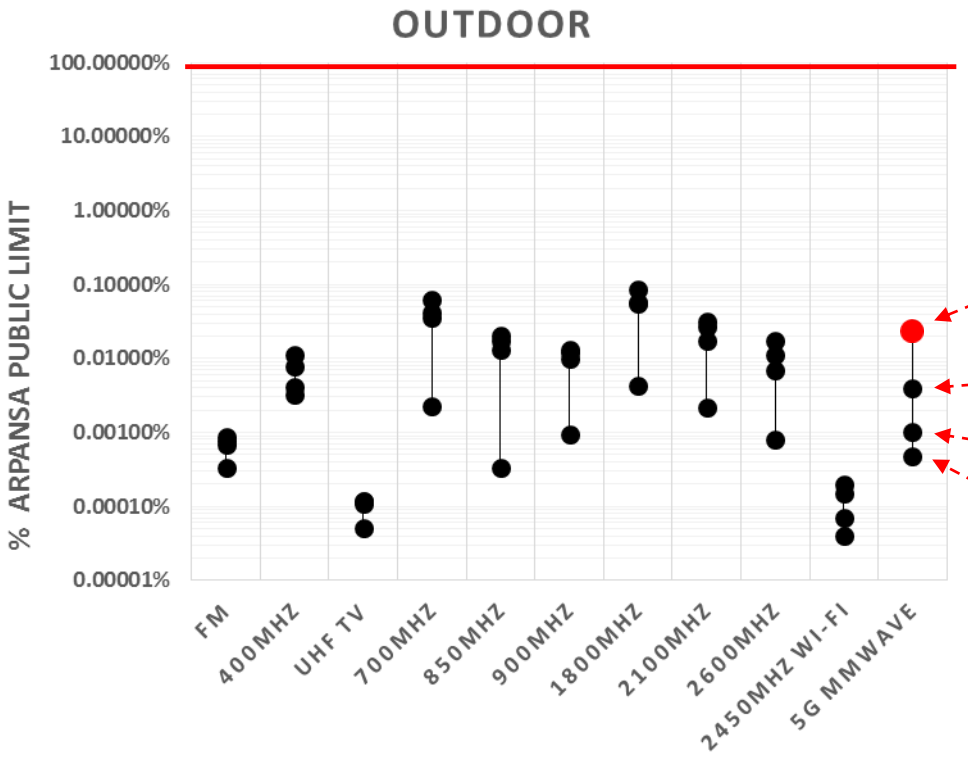




Highest exposure	
Cumulative: 27MHz to 3GHz	1.34%
3G, 4G, Wi-Fi	0.025%
5G (near UE antenna)	0.032%
5G (general environment)	0.012%

- Measurements at different positions

Environmental EMF levels - outdoor



Sum of car mounted 5G UE + BS @ 0.3 m from car, carpark

Sum of car mounted 5G UE + BS @ 1.5 m from car, carpark

Towards BS, carpark

Towards BS, pizza shop

Highest exposure	
Cumulative: 27MHz to 3GHz	0.19%
5G	0.025%

- Measurements at different positions

Observations

- **Overall EMF Levels** – all mobile technologies including 5G significantly below ARPANSA RPS3 / ICNIRP

- **What does 5G add?**

  Indoor & Small cells – similar EMF to current technology (more data/ more users)
  Outdoors Macro cells – predict similar EMF to current macro technology (more data/ more users)

  5G is more efficient – more data/users for same power. (will replace older less efficient technologies)

- **Many more devices** – no significant increase in environmental/background EMF
  - devices will have increased efficiency
  - devices will comply with EMF limits
  - EMF levels from devices decrease very rapidly with distance
  - many devices have intermittent transmission (low EMF)

Findings

- Good alignment between predicted 5G levels and measured 5G levels under test conditions - provides confidence in calculating 5G EMF levels
- Measurements show 5G signals comparable to other radio signals in the environment and significantly lower than the ARPANSA public limit
- Indoor measurements with a multitude of radio technologies and devices inc 5G were well below the ARPANSA public limit
- Massive MIMO systems increase measurement complexity in a live network environment (e.g. dynamic beam steering). IEC is working on standards to assess Massive MIMO systems
- Measurement instruments found to be suitable for the trial – further development needed
- Requires a good understanding of measurement practices and the mobile technology

Team effort

John Parker

Geoff Bail

Phill Knipe

Eman Younus

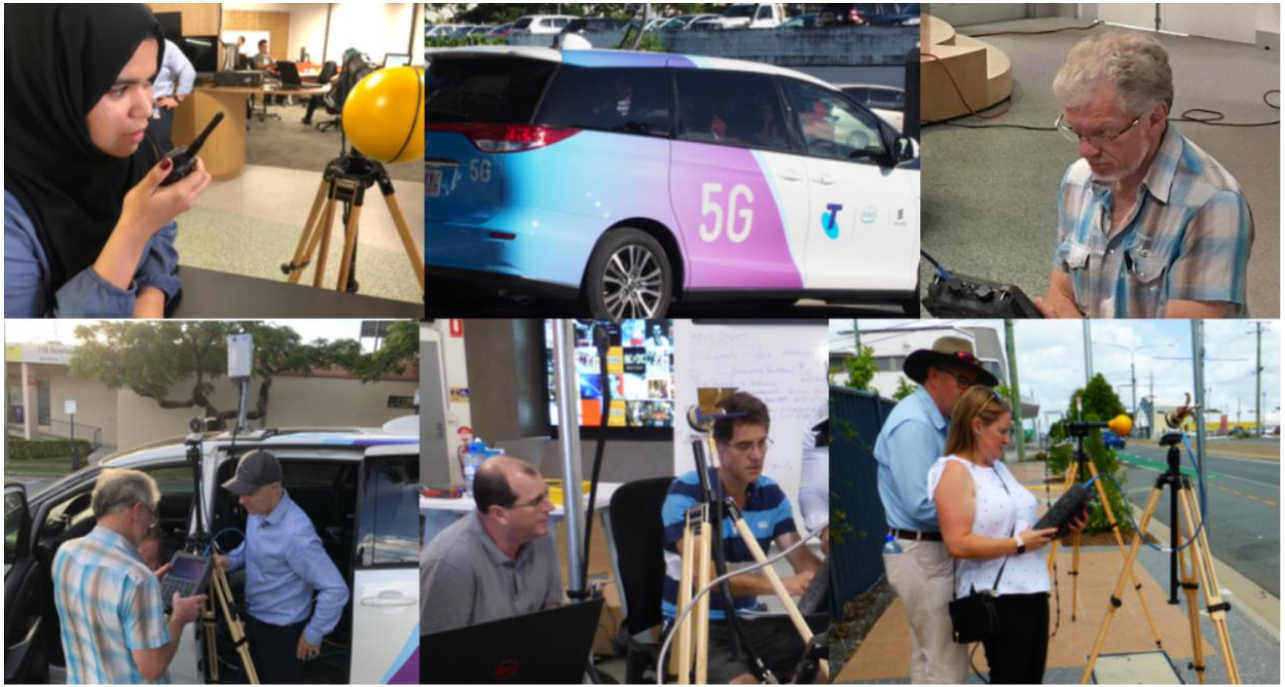
Debbie Wills

Steve Iskra

Mike Wood

Telstra staff at Southport exchange

Ericsson staff



Thank you

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