5G – EMF Assessment

Exposure Scenarios

Poland Ministry of Digital Affairs and National Institute of Telecommunications

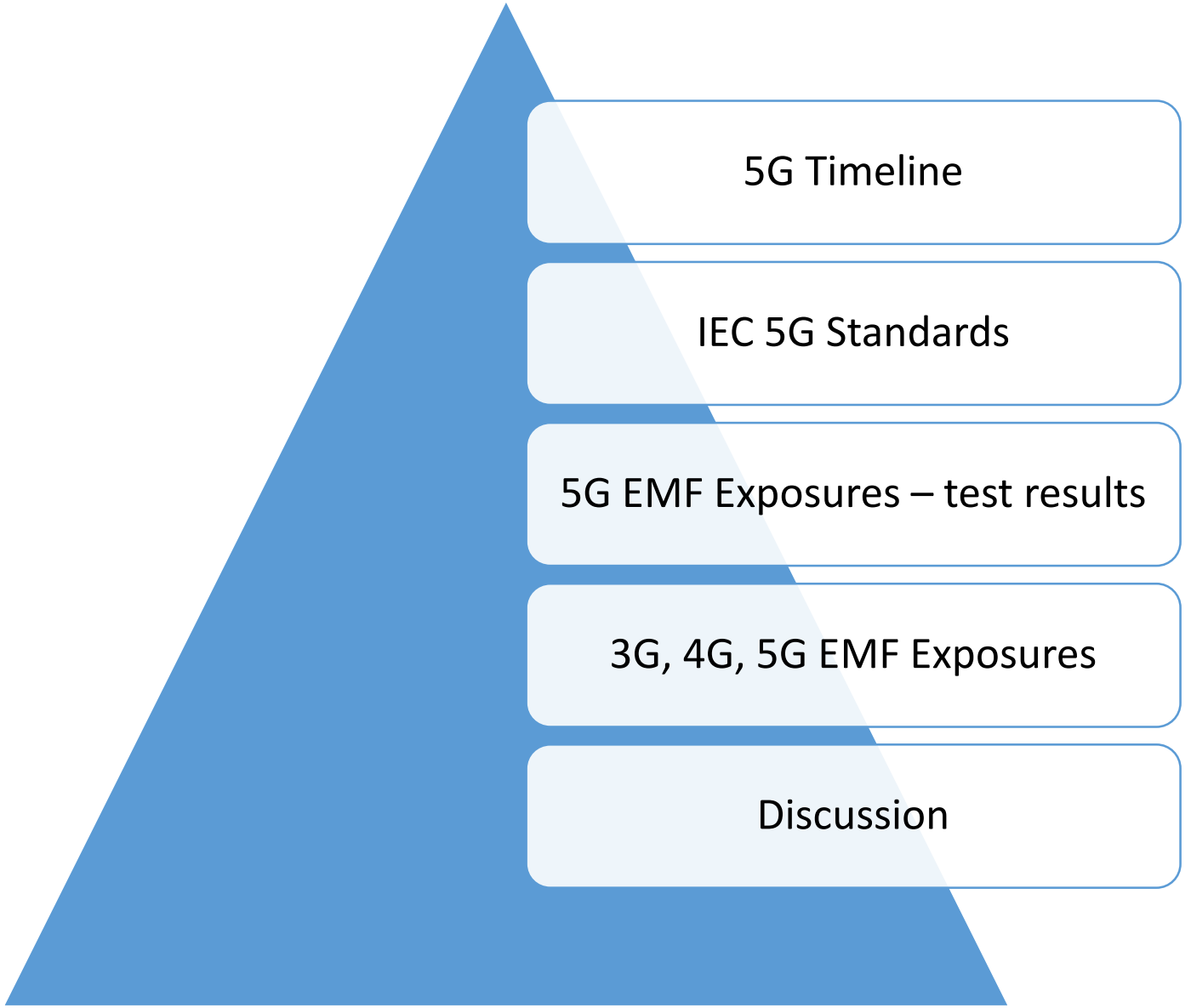
Electromagnetic field and the future of telecommunications.
Research. Monitoring. Domestic and foreign experience

3-4 December 2019

Mike Wood - Chairman
International Electrotechnical Commission
Technical Committee 106

Debbie Wills - Principal
Governance & Compliance Telstra Wireless

Presentation Overview



5G Timeline

Fixed wireless access for homes and **enhanced mobile broadband** first applications using new 5G.

5G & IoT applications will be widespread by 2025.

IEC Overview

International Electrotechnical Commission: (est1906)

International Standards and Conformity Assessment for all electrical, electronic and related technologies

Vision

“IEC everywhere for a safer, more efficient world.”

IEC Masterplan

A global network of some 170 countries that covers 99% of world population and electricity generation

Offers an Affiliate Country Programme to encourage developing countries to use and participate in IEC work free of charge

Develops International Standards that represent a global concensus of state-of-the-art know-how and expertise. Administers Conformity Assessment Systems

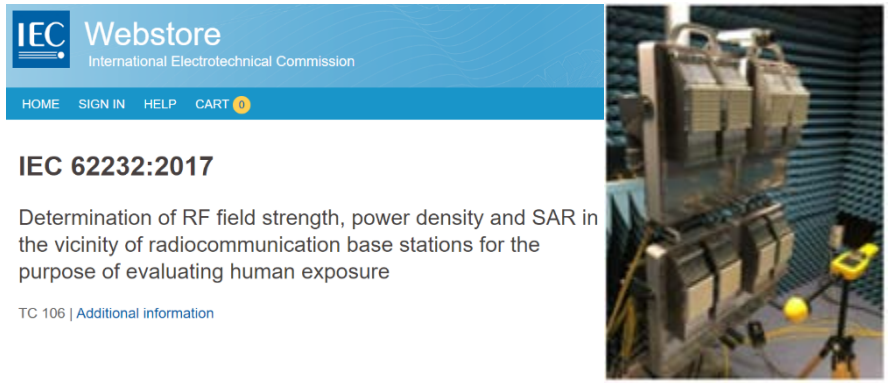
Over 20 000 experts

100 years expertise.

IEC - Preparing for 5G

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

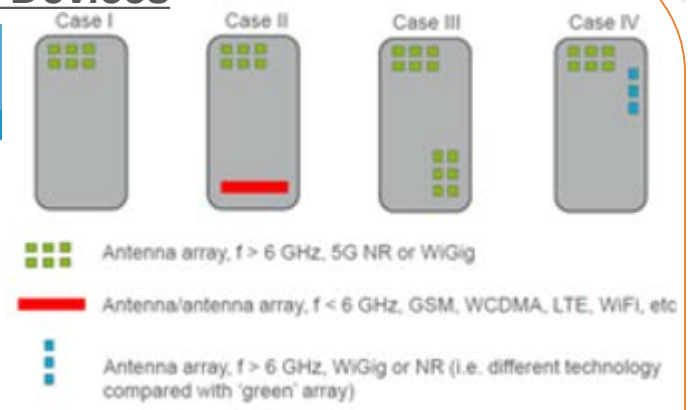
5G Base Stations



Standards

IEC 62232-2 Int Std	110MHz -100GHz – Aug 2017
IEC 62669-2 Tech Report	6GHz -100GHz – April 2019
IEC 62232-3 Int Std	110MHz - 300GHz –June 2020

5G Devices



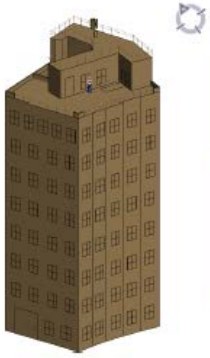
Standards

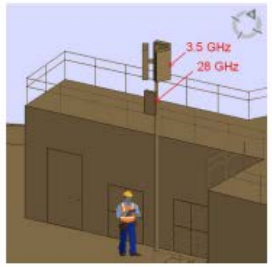
IEC TR36170 Technical Report	6-100GHz – July 2018
IEC / IEEE 62704-5 Int Std (Calc)	6-100GHz – Dec 2020
IEC / IEEE 63195-1 Int Std (Meas)	6-100GHz – Dec 2020

IEC Standards - 5G Base Station Testing

Example: 5G site with massive MIMO

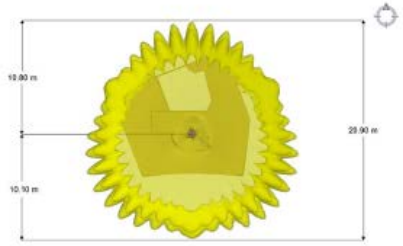
3.5 GHz and 28 GHz, actual maximum power





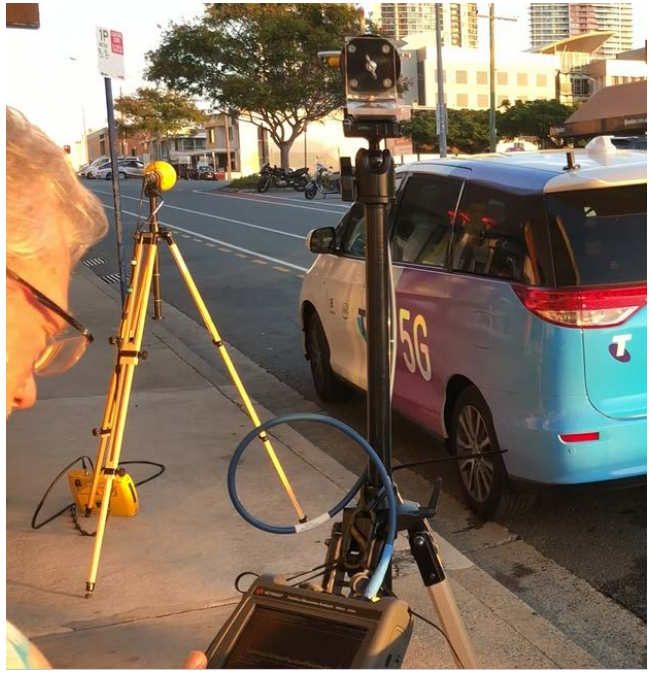
5G urban roof-top installation

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



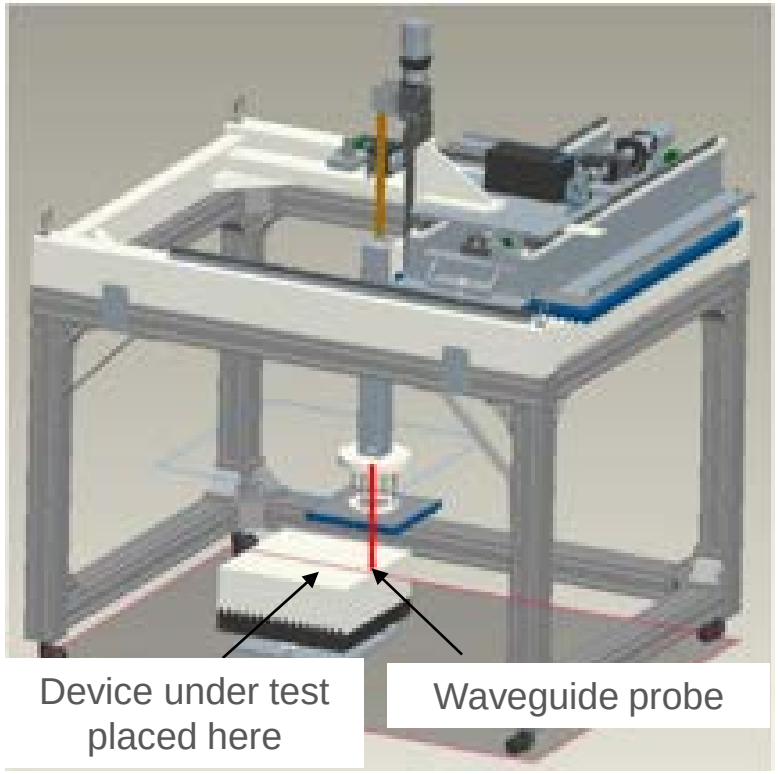
Measurements of 5G in Australia using IEC 62232
Locating beam and observing level variation

IEC Standards - 5G Device Testing

5G at 3.5GHz – existing SAR test systems are used

5G at mmWave - test laboratories initiated development of new 5G mmWave device test systems

IT'IS EUmmW Poynting vector probe



Art-Fi mmWave guide probe development

APREL mmWave probe development

5G Measurements – Using the IEC Standards

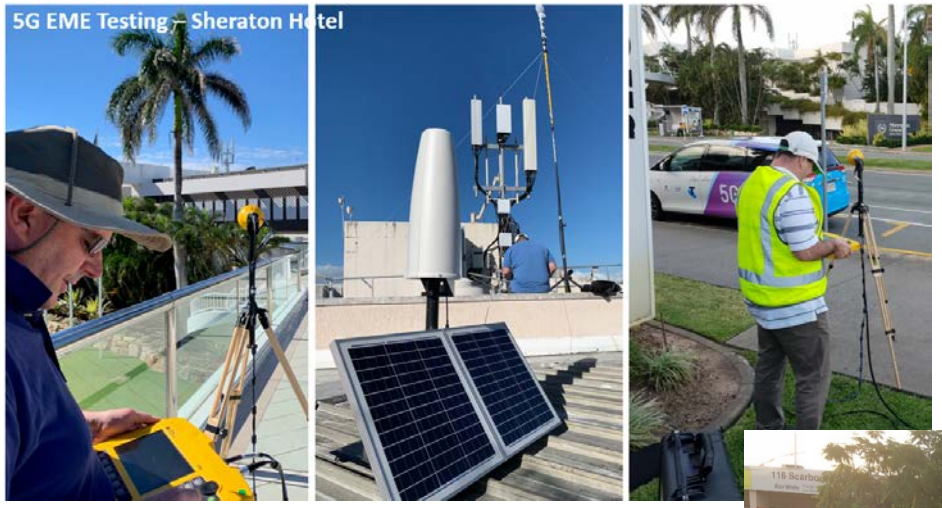
Telstra, Ericsson, Narda, & TRS have conducted extensive EMF testing of 5G on the trial 27GHz mmWave network in 2018 and the new 3.5GHz commercial network in 2019 in Australia

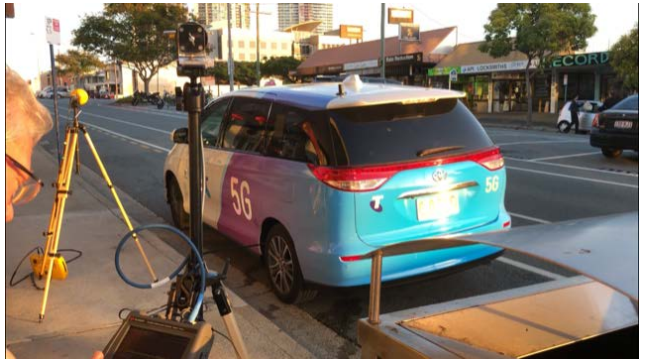
EMF tests included

- 27 GHz mmWave trial 5G network
  - indoor
  - outdoor

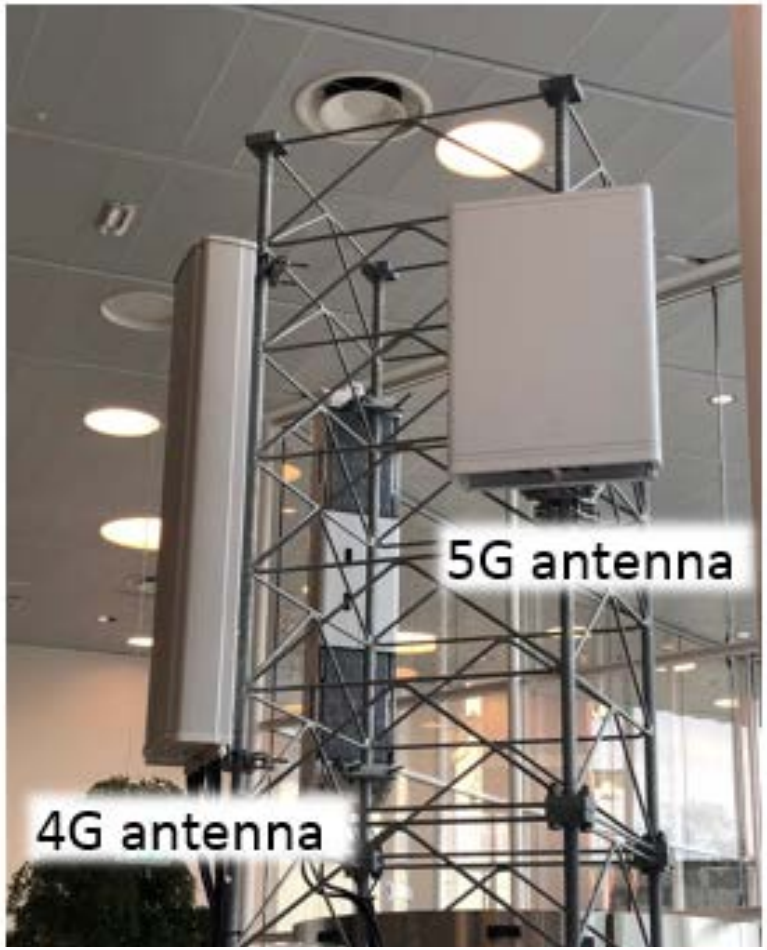
- 3.5GHz Commercial 5G Network

  - cafes
  - homes
  - schools
  - apartments
  - sporting fields
  - shopping centres





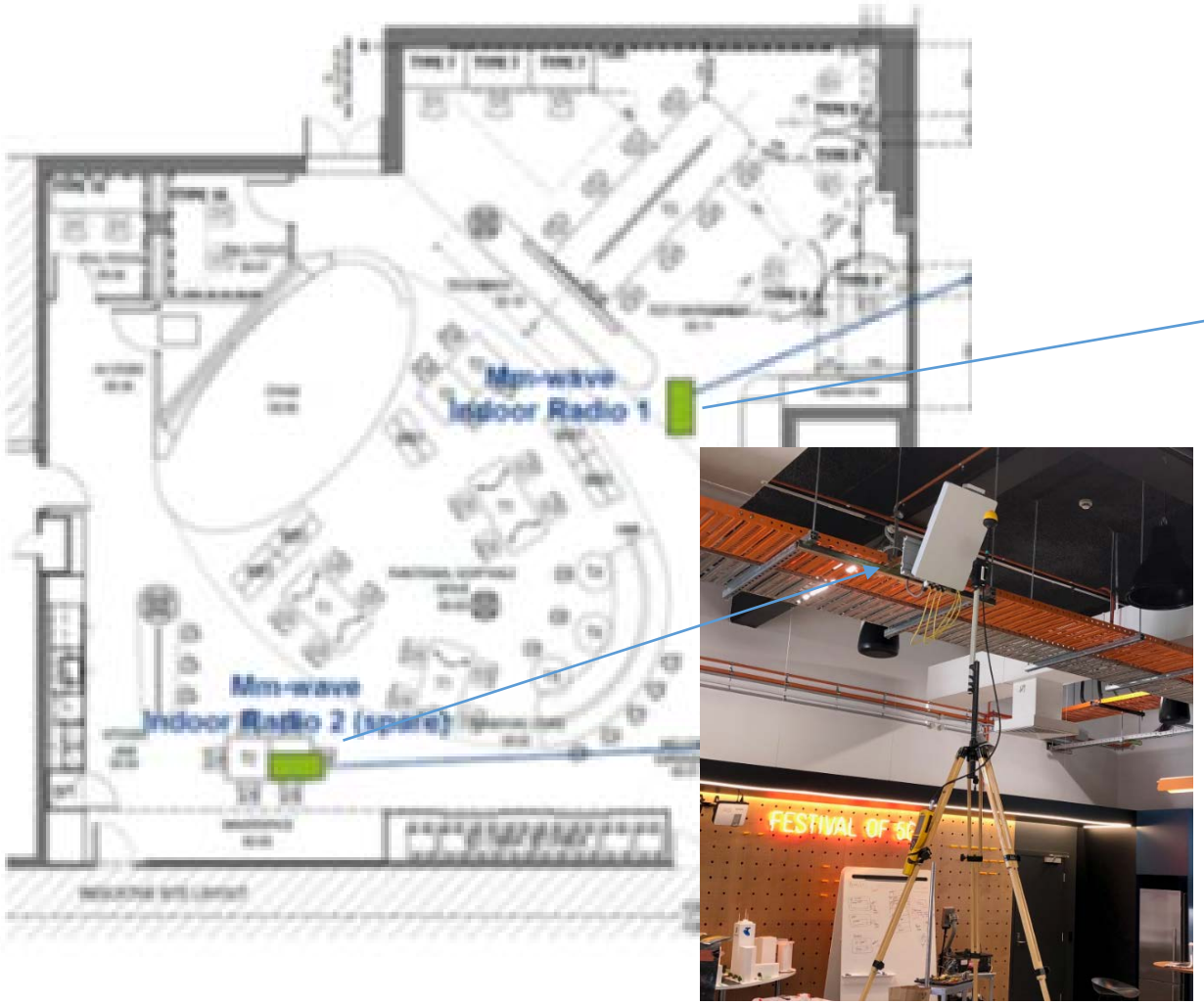
5G Antennas – 3.5GHz & 27GHz

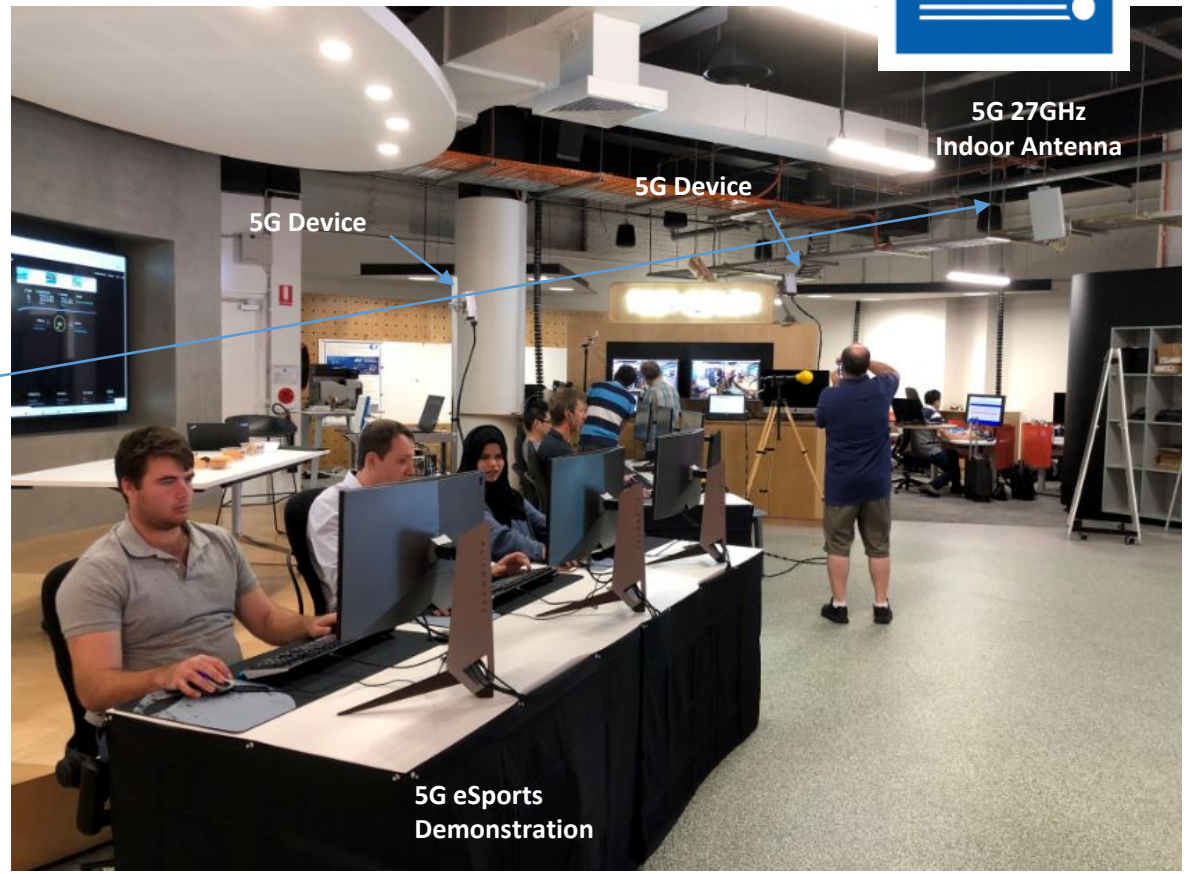


Ericsson Display in Kista Sweden
3.5GHz 5G antenna

Southport Radio Tower
27GHz mmWave 5G antenna

5G EME measurements – mmWave trial





EMF measurements - mmWave 5G base station

Transmitter configuration

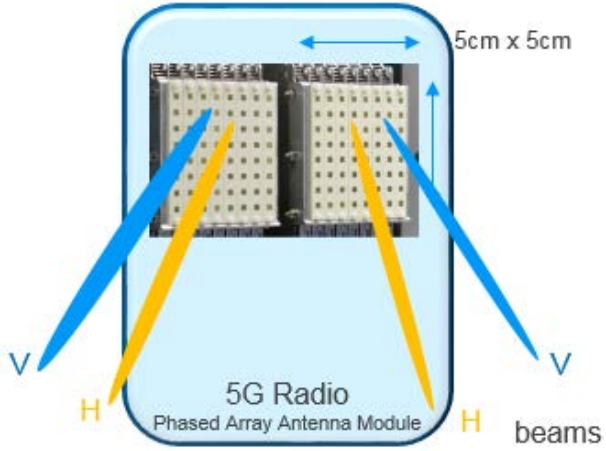
- Line of sight along the boresight beam

❑ 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)

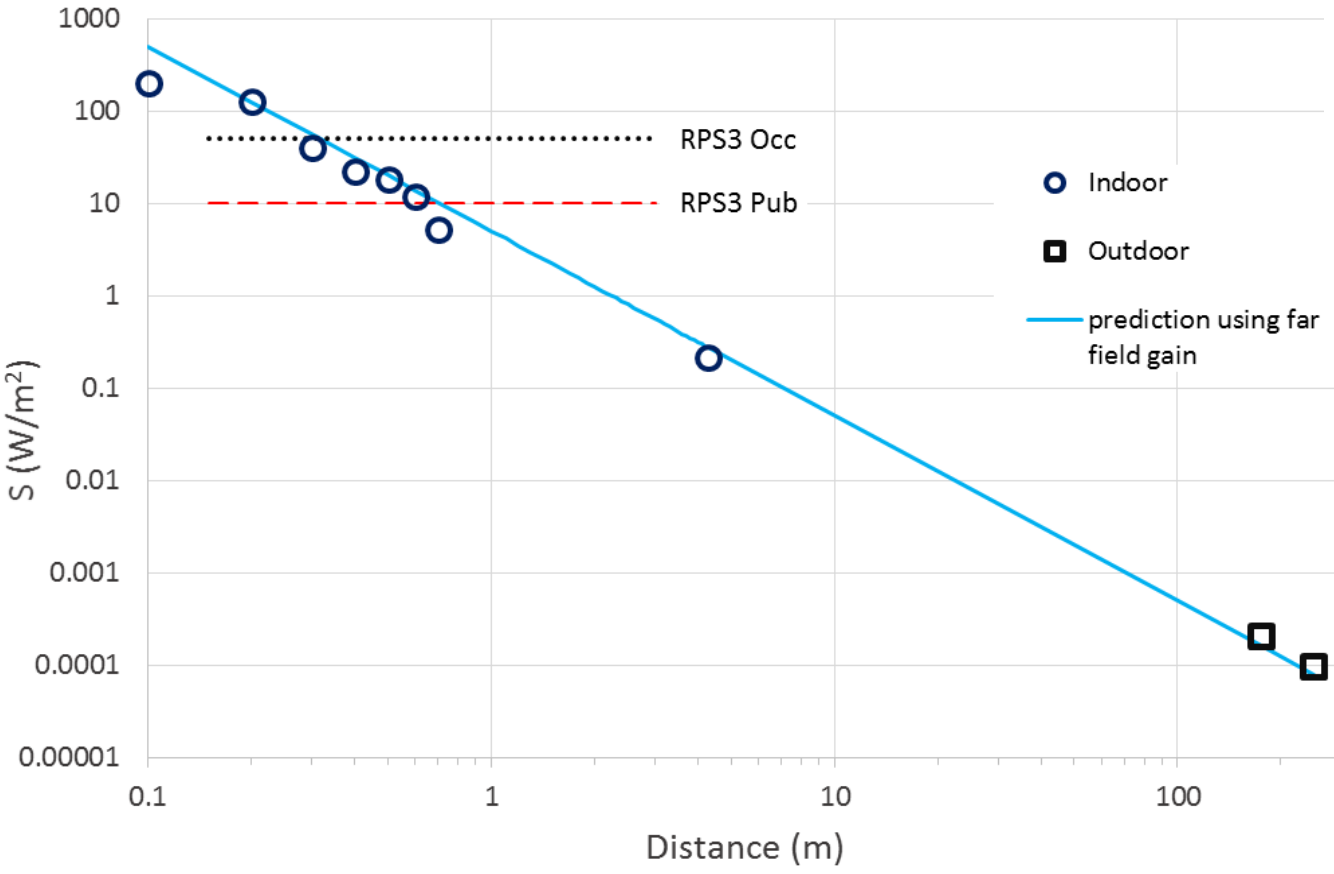
❑ TDD downlink/uplink ratio 23:1, high downlink (dummy) traffic generating 1-2 Gbps



Massive MIMO antenna

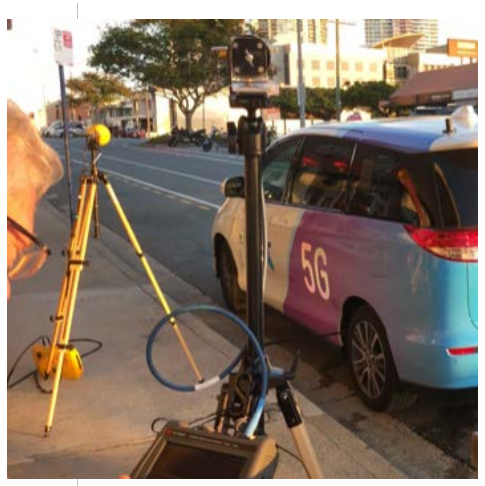
5G EME measurements – mmWave trial

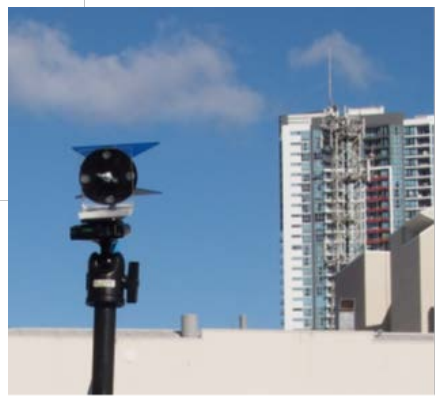
5G EMF measurements along boresight beam



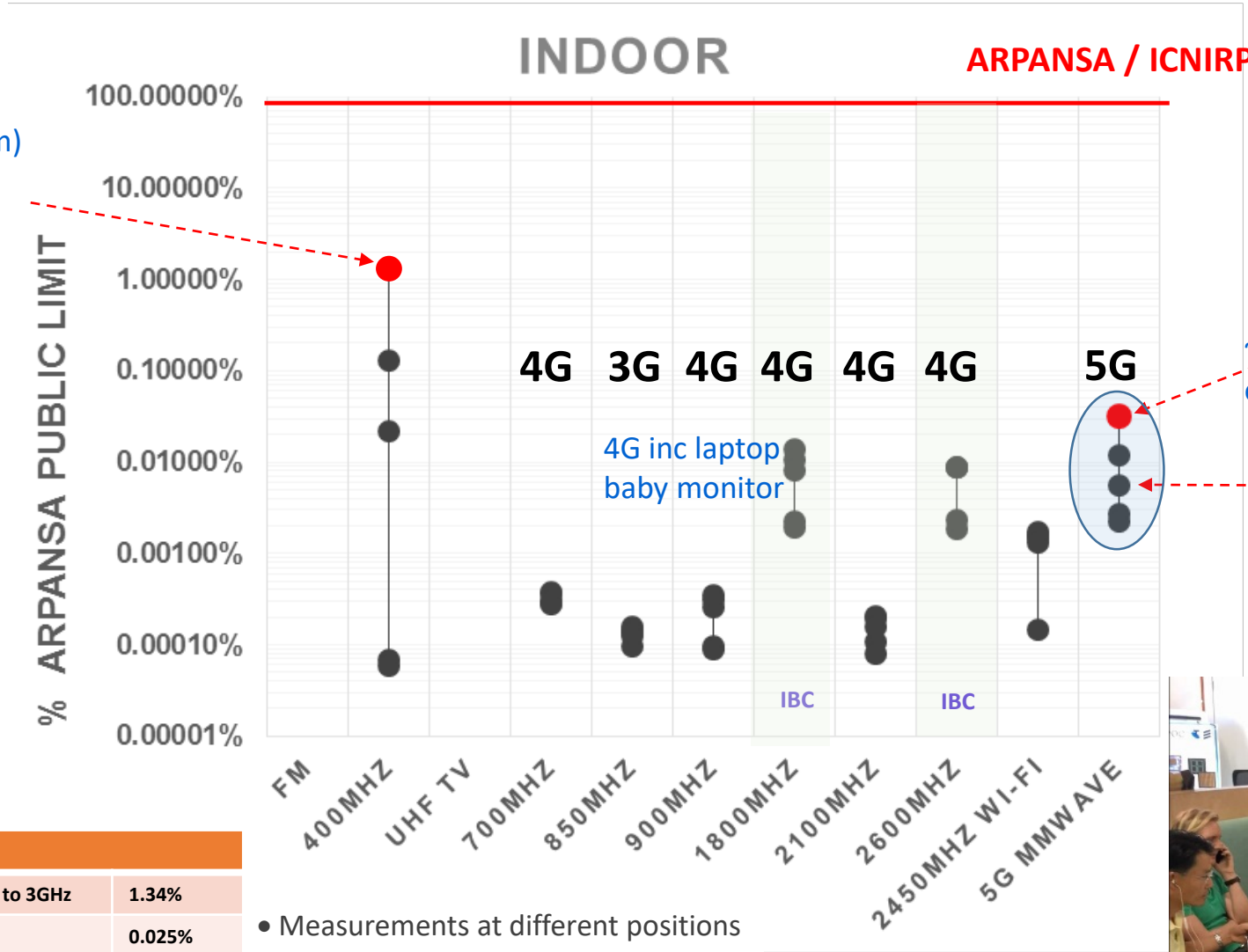
Notes

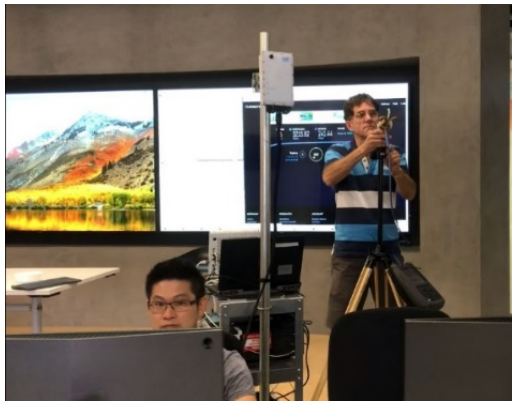
- Measurements scaled to 63 W total EIRP
- Uncertainties: precise measurement location with respect to boresight, field scattering, calibration.

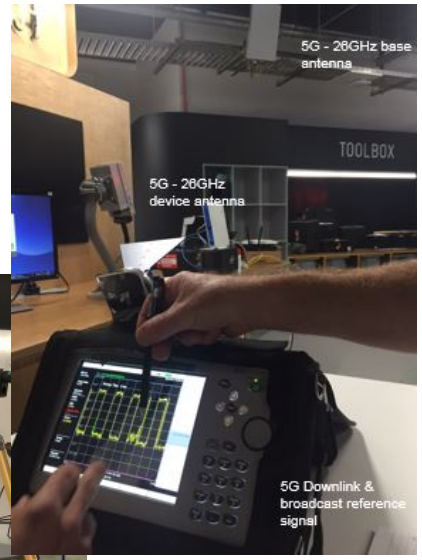


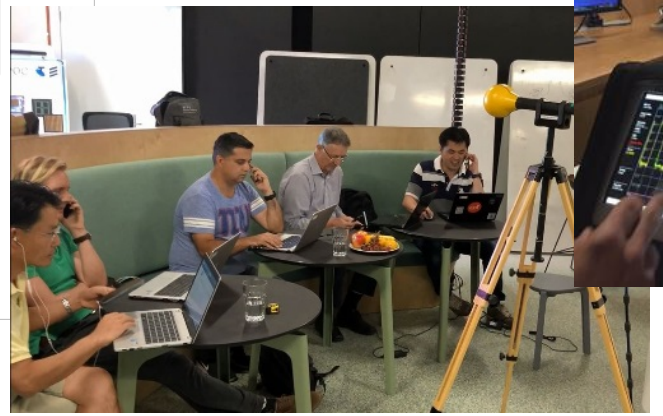


5G EMF Measurement Results – mmWave trial







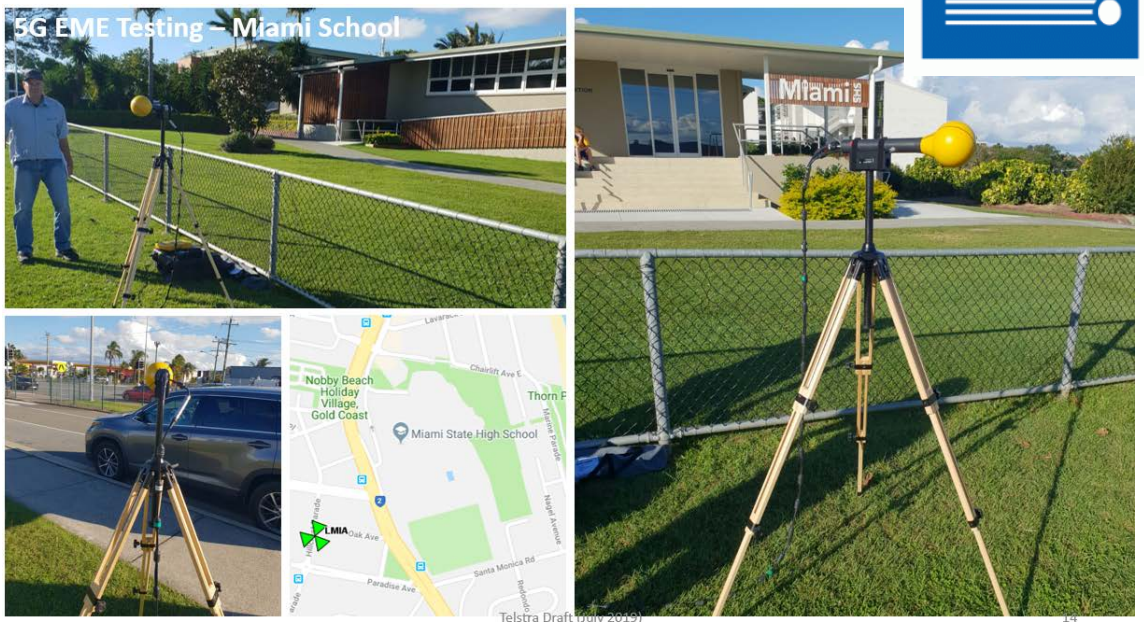


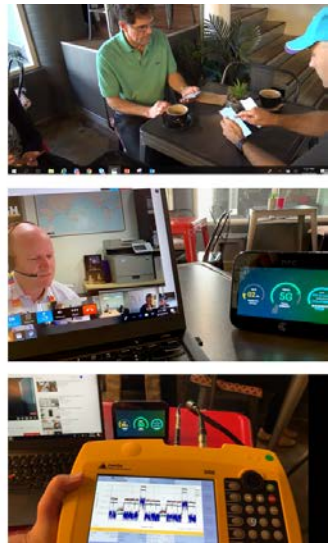
Highest exposure	
Cumulative: 27MHz to 3GHz	1.34%
3G, 4G, Wi-Fi	0.025%
5G (near UE antenna)	0.032%
5G (general environment)	0.012%

- Measurements at different positions

5G EMF Measurements – Gold Coast 2019

5G EME Testing – apartment with young engineers





5G EMF Measurements – Gold Coast 2019

5G Network configuration – Non Stand Alone

Ericsson NR6488
Frequency = 3.5GHz
Bandwidth = 80MHz
Transmit Power = 160Watts
Time Domain Duplex Ratio TDD = 3:1
Broadcast Beam Gain 17dBi
Traffic Beam Gain = 24dBi

Note – Network currently operating 8 CSI RS in non beamforming mode

5G EMF Measurements – Procedure

Channel power measurement of 5G EME level at high NR utilisation

Draft under development at IEC

1. Identify the NR carrier centre frequency (e.g. 3.585 GHz)
2. Identify the NR channel bandwidth (40, 60, 80 MHz)
3. Configure the spectrum analyser to measure the full NR carrier – apply the settings in Table 1
4. Perform a speed test using a 5G UE to check NR activity and instrument setting.
5. Adjust the spectrum analyser sensitivity to ensure the receive signal is a minimum of 10dB above the noise floor
6. Configure an iPerf session to run a continuous, downlink high bit rate UDP data stream (e.g. 1500 Mbps) from a network server to the 5G UE over the 5G network.
7. If iPerf is not available, use a freely available, internet-based speed test application.
8. Measure the channel power using the spectrum analyser – set the channel markers to either side of the NR carrier
9. Confirm that the contribution to measurement from UE is minimal.
10. Run the measurement for a minimum of 1 minute to ensure the average is captured.

Record the average received level. Example: The iPerf DL session is established between the network iPerf server and the 5G UE running an application such as ‘Magic iPerf.’ To initiate the iPerf DL session, the 5G UE IP address is obtained using an application running on the UE, such as ‘G-NetTrack Lite.’ A second UE (need not be 5G capable) running an application such as ‘Termius’, will be used to send a command line to the iPerf server, which will include the 5G UE’s IP address and a desired DL bit rate, to trigger a DL session. Before the command is sent to the iPerf server, the 5G UE is made ready for the session by launching the application ‘Magic iPerf.’

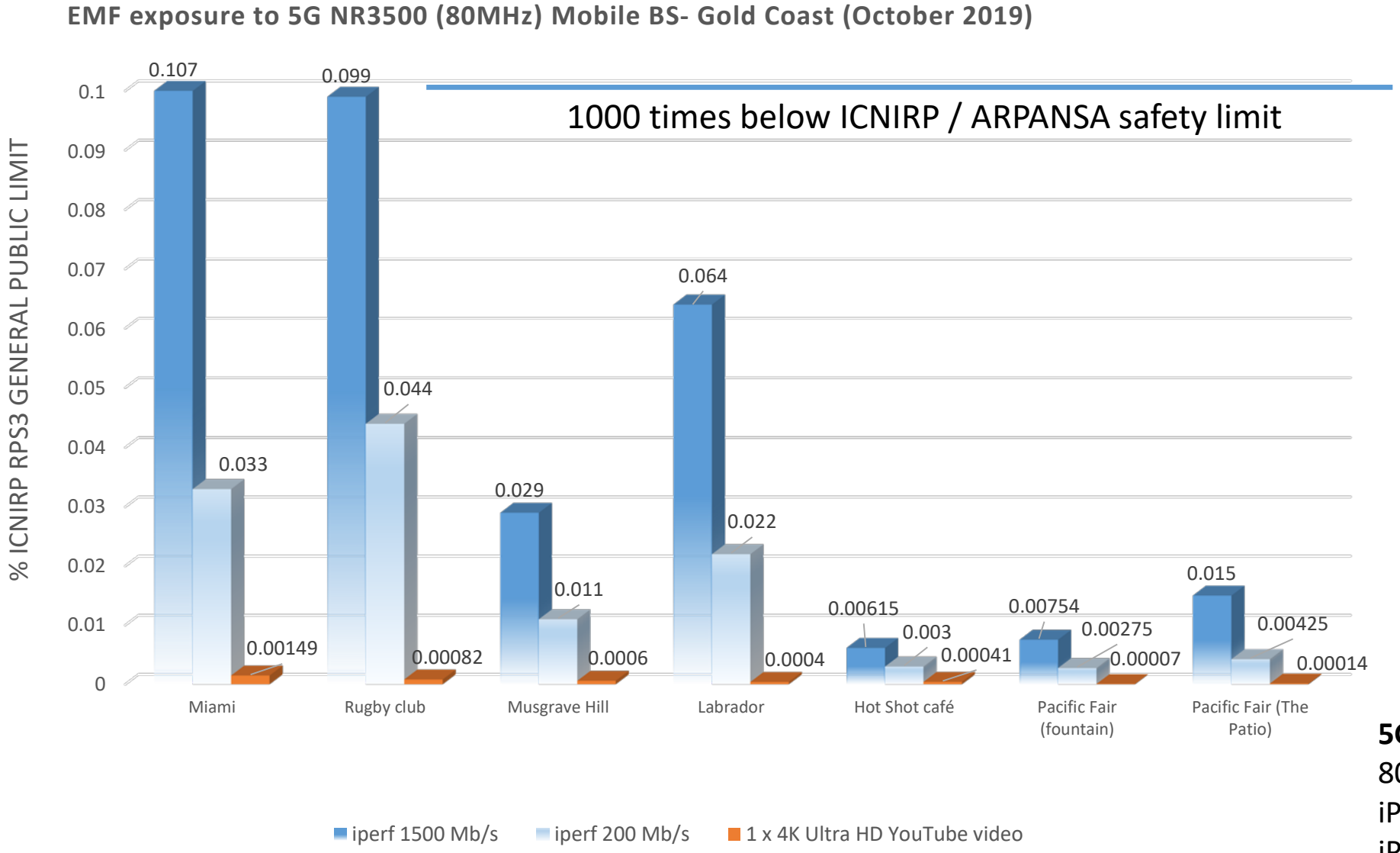
5G EMF Measurements – Procedure

Channel power measurement of 5G EME level under common user scenarios

Draft under development at IEC

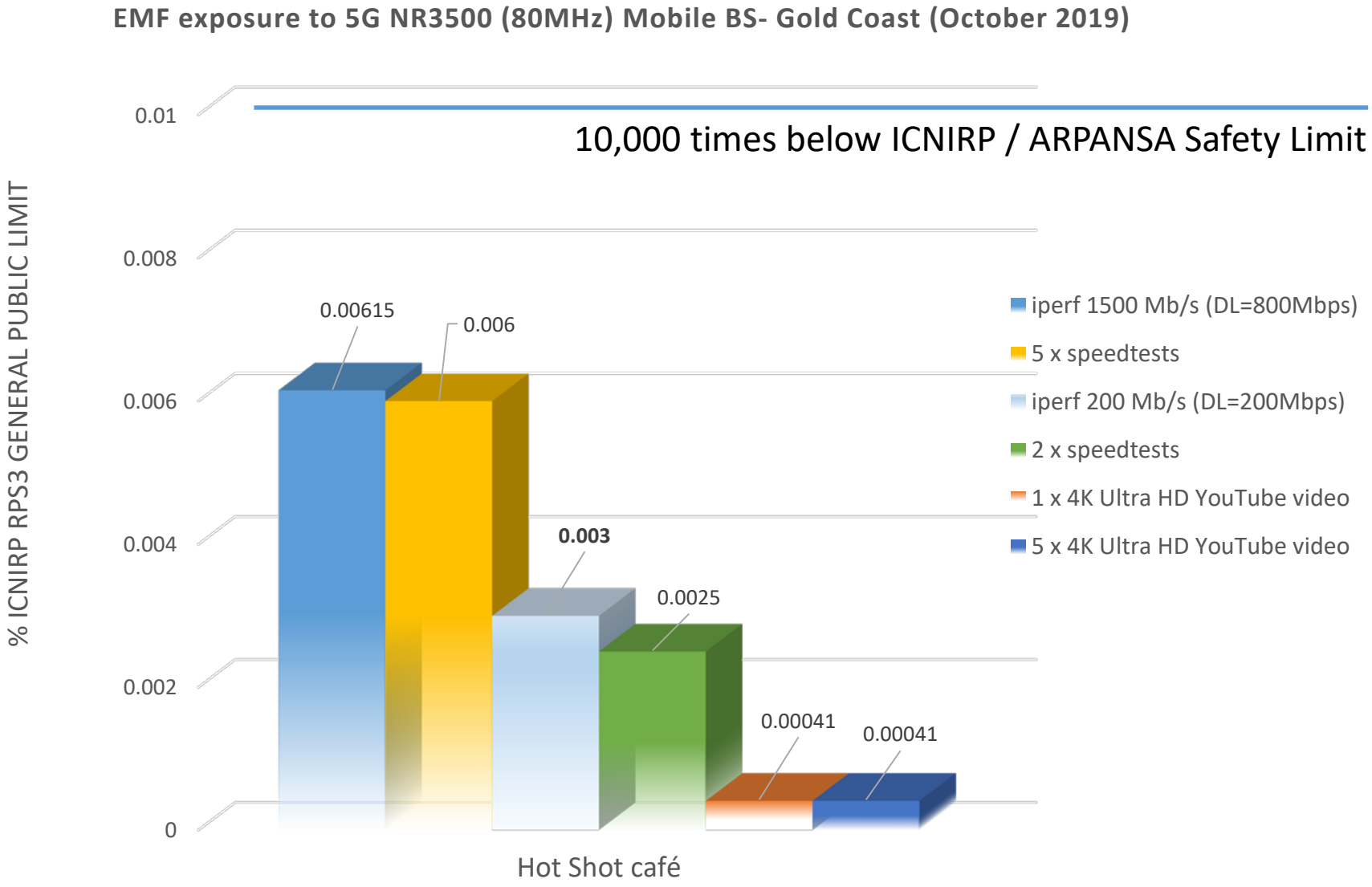
1. Identify the NR carrier centre frequency (e.g. 3.585 GHz)
2. Identify the NR channel bandwidth (40, 60, 80 MHz)
3. Configure the spectrum analyser to measure the full NR carrier – apply the settings in Table 1
4. Perform a speed test using a 5G device to check NR activity and instrument setting.
5. Adjust the spectrum analyser sensitivity to ensure the receive signal is a minimum of 10dB above the noise floor.
6. Common user scenarios: Speedtest, YouTube video (e.g. 4K HD), livestream TV, file download (e.g. 1 GB data file).
7. Measure the channel power using the spectrum analyser – set the channel markers to either side of the NR carrier
8. Confirm that contribution to measurement from UE is minimal.
9. Run measurements for a minimum of 6 minute – to ensure the average is captured over a number of different usage scenarios.
10. Record the average received level for each scenario.

5G EMF Measurements – Gold Coast Oct 2019



5G Network configuration
80MHz / 160Watts
iPerf 1500 = near max pwr
iPerf 200 = 0.5 to 0.3 max pwr

5G EMF Measurements – Main Beach



5G Network configuration
80MHz / 160Watts
iPerf 1500 = near max pwr
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5G EMF Measurements – Main Beach

5 x 4K HD Videos streaming on 5G – short bursts of data enable high quality video on 5G

5G EMF Measurements – Main Beach

5G Network configuration
80MHz / 160Watts
iPerf 1500 = near max pwr
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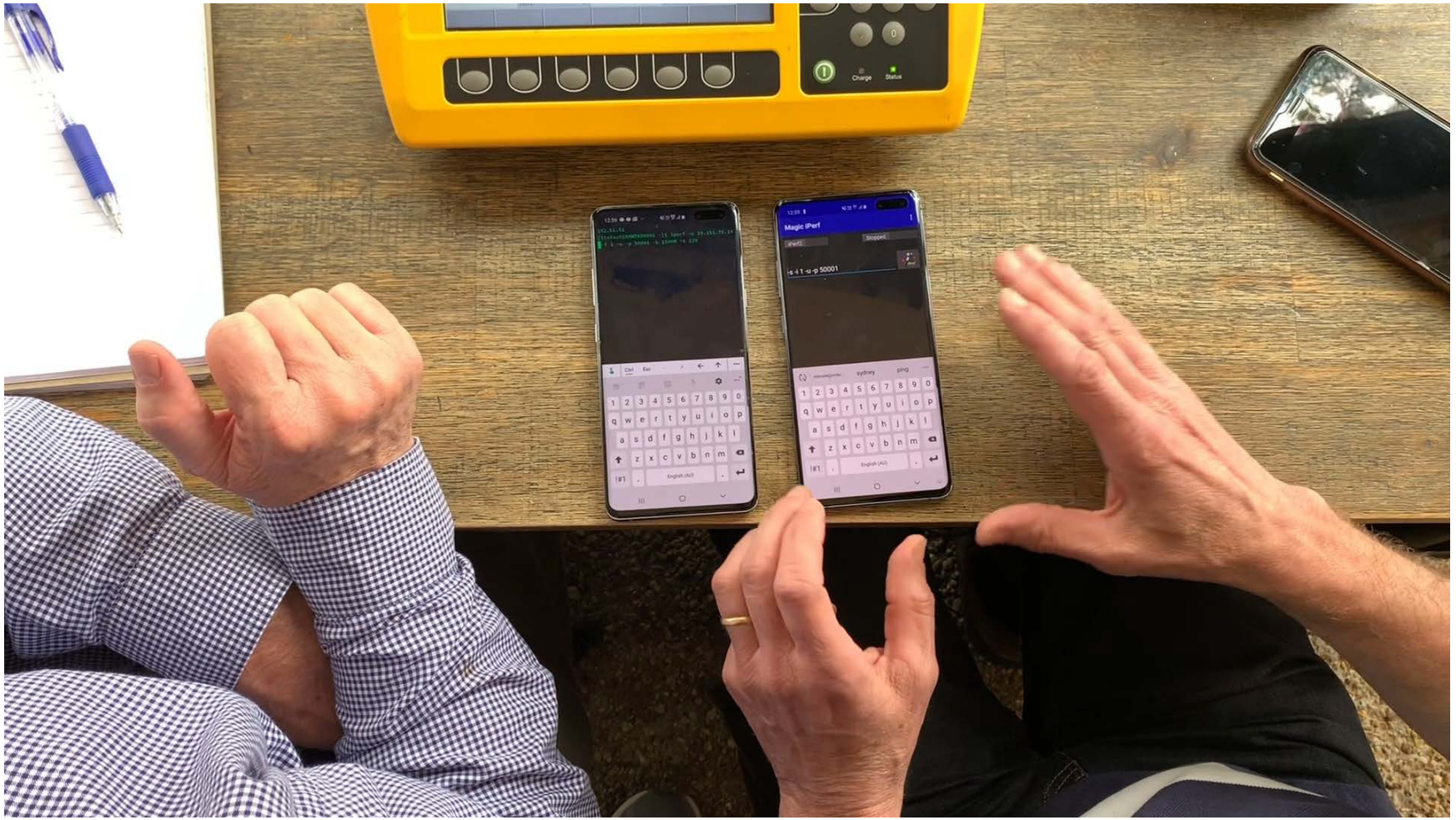
5G EMF Measurements – Main Beach



5G Network configuration
80MHz / 160Watts
iPerf 1500 = near max pwr
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5G EMF Measurements – Gold Coast Oct 2019

EME levels on a mobile tower

5G EMF Measurements – Gold Coast Oct 2019

5G & EMF – Conclusions & Observations

- **5G Technology** - uses radio frequency like existing mobile technologies and other radio services inc TV, FM, emergency and commercial services, microwave links & satellite
- **5G EMF testing standards -** have been developed by the IEC / IEEE & ITU
- **5G EMF levels from base stations -** are similar to 3G, 4G and Wi-Fi.
- **5G EMF levels were found to be well below the ICNIRP exposure limits -** and in many cases over a thousand times lower.

Thank you - Questions ?