50 surveys of 5G mmWave

Small Cell EME Testing

AMTA EME Symposium - September 2021

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Supported by Ericsson Labs and Ericsson Australia

Agenda

1. Overview
2. Locations
3. Survey Equipment
4. EME Survey Results
5. EME Survey Validation
6. Observations & Conclusions

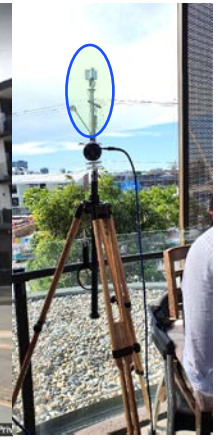
Overview

5G mmWave trial - During 2020 and 2021, Telstra conducted a 5G mmWave small cell trial in Melbourne, Brisbane, and the Gold Coast.

50 mmWave EME Surveys - as part of the trial to assess EME, we conducted extensive 5G mmWave small cell EME testing at over 50 locations in real world settings

Low EME - Our test results show that the 5G mmWave small cells produce low EME levels <1% of EME safety limit

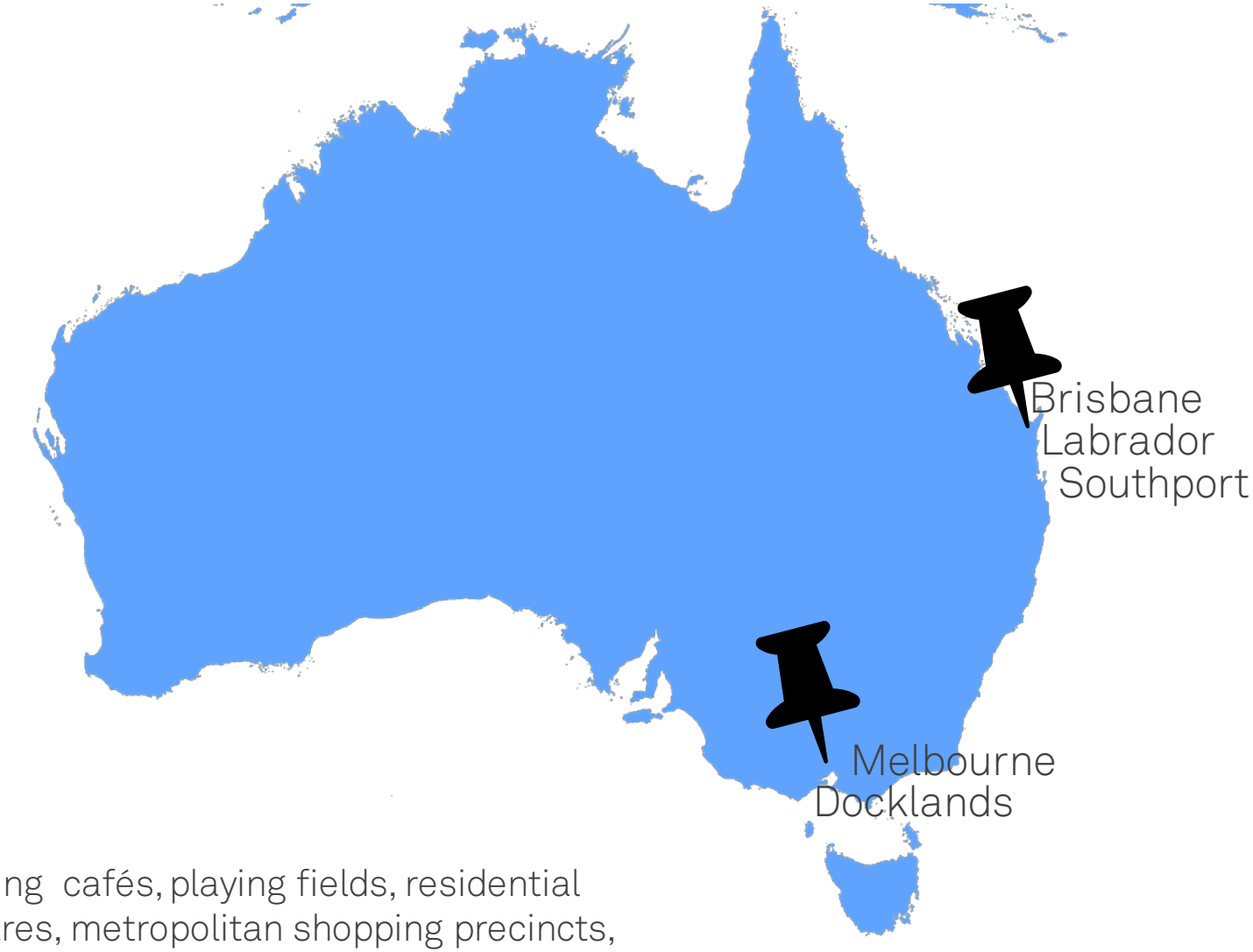
0.28 to 0.0005 % of the public safety limit even under high activity.



Small Cell Test Locations

50 surveys across 5 areas

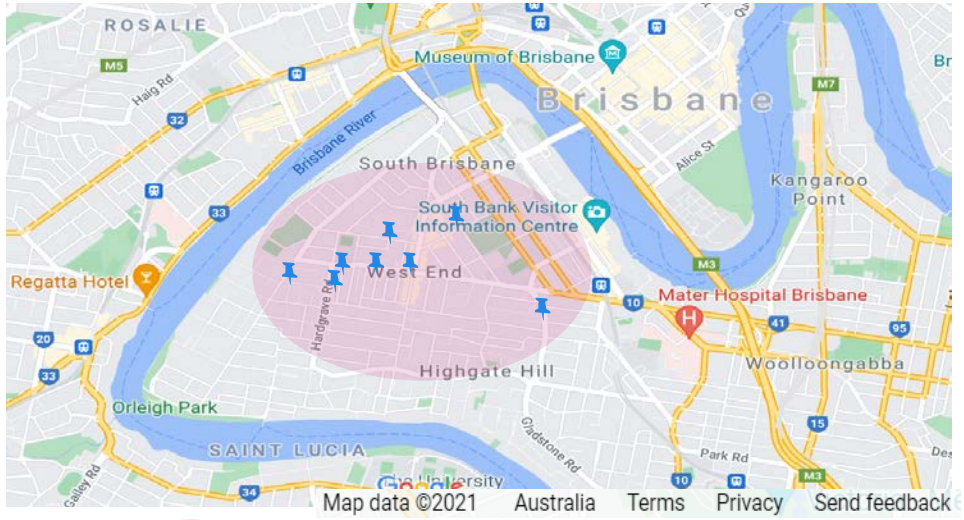
Capital City Centre
Regional Tourist Area
Inner City Apartments
Suburban Sports Fields
Suburban & Residential Area

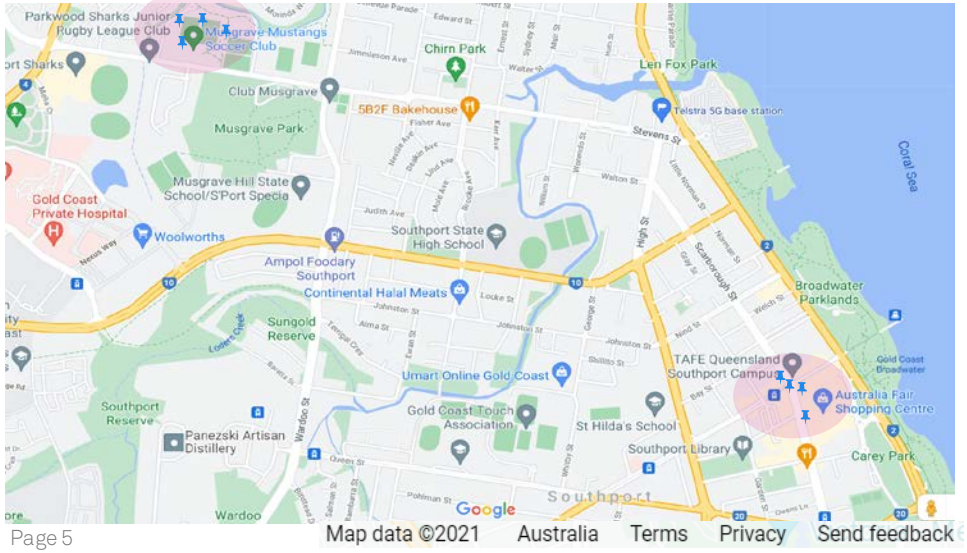


We tested 5G mmWave in real world settings including cafés, playing fields, residential streets, apartments, homes, schools, childcare centres, metropolitan shopping precincts, CBDs, public transport hubs, and our own laboratory and demonstration centres

Small Cell Test Locations

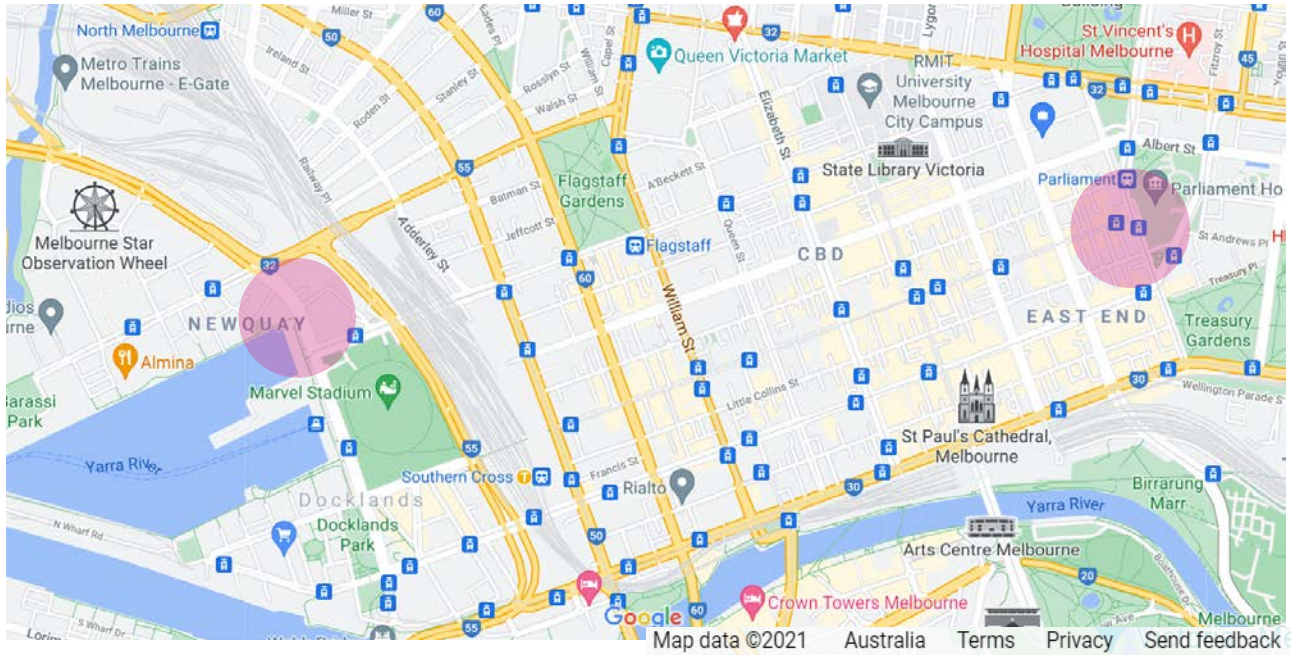
South Brisbane & West End



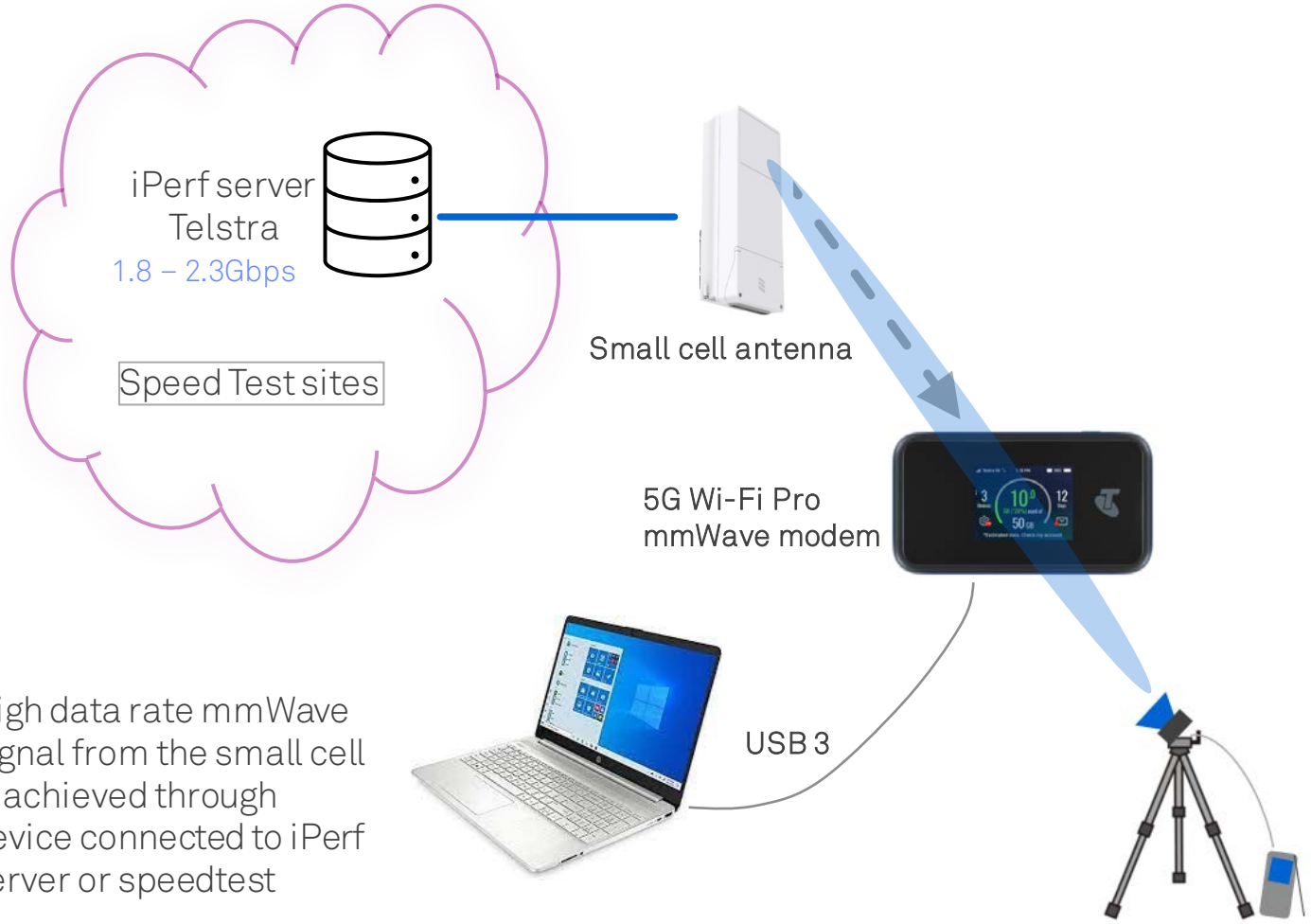


Gold Coast - Southport & Musgrave Playing Fields

Melbourne Docklands and Parliament Precinct



Environmental EME Test Setup – high data rate

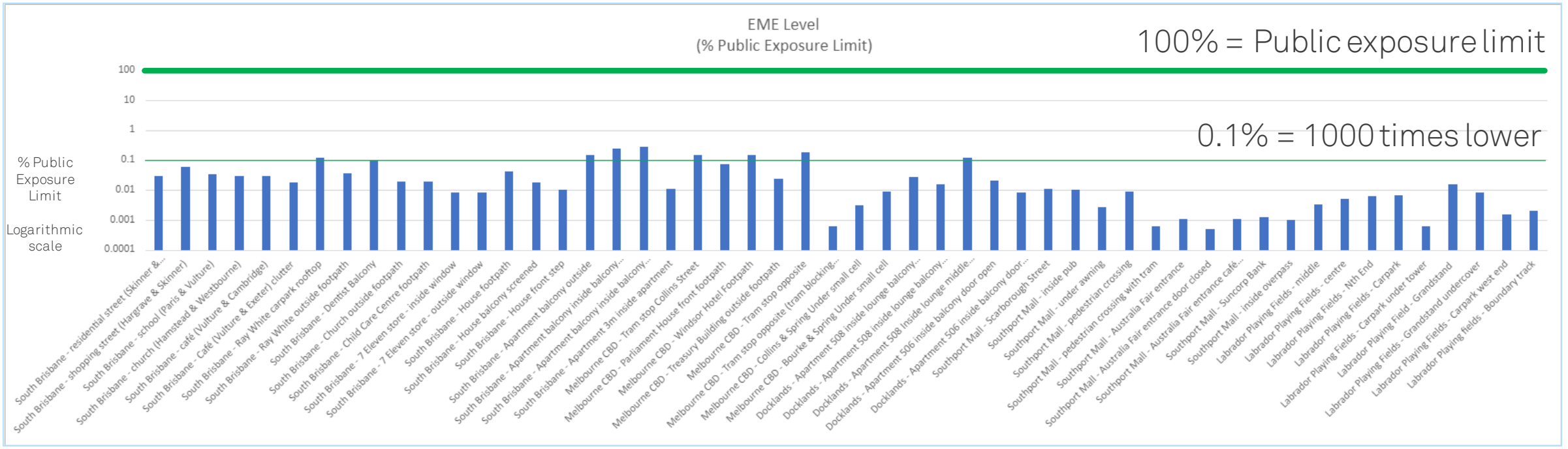


High data rate mmWave signal from the small cell is achieved through device connected to iPerf server or speedtest

EME Levels – from mmWave small cell trial

Notes

- EME was measured at over 50 real world locations – beam from small cell to active device
- mmWave small cells were operating at 1.8-2.4Gbps – loads the small cell to a very high capacity
- EME levels measured are maximum - under very high capacity
- Real world or actual EME levels - will be much lower than maximum



5G mmWave EME Survey at over 50 locations

EME Levels – from mmWave small cell trial

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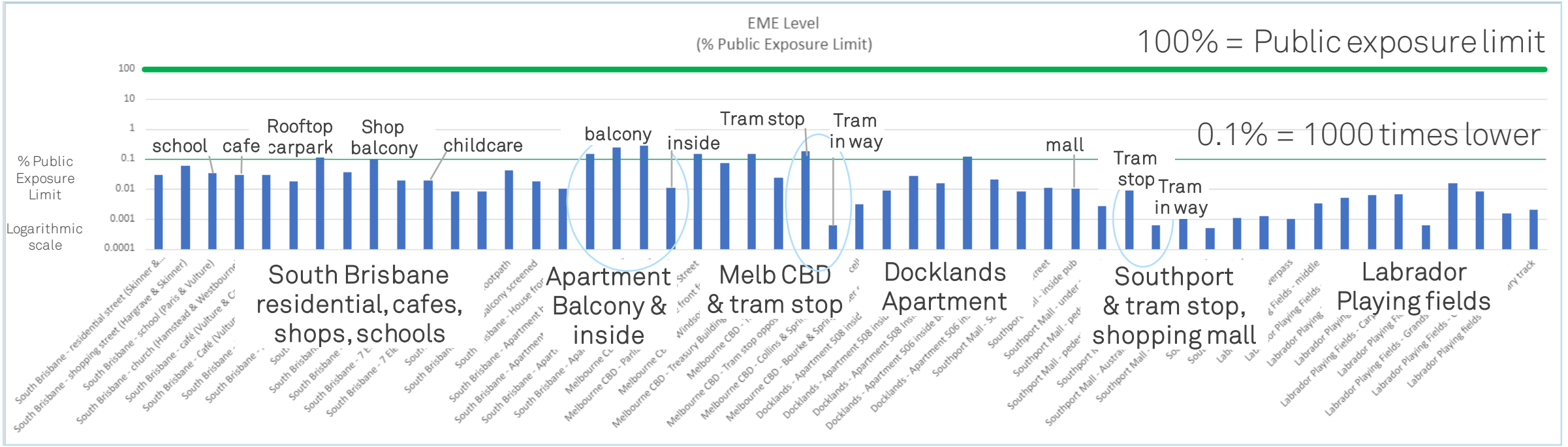
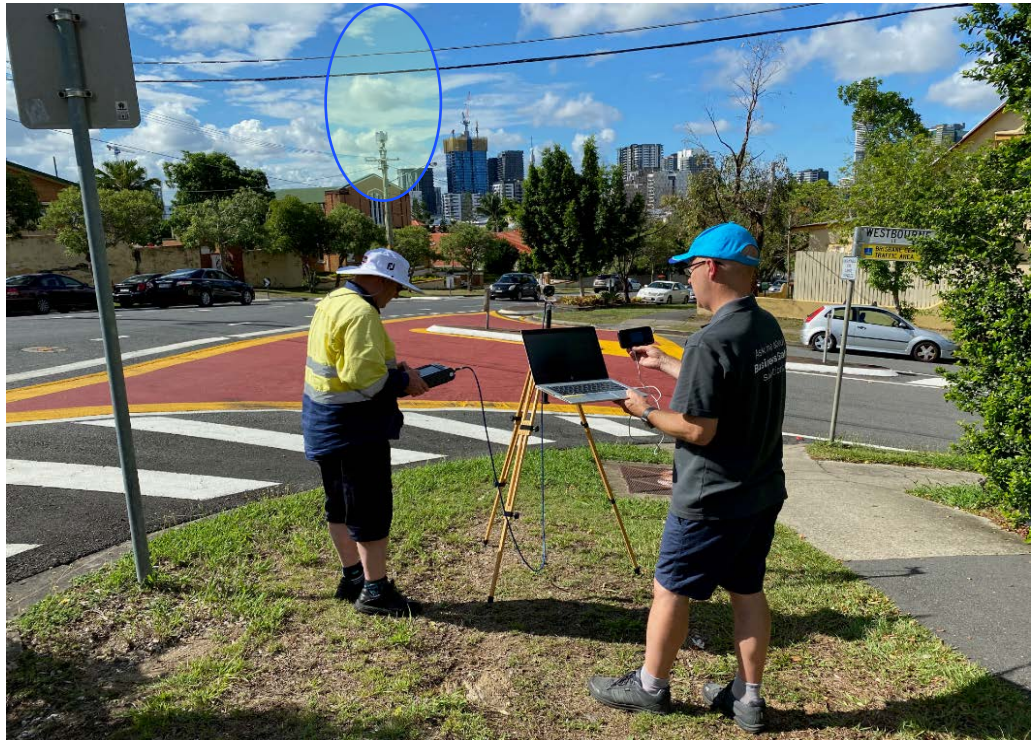


5G mmWave EME Survey at over 50 locations

Residential Streets

EME Level measured = 0.008%
5G connection – 1.8Gbps



EME Level measured = 0.024% – 0.029 %
5G connection – 1.8Gbps

Residential Streets – measuring the narrow beam

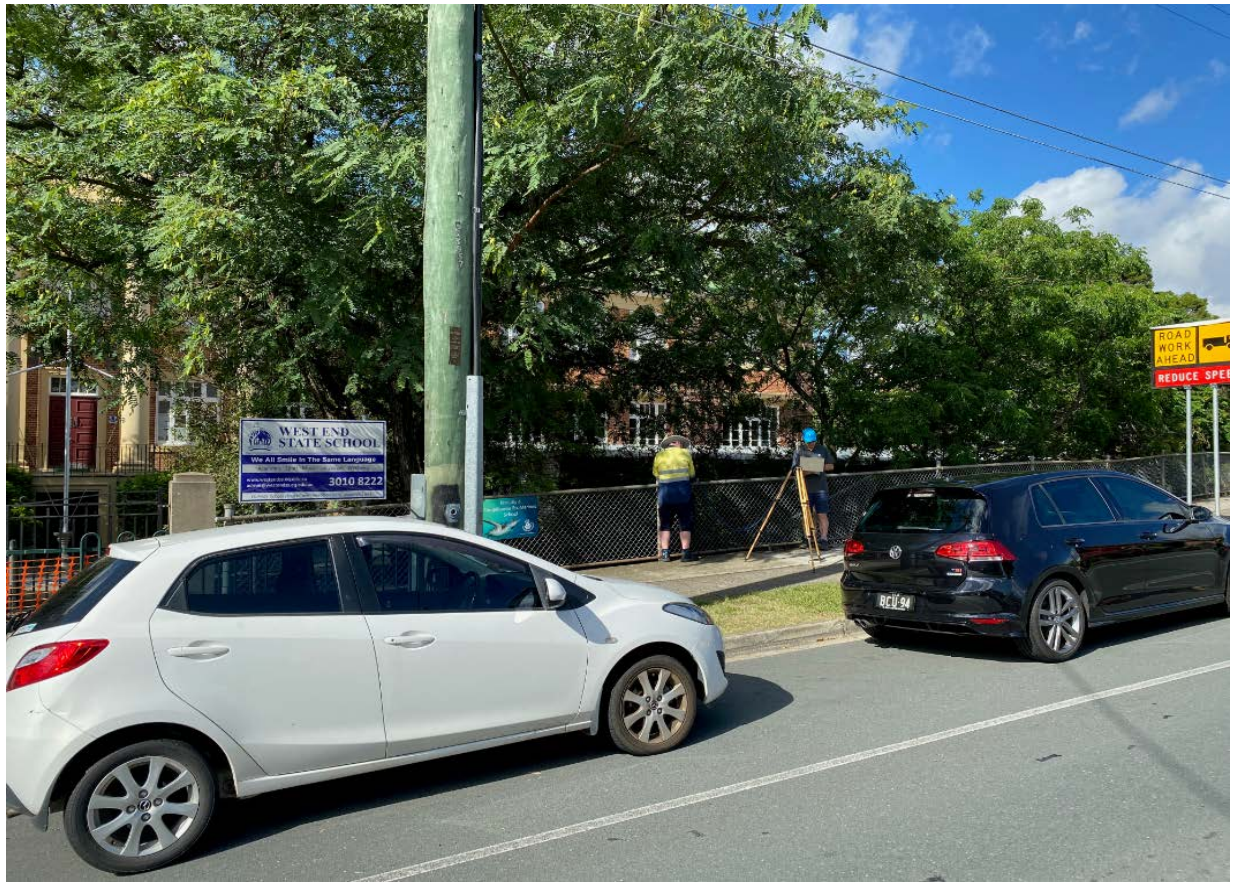
EME level reduces significantly when the device moves to a different beam 0.029% to 0.008%

beam width is 3.5deg

Café – with high 5G usage

EME Level measured = 0.018% - 0.03%
5G connection – 1.8Gbps, multiple users, 3 mmWave devices

Local School – front gate



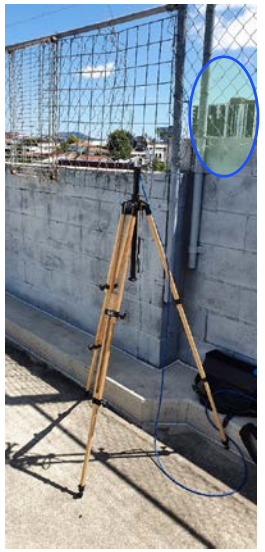
EME Level measured = 0.033%
5G connection – 1.8Gbps

Child Care – footpath

EME Level measured = 0.019%
5G connection – 1.8Gbps

Retail – Rooftop & footpath

EME Level measured = 0.117%



EME Level measured = 0.035%

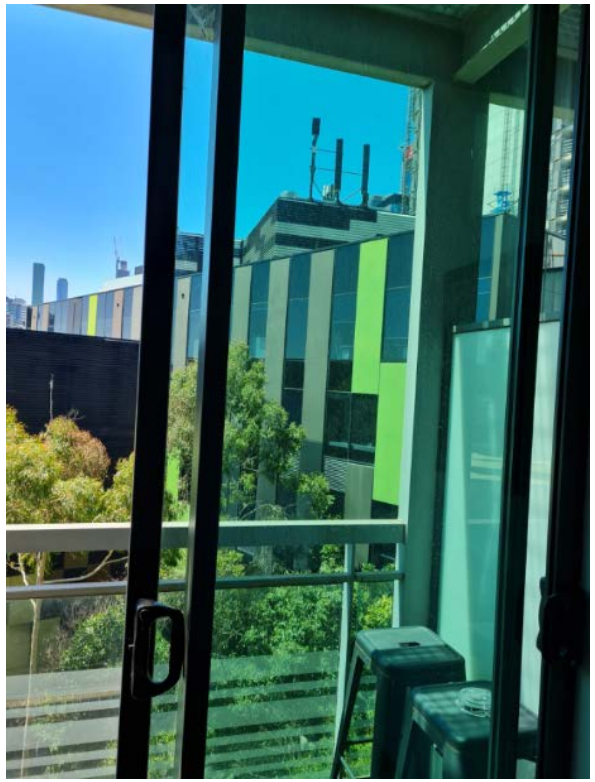
Apartment – opposite small cell

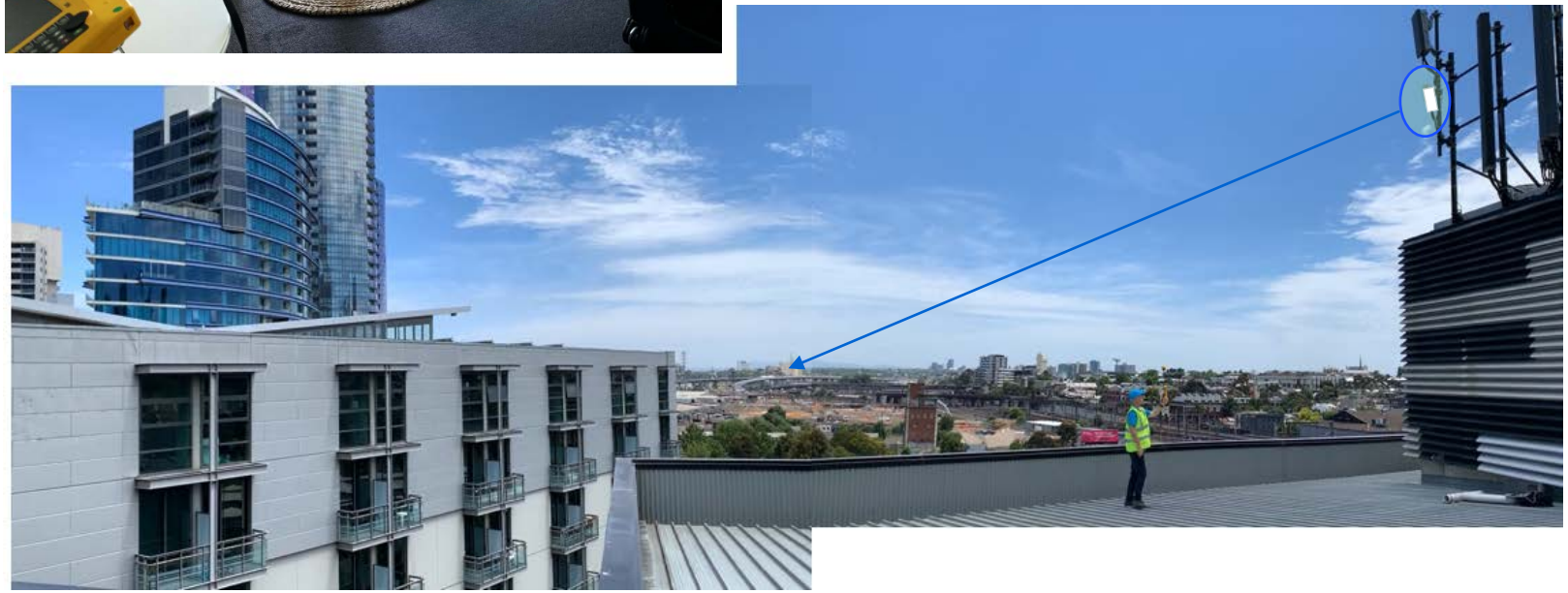
EME Level measured

Apartment – on balcony outside = 0.152%
Apartment – just inside balcony door open = 0.28%
Apartment – 3m inside balcony door open = 0.011%

5G connection – 1.8Gbps

Docklands Apartments – opposite rooftop



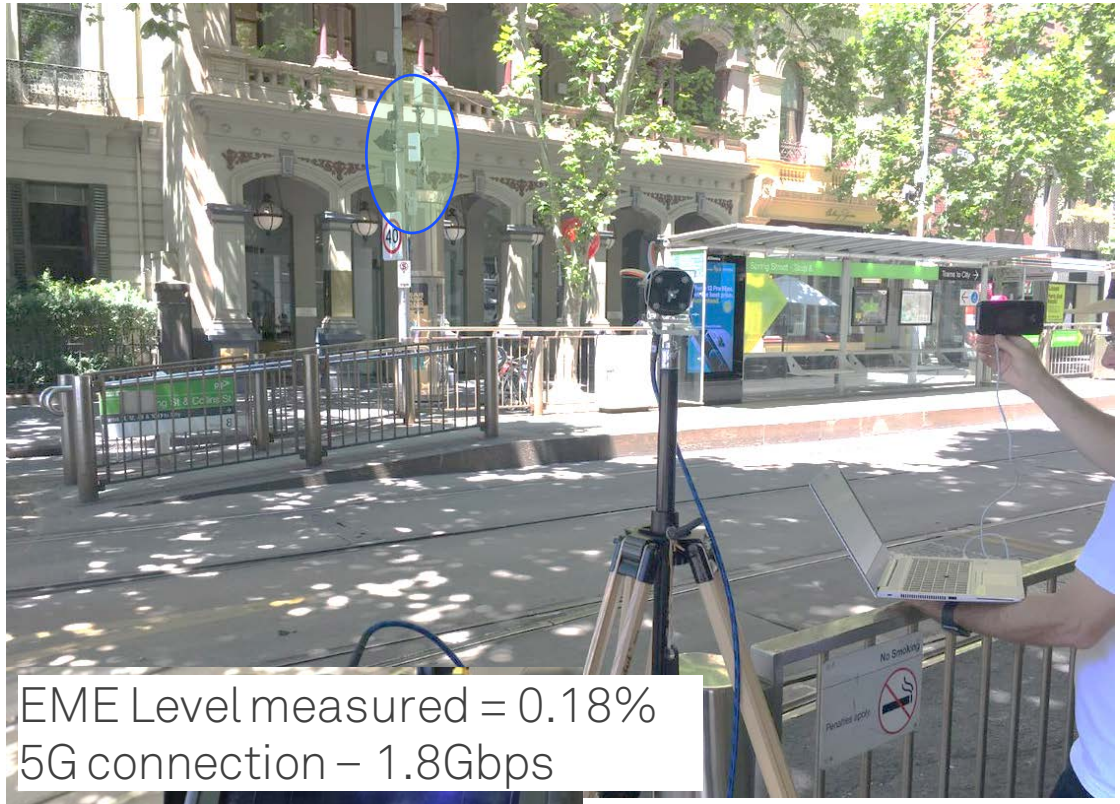


EME Level measured = 0.004% – 0.12%

Glass door – reduced EME by 3dB

5G connection – 2.1 – 2.5 Gbps

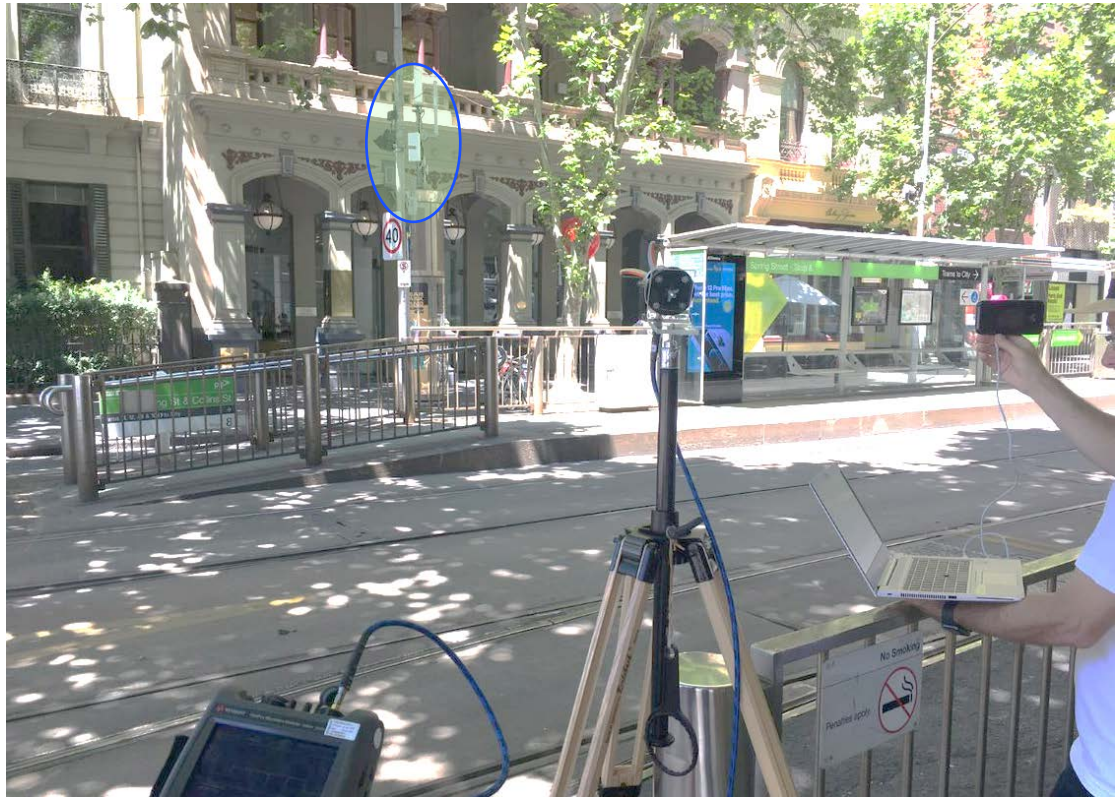
Melb CBD – Tram stop & behind small cell



EME Level measured = 0.18%
5G connection – 1.8Gbps

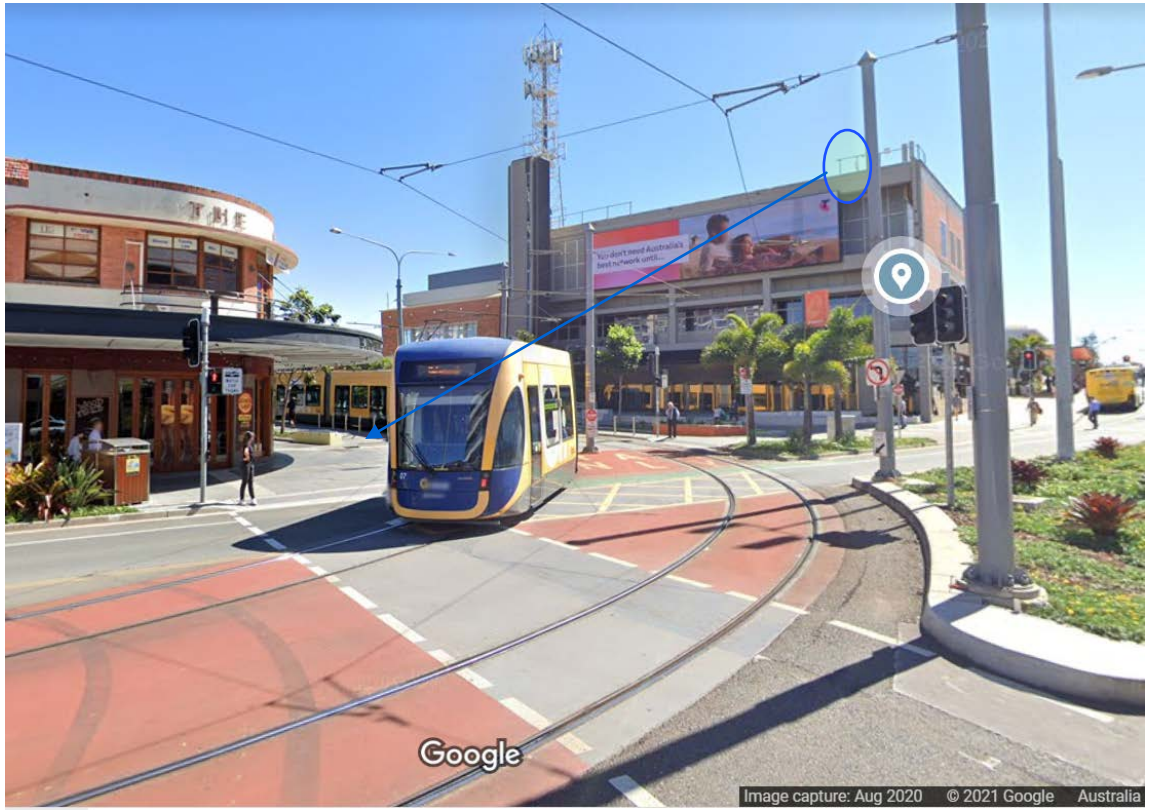
EME Level measured = 0.003%
5G connection – 1.8Gbps

Melb CBD – tram stop with tram crossing



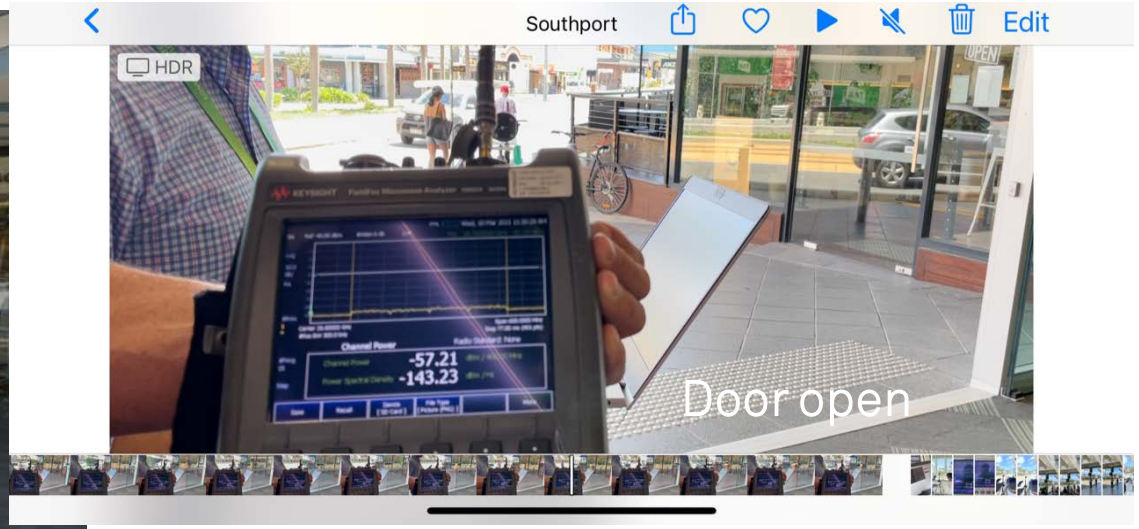
EME Level measured = 0.18 to 0.0006% (Tram crossing
5G connection – 1.8Gbps

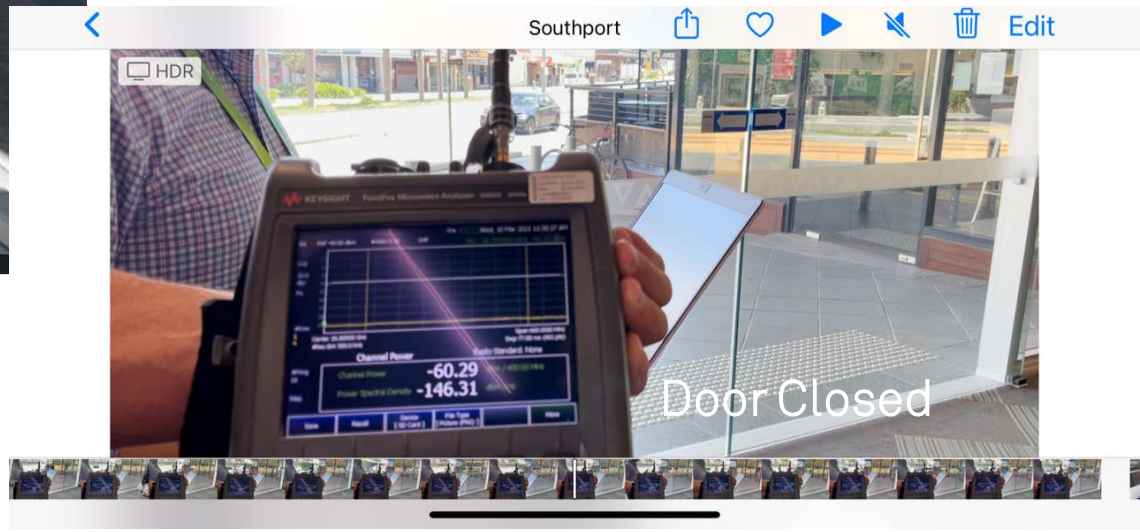
Southport – Mall (pedestrian crossing with tram)



EME Level measured = 0.0091% - 0.0006 (tram crossing)
5G connection – 1.8Gbps

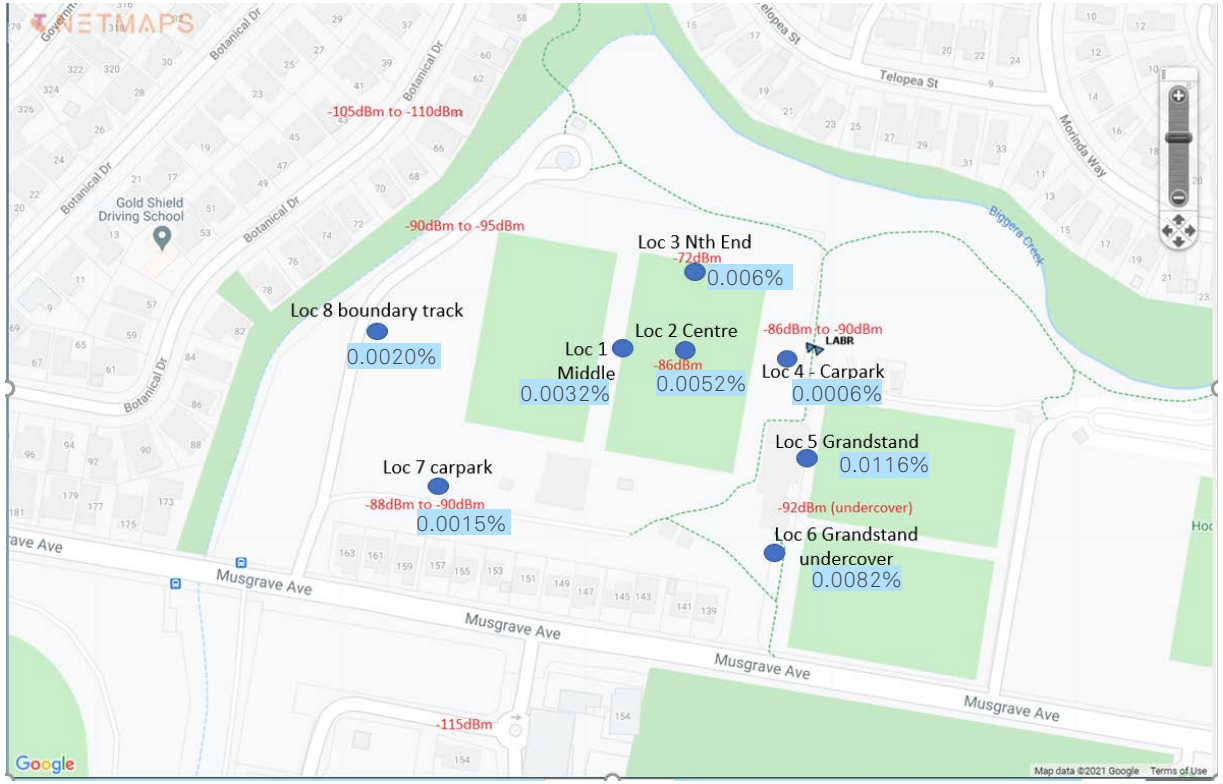
Southport – Australia Fair entrance

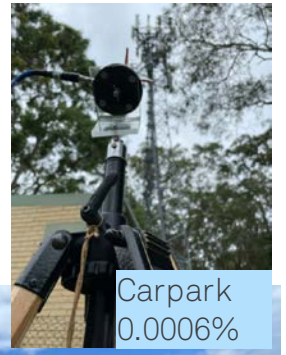




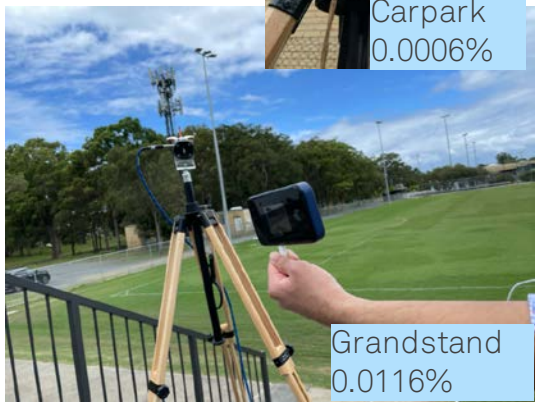
EME Level measured = 0.0011% - 0.0005 (door closed)
5G connection – 1.8Gbps

Labrador Playing Fields





Carpark
0.0006%



Grandstand
0.0116%

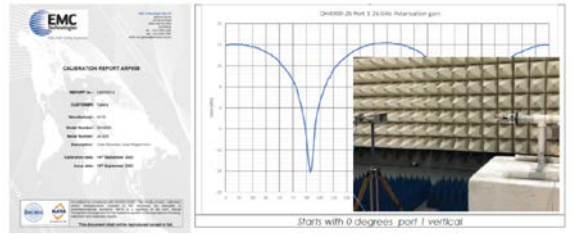
EME Level measured = 0.0006 – 0.016% (8 locations)
5G connection – 1.8Gbps

Environmental EME Test – validation steps

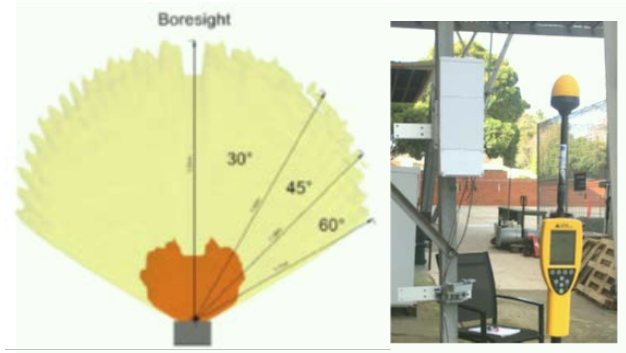
Calibrated Equipment – Narda NBM, Spectrum analyzer and horn antenna

Measurement comparison – side by side check

Measurement vs calculation



Laboratory Calibration



Angle (°)	Predicted distance (m)	Measured distance (m)
0	1.51	1.55
30	1.42	1.51
45	1.28	1.4
60	1.11	1.15

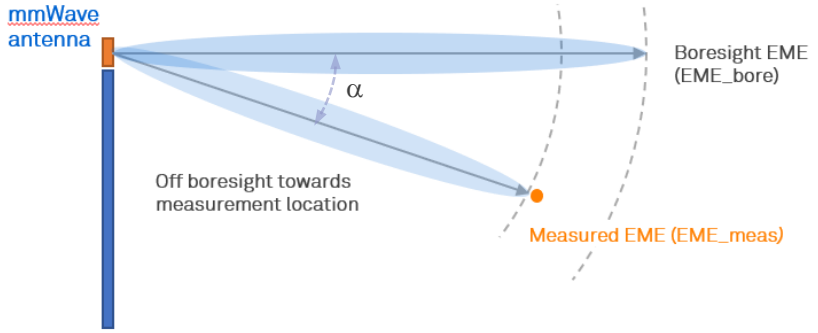
Measurement vs calculation

Distance	Horn (V/m)	NBM (V/m)
Varying bit rates, 6 m distance	6.5	7.4
	8.0	10.5
	13.8	18.1
9.5 m	5.4	6.4
16 m	2.4	4.0

Measurement comparison – side by side check

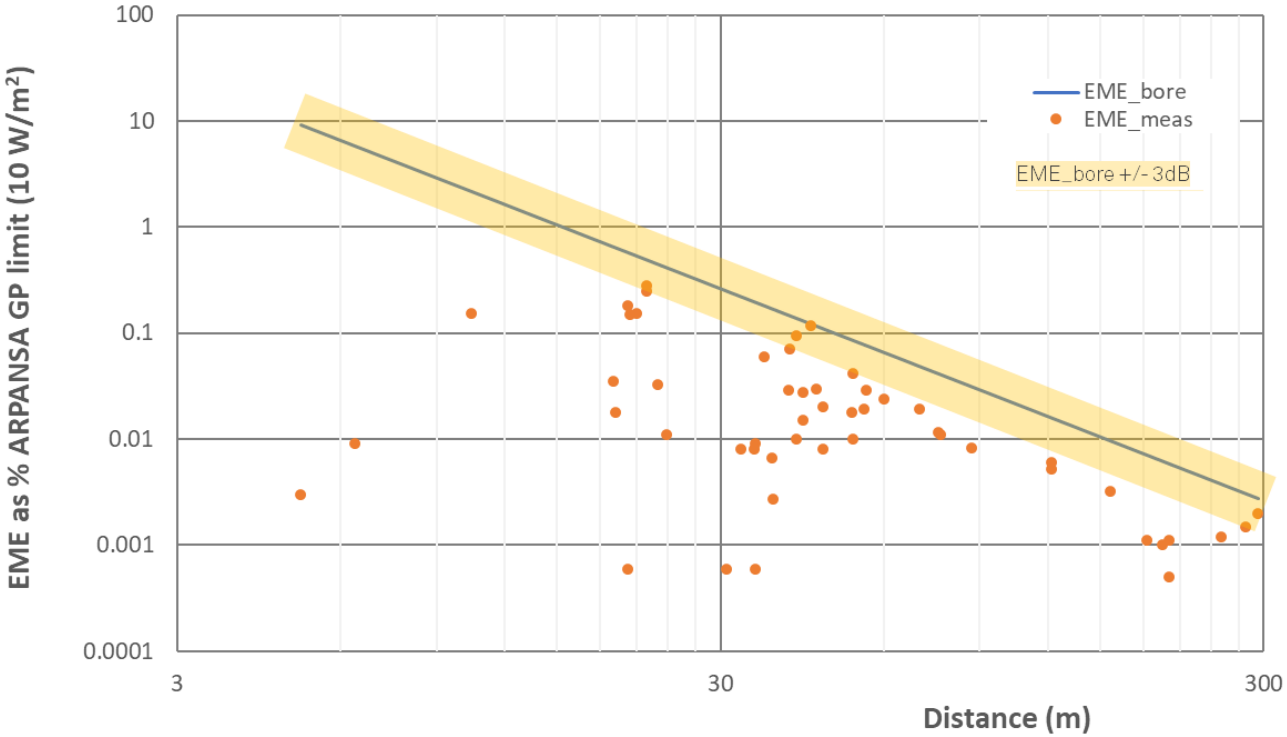
Key Point:
equipment, measurements and calculations validated

Environmental EME – measured vs predicted



- Graph shows the calculated, free space boresight EME and measured EME levels as functions of distance from the antenna.
- Distance is the direct line from antenna-to-measurement location.
- measured EME levels are less due to lower off boresight gain and environmental attenuation

$$EME\_bore = \frac{Antenna\_power \times Gain\_max}{4\pi \times distance^2}$$



Environmental EME - General measurement conditions

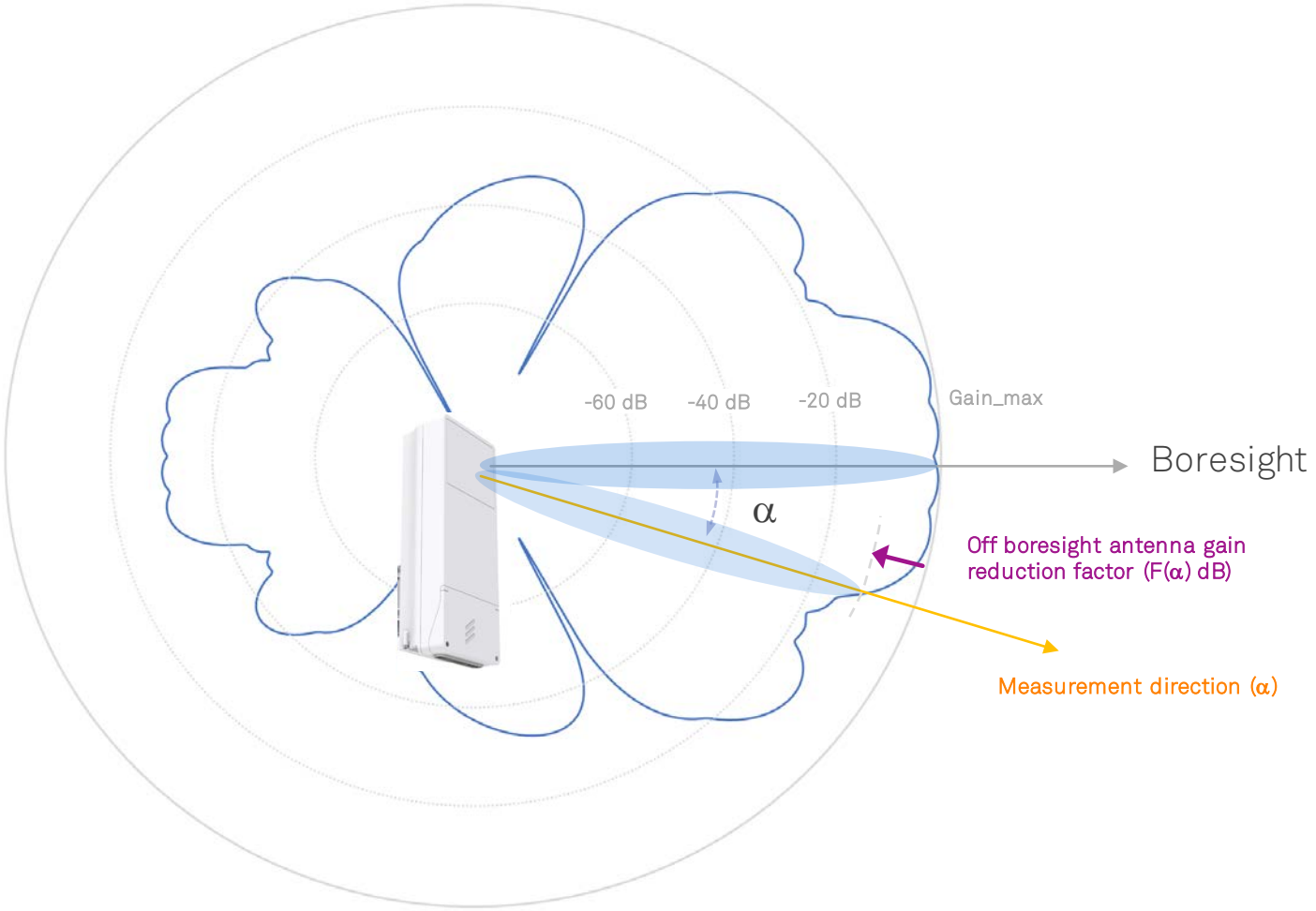
SM6701 antenna radiation pattern in vertical direction – envelope of all narrow beams

Boresight represents the direction of maximum antenna gain (Gain_max) and EME

Measurement locations in this study were mainly off boresight

Measured EME levels will be lower than boresight EME by the antenna gain reduction factor F(α) dB and ..

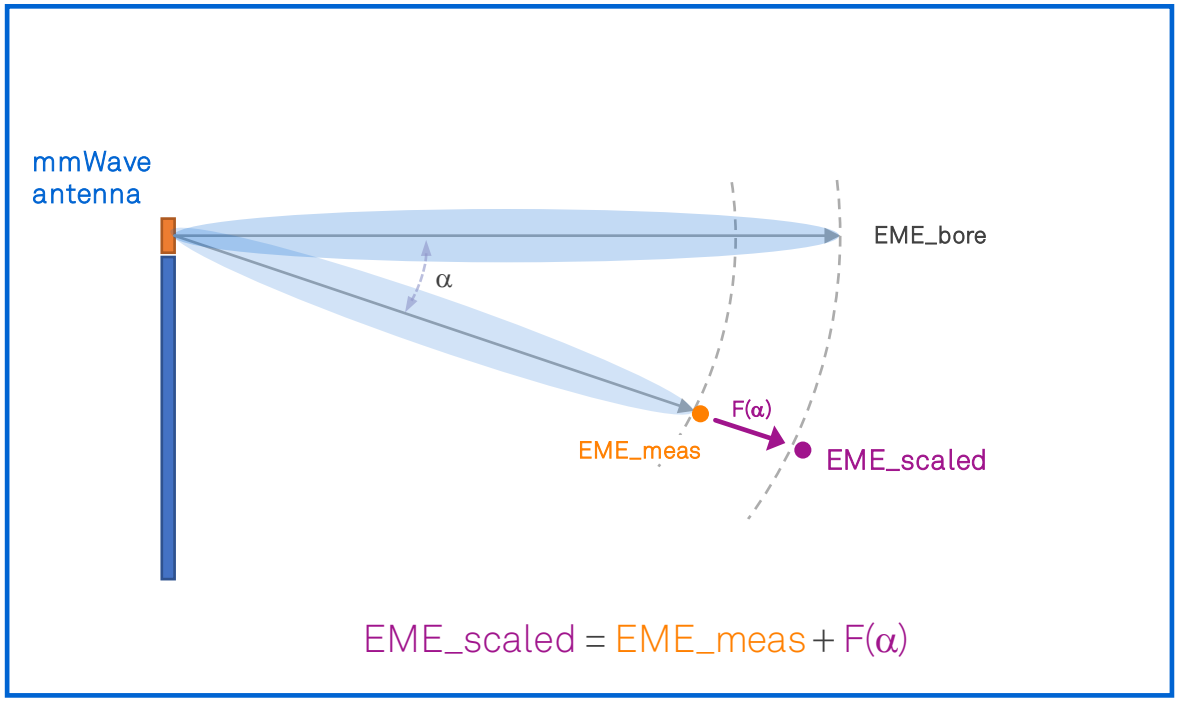
Additional local environmental loss factors (e.g. scattering and losses from buildings/trees/etc) contribute to the measured EME



Environmental EME – measured vs predicted

How well would a free space, far field calculation predict the EME level at a measurement location?

Compare measured EME level, scaled by the off boresight antenna gain reduction factor, with boresight EME



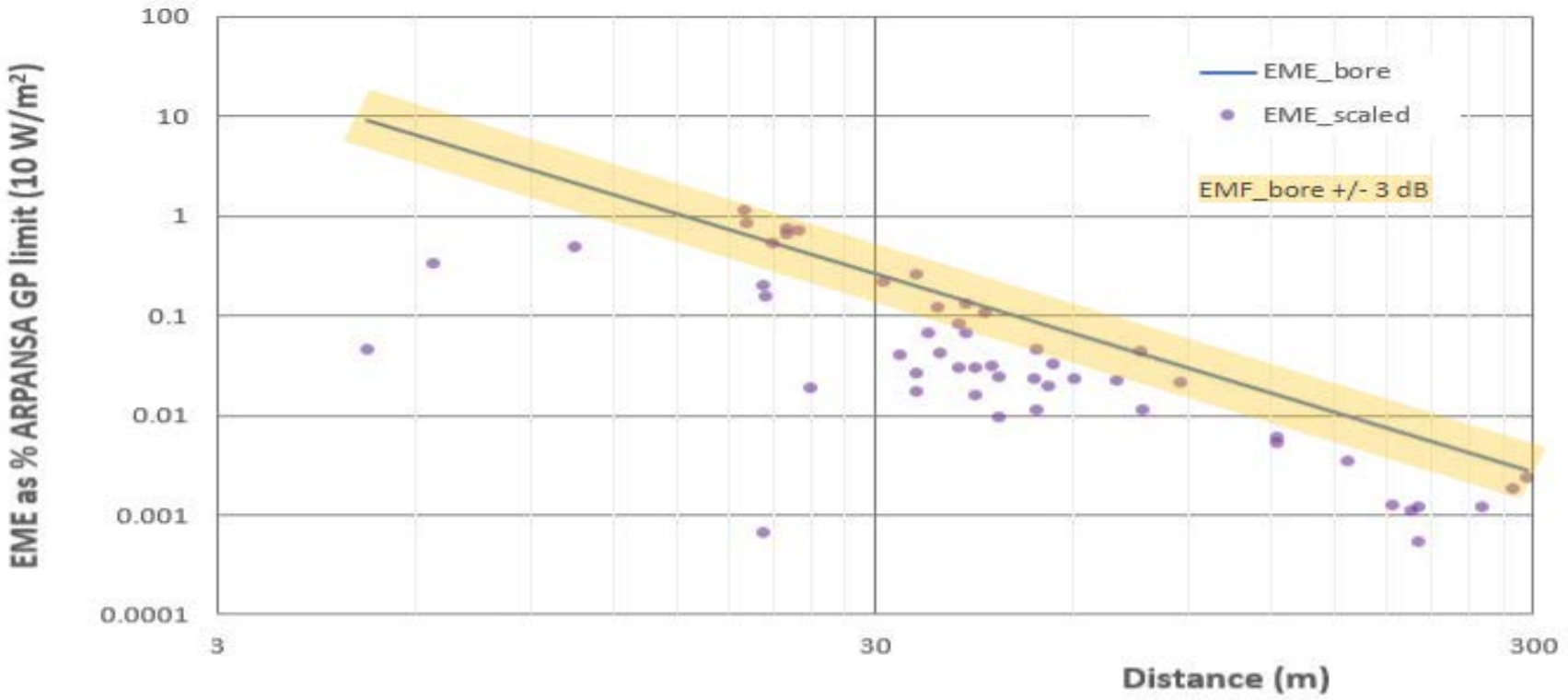
Environmental EME – measured (scaled) vs predicted

Measurement vs calculation – comparison of 50 measurements and calculations

Comparison Notes

- In a free space lossless environment, EME_scaled would lie along the line EME_bore.
- EME scaled values are consistent with free space far field trend.
- Values well below EME_bore – include losses due to clutter, trees, buildings
- The largest positive difference between EME_scaled and EME_bore is +2.4 dB which is within the uncertainty

Key Point:
Real world measurements align with calculations



Small cell EME calculation vs distance

50 EME measurements
results match calculation trend or below due to environmental clutter, trees, buildings

Key Observations

Small cell utilisation – our EME tests used continuous high data in one single beam. This is an unrealistic maximum.

Low average EME levels – mmWave small cells with beam forming direct a signal to where the devices are. In areas with many users, there will be low average EME levels as beams move around between users.

Signal Attenuation - Our testing shows trees, buildings and windows attenuate or block mmWave signals.

Apartments & Homes – Our testing shows mmWave signals may just reach inside a room if there is a clear view of the small cell through a window or glass door, and the mmWave signal reduces rapidly inside.

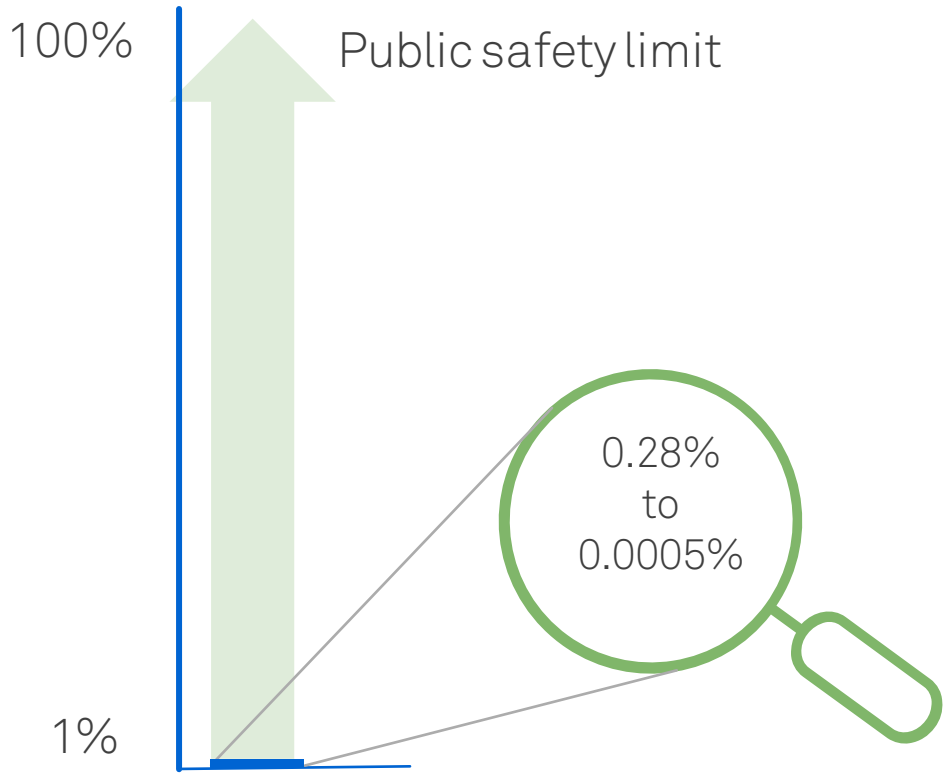
triple glaze, tinted and gas filled windows may block mmWave signals

Measurements & calculations align - Our testing shows measurements and calculations align using calibrated equipment and applying test methods from Standards Australia and the International Electrotechnical Commission (IEC).

Summary & Next Steps

Conclusion

- **5G mmWave is very efficient** – very high data and low EME.
- **Low EME** - our testing results show the **typical EME levels** in the general environment from the 5G small cells to be very low, less than 1% of the EME safety limits, and ranged from **0.28 to 0.0005 %** of the public safety limit.
- In most cases the 5G small cells produced **EME levels over 1000 times lower** than the public safety limit even under high activity.



EME from 5G mmWave small cells we tested
Less than 1% of the public safety limit

Next Steps

1. Our testing will continue as we build more small cells
2. Focus on testing in areas of high usage & multiple devices
3. Continue sharing our test results

Thank you

Further information and questions?
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www.telstra.com.au/eme

Technical Specifications & Standards

5G mmWave Radio
Ericsson SM6701
EIRP 53 & 56dBm
Frequency 27GHz

EME Exposure Standards
ARPANSA RPS S1
ICNIRP 2020

5G Device
5G Wi-Fi Pro
mmWave modem

EME Assessment Standards
IEC 62232
IEC TR 62669
AS/NZS 2772.2

Our testing applied these standards